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Study of the Impact on Industry of the use of Knowledge Providers

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Abstract

This study summarizes the main conclusions from an extensive review of the empirical state-of-the-art literature regarding the impact of knowledge providers on industry. The conclusions come mainly from three types of studies: (i) those studying the determinants of the use of knowledge providers; (ii) those addressing the different impacts (technical, economic, etc.) on firms out of the use of knowledge providers, and (iii) those aiming to analyze the determinants of the intensity of impact of knowledge providers.

Jelcodes:O32,O38

Study of the Impact on Industry of the use of Knowledge Providers: A Systematic Review of the Literature

Keywords

Impact Assessment, Industry, Knowledge Providers, Collaboration, Innovation, R&D, Firms, Literature Review

Abstract

This study summarizes the main conclusions from an extensive review of the empirical state-of-the-art literature regarding the impact of knowledge providers on industry. The conclusions come mainly from three types of studies: (i) those studying the determinants of the use of knowledge providers; (ii) those addressing the different impacts (technical, economic, etc.) on firms out of the use of knowledge providers, and (iii) those aiming to analyze the determinants of the intensity of impact of knowledge providers.

1. Introduction

Firms' direct links with knowledge providers has grown remarkably in the last decades (Hagedoorn, 2002; Amara and Landry, 2005) fostering the interest of academics and policy-makers in this area (Perkmann and Walsh, 2007). On the side of government and policy-makers, several initiatives have been launched for fostering links between firms and knowledge providers (Geroski, 1992; Martin, 1996). As a consequence, these linkages are currently being analyzed and evaluated more systematically to improve political instruments promoting collaboration (Mowery, 1999; Jaffe, 2008). Yet this growing literature is highly fragmented (Lichtenthaler, 2005). The purpose of this work is to analyze how the scientific community has approached the evaluation of direct linkages between firms and knowledge providers and to develop stylized facts from this literature. More precisely, the aim is to find existent evidence about the benefits achieved by firms as a consequence of their use of knowledge providers.

The term 'knowledge providers' is restricted in this work to those organizations whose direct interactions with firms are focused on provision of knowledge services[1]. Such organizations can be grouped into three categories: universities, research institutes and knowledge intensive business firms (including consultants).

The method followed for such analysis is the systematic literature review procedure (Tranfield et al, 2003). A systematic search for articles published on this topic was executed employing specific criteria for inclusion and exclusion of articles in and from the review. A total of 62 articles were

[1] That is, customers, providers of goods and machinery, or competitors are excluded from the analysis, even if they usually are also important sources of information for the innovation process.

included. These articles' key information was stored in a data repository specifically designed for recording their characteristics. The articles were then classified into three groups according to the research question they addressed: (i) What are the determinants of the use of knowledge providers, (ii) Do knowledge providers have an impact on firms' results (and how much impact do they cause)? and (iii) What are the determinants of impact? This strategy allows for an analysis of the approach followed by researchers to deal with this topic and for the development of some stylized facts on the benefits achieved by firms as a result of their relationships with knowledge providers.

The rest of the paper is organized as follows: Section 2 describes the methodology followed in the literature review; section 3 describes the main features of the final dataset of papers; section 4 provides the results from an in-depth review of the papers; and section 5 discusses the main findings and conclusions.

2. Methodology of the literature review

For achieving the goals of this research, a systematic review of the empirical literature was executed. This study followed the procedure described by Tranfield et al. (2003). Overall, the procedure describes three main stages. In the first stage the main goal of the research and the review plan are defined. Both of these elements are employed for guiding the execution of the review at all times. During the second stage is when the articles are selected, classified and reviewed. As a result the information of interest to this research is stored for its analysis in the data repository. Finally, in the last stage, the main conclusions from the analysis of the data repository are presented. The goal is to give a synthesis of patterns and common results in the literature. The synthesis of the results is to be used to state recommendations for improving the study of the impact of knowledge providers as well as to report convergences and divergences found in the literature. Also, it will be possible to assess the value of the results of the literature review for improving research, innovation policy and management practices.

Table 1 – Systematic Review Procedure

SYSTEMATIC REVIEW PROCESS DIAGRAM		
Stage I – Planning	**Stage II – Executing**	**Stage III - Reporting**
- Identification of the review inquiry - Preparation of the review plan (protocol)	- Identification of studies - Selection of studies - Quality assessment - Data extraction and Data Repository	- Elaboration of the systematic review report (Meta-Analysis) - Recommendations

Source: own elaboration based on Tranfield et al (2003)

2.1 Identification of Studies

In order to fulfill this study objective, it became essential to find a procedure for selecting keywords that would maximize the quality and efficiency of the search. It was necessary to choose keywords that would be (i) relevant for finding articles addressing the utilization of knowledge

providers and (ii) precise enough to avoid as much as possible the inclusion of non-relevant publications to this research. To achieve so, a list of 23 articles was created out of previously-read key literature. These articles were used to extract keywords for the search string. The chosen keywords were grouped into four categories. The first category was created for grouping keywords referring to impact assessment (C1 – Impact). The second category collected terminology referencing firms (C2 – Industry). The third group included terms to describe a "utilization" condition (C3 – Relationship). The fourth and final group collected keywords addressing the linking activity (C4 – Activity). Due to the multiplicity of names and terminology given to some knowledge providers, the inclusion of the typology of knowledge providers, as part of the search string, was considered inappropriate.

Once relevant keywords had been selected, the most frequently used ones were included in the search string. The search string was first tested in ISI Web of Knowledge (WoK), the chosen publication database for this study. In order to consider the search string valid, it had to include the 23 articles from the first list among the search results. Only two of the articles were not listed because neither was included in WoK's database. So the string was considered appropriate and it was then used to retrieve the state-of-the-art literature. The first search returned a total of 18,337 publications. This list of publications was then narrowed to only those articles under the social science category. The total number lessened to 7,659 results. Finally the results were refined by subareas. A total of 34 subareas were included in the search string. The search returned a total of 7,104 publications.

Table 2 – Keywords and Search Strings

CATEGORY	KEYWORDS
C1 – IMPACT	impact* OR assess* OR evaluat*
C2 – INDUSTRY	Firm* OR Enterprise* OR "Private Sector" OR Industr* OR SME* OR Compan*
C3 – RELATIONSHIP	Link* OR Relation* OR Cooperat* OR Collaborat* OR External OR Partner* OR Alliance
C4 – ACTIVITY	Innovat* OR R&D OR research OR transfer* OR support OR consultan*
SEARCH STRING 1 Feb 22nd 2010 18.337 Results	Topic=(impact* OR assess* OR evaluat*) AND Topic=(Innovat* OR R&D OR research OR transfer* or support or consultan*) AND Topic=(Firm* OR Enterprise* OR "Private Sector" OR Industr* OR SME* OR Compan*) AND Topic=(Link* OR Relation* OR Cooperat* OR Collaborat* OR External OR Partner* OR Alliance)
SEARCH STRING 2 Feb 22nd 2010 7.659 Results	Topic=(impact* OR assess* OR evaluat*) AND Topic=(Innovat* OR R&D OR research OR transfer* or support or consultan*) AND Topic=(Firm* OR Enterprise* OR "Private Sector" OR Industr* OR SME* OR Compan*) AND Topic=(Link* OR Relation* OR Cooperat* OR Collaborat* OR External OR Partner* OR Alliance) Refined by: General Categories=(Social Science)
SEARCH STRING 3 Feb 22nd 2010 7.104 Results	Topic=(impact* OR assess* OR evaluat*) AND Topic=(Innovat* OR R&D OR research OR transfer* or support or consultan*) AND Topic=(Firm* OR Enterprise* OR "Private Sector" OR Industr* OR SME* OR Compan*) AND Topic=(Link* OR Relation* OR Cooperat* OR Collaborat* OR External OR Partner* OR Alliance) Refined by: General Categories=(Social Science AND 34 Sub Areas)

2.2 Selection of studies

Once all results had been collected, they were imported into citation management software – EndNote™ X2. Afterwards, the 7,104 articles' titles and abstracts were reviewed and classified into four categories: a) Relevant, b) Partially-Relevant, c) Non-Relevant and d) Excluded. To do so, four inclusion criteria were used. Those articles matching all inclusion criteria would be placed in the Relevant Category. If just three out of four of the inclusion criteria were matched they would be grouped into the Partially-Relevant Category. The possibility of selecting some articles from the Partially-Relevant category was considered in case the number of articles from the Relevant one was too low. If an article matched less than three of the inclusion criteria it would be placed into the Non-Relevant or Excluded categories depending on the number of criteria it matched. The titles and abstracts were read and classified according to the following inclusion criteria:

1. The article must refer to the impact of the use of knowledge providers. The knowledge providers were grouped as: Universities (UNI), Research Institutes (RI) and Knowledge-Intensive Business Firms (KIBS).
2. The impact must be inflicted upon firms. Hence the unit of analysis is to be the firm itself rather than the sector or geographical region.
3. There must be a direct or formal relationship established between the impact-inflicting and the impact-receiving party.
4. The article must use empirical quantitative methods.

A total of 103 articles were listed within the Relevant category once the title and abstract review had been done.

2.3 Quality Assessment

The 103 articles from the review were fully read. However the final sample was reduced to a total of **62** articles. The additional exclusion of articles came as a result of the full text review of the 103 articles. This activity provided information not possible to extract from the titles and abstracts of the articles. The main reasons for excluding additional articles were:

- The utilization of knowledge providers was combined with the utilization of other categories of agents of no interest to this research. As a result, the impact from knowledge providers could not be distinguished. The indicators usually merged the utilization of knowledge providers with customers, providers and/or competitors.
- No formal relationships existed between firms and knowledge providers. That is to say, pure spillovers were the focus of the analyses.
- The unit of analysis was not the firm but the knowledge provider, the region or the sector.
- The results of the analysis were not useful to this research because the data analysis was merely descriptive.

2.4 Data extraction and Data Repository

During the review of the literature, each article was analyzed. Data from each article specific was retrieved and stored in the data repository. The data of interest was grouped into two general categories. The first category was used for recording general information from the articles. This information allowed for the description of the sample of articles from the review. The second category of data was specific to the typology of each article: (i) those studying the determinants of the use of knowledge providers (T1); (ii) those addressing the different impacts (technical, economic, etc.) on firms from the use of knowledge providers (T2), and (iii) those aiming to analyze the determinants of the intensity of impact of knowledge providers (T3).

3. Overview of articles resulting from the literature review

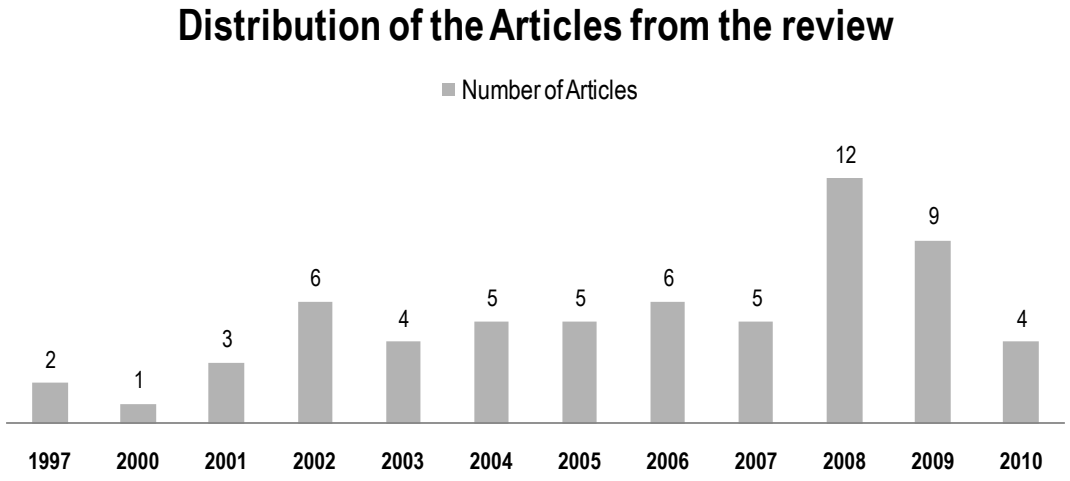
It is possible to summarize the main characteristics of the general information of the literature from the analysis. This description will allow for the framing of the scope of articles from the review as well as for the contextualization of the results and conclusion from this research.

3.1 Year, empirical method and data of the sample

The sample's year distribution is from 1997 to 2010. Over 58% of the sample is from articles published between 2006 and 2010. Hence most of the articles included in this research are very recent studies. The greatest percentages of articles in a single year are from 2008 (12 articles, 19%) followed by 2009 (nine articles, 15%) and 2006 (six articles, 10%). The most commonly exploited data sources were Community Innovation Survey (CIS) and other compatible[2] surveys (22 articles, 35%). CIS was utilized in 14 articles from the sample (23%). The list of CIS-compatible surveys is made up of Mannheim Innovation Panel (MIP) from Germany, Panel de Innovación Tecnológica (PITEC) from Spain and surveys from Canada, Korea and Taiwan. Other renowned surveys employed are Cambridge Business Research Survey (CBR) and Know Survey.

The number of articles published from 1997 to 2001 was very small (always less than four articles per year). Between 2002 and 2007, the number of articles rose to four to six per year. Finally, it is possible to see a significant increment in the number of articles published in 2008 and 2009 (12 and nine articles, respectively). This behavior shows an increasing interest from the scientific community on this topic.

[2] Use the Guidelines for Collecting and Interpreting Innovation Data included in the Oslo Manual



3.2 Journals

The articles from the sample were published in a total of 26 different journals. Out of the total list of journals, *Research Policy* is the one with the largest number of articles from the sample (15 articles, 24%) followed by *Technovation* (seven articles, 11%) and *Regional Studies* (four articles, 6%).

Table 3 – Most found Journals from the review

JOURNAL	ARTICLES
Research Policy	15
Technovation	7
Regional Studies	4
Applied Economics	3
International Journal of Industrial Organization	3
Journal of Product Innovation Management	3
Review of Industrial Organization	3
Ieee Transactions on Engineering Management	2
Industrial and Corporate Change	2
International Journal of Technology Management	2
R&D Management	2
Review of Economics and Statistics	2

3.3 Studied countries and industrial sectors

The utilization of knowledge providers was studied in 13 countries, most of which are European. The share of EU countries accounts for 61% of the countries from the sample. Out of the list of EU countries, the UK and Spain have the leading position with 12 articles each. The phenomenon has also been studied several times in USA. Fifteen percent of the articles study the utilization of knowledge providers in the American country. From the sectoral perspective, the study of the impact of the utilization of knowledge providers was always addressed in firms from manufacturing sectors. Articles addressing only manufacturing firms accounted for 52% of the sample. The

service sector was always addressed together with the manufacturing sector in the remaining 48% of the articles.

4. What is known about the impact on firms of the use of knowledge providers?

The articles resulting from the review of the literature were grouped into three categories. The grouping criteria depended upon the focus of the study regarding the utilization of knowledge providers. The categories are not exclusive. Some articles can fit within more than one category. About 23% of the articles were classified into more than one group.

The first category – T1 – grouped those articles dealing with the characteristics of firms that use knowledge providers. In other words, these are studies aiming to determine what kinds of firms do use knowledge providers. Forty-five percent of the included studies were classified as T1 (28 articles). The articles classified into the second group – T2 – were those addressing the impact or effect on companies out of the utilization of knowledge providers (39 articles). This group accounted for 63% of the sample. This type of study is the most frequent one in the literature. Finally, the third group – T3 – collects articles investigating the characteristics of the firms that influence the impact of using knowledge providers (18 articles). The center of attention is to know which types of firms receive the greatest impact out of the use of knowledge providers. The articles from T3 were divided into two subcategories of articles. The first subcategory – T3A – is made up of articles aimed at studying the characteristic of firms affecting the impact of using knowledge providers (nine articles). The second subcategory – T3B – was a direct result of the review of the articles. It is made up of T2 articles analyzing the impact of using knowledge providers in different subsamples of firms according to some specific characteristics (e.g. small vs. large firms), allowing for the determination of characteristics of the firms that influence the impact of knowledge providers (nine articles).

4.1 What kinds of firms do use knowledge providers?

To give an answer to this question, the articles from T1 were analyzed. As explained in previous sections, these articles aimed to find the determinants for using knowledge providers. To do so, the authors mainly explored the particular characteristics of the firms using knowledge providers. About 45% of the articles from the review were classified into T1 (28 articles). Out of the 28 articles from T1, 54% jointly studied the determinants of using several knowledge providers. That is, together they analyzed different partners. For example, research institutes and universities were considered as a single type of organization. Another 10 articles analyzed the determinants of just one knowledge provider each (36%). Finally just three articles analyzed the determinants of using knowledge providers separately (Montoro-Sanchez et al., 2006; Segarra-Blasco and Arauzo-Carod, 2008; Tether, 2002). All in all, universities were included in 21 articles (75%), research institutes in 19 articles (67%) and KIBS in nine articles (32%)

In these studies **dependent variables** (Yi) are an indicator of utilization. In most cases the indicator is a binary variable tracking whether the firm had some kind of link with knowledge providers (89%). The articles employing continuous variables use the value of the number of R&D projects or number of links between the firm and knowledge providers. In only one case was the R&D monetary amount spent on knowledge providers, as a share of total R&D expenditure, used. The exploited **databases** are mostly made out of data from surveys like CIS, MIP, KNOW, CBR or public agency surveys. CIS is the most frequently exploited one (32%). For the **sample of firms**, there are a couple of parameters to consider: (i) *number of observations per firm* and (ii) *number of firms* from the sample. The *number of observations per firm* is mainly equal to one observation (93%). Since the sample employs data that ranges between one to six years, each firm is observed only once, or twice in cases where panel-data is used. With respect to the *number of firms*, there are a couple of figures to talk about. First, the total number of firms from the sample (N) and, second, the total number of firms from the sample using knowledge providers (n). The total sample *N* varies from a few hundred to several thousand firms. The largest samples are often from articles using CIS. On average, the sample is made out of approximately 2,410 firms. The subsample *n* is on average 43% of *N*. As well as the total sample *N*, the largest values from *n* are used in articles with data from CIS. On average, *n* is made out of 781 firms.

The last element to consider are the **independent variables** (Xi). These variables were grouped into (i) those referring to characteristics of the firm and (ii) those addressing firms' motives for using knowledge providers. Eighty-nine percent of the articles from T1 assess variables referring to characteristics of the firm. Articles studying the motives for using knowledge providers stand for 39%. Each of these groups is described in following sections.

4.1.1 Main studied characteristics for using knowledge providers

The most frequently studied characteristic of the firms using knowledge providers is the ***Size*** (22 articles). The size is studied employing both continuous (86%) and discrete (14%) variables. Out of the studies using continuous variables, the most frequently employed indicators are the *logarithm of the total number of employees* (36%), *total number of employees* (23%) and *logarithm of sales* (14%). In the case of discrete indicators, they are grouped using values either from predefined ranges (9%), quartile position (5%) of the number of employees of the firm. Regardless of the indicator type, the results are conclusive. The size of the firm influences the utilization of knowledge providers in a positive and highly significant way.

RESULT 1: The size of the firm positively affects the utilization of knowledge providers

The second most studied characteristic is ***R&D Activity*** (20 articles). This characteristic is studied employing several types of indicators. Most of the studies employ continuous indicators (65%). Nearly all continuous indicators are some measurements of R&D intensity of the firm (55%). In most cases the intensity is studied evaluating the share of R&D employees. Out of the articles using discrete indicators (12 articles), over half of them target *Continuity* and *Recurrence* of the

research and/or innovation activity (seven articles). As expected, it is very significant and positive for the use of knowledge providers.

RESULT 2: Internal R&D Activities positively affects the use of knowledge providers

The firm's ***Sector*** is the third most studied characteristic of the firms using knowledge providers (14 articles). Out of the indicators assessed, the most frequently employed sector taxonomies are OECD's (50%) and Pavitt, K. (1984) (21%). The rest of articles address specific sectors of activity. As mentioned in previous sections, the articles usually evaluate manufacturing firms. The service sector is specifically assessed in quite few studies (36%). Due to the convergences from the OECD and Pavitt taxonomy in their way of classifying industrial sectors, the results from both taxonomies are compatible. It is possible to state that as the technological level of the firm increases, so does the utilization of knowledge providers.

RESULT 3: The technological level of the sector positively affects the use of knowledge providers

The rest of the characteristics are not studied as often as the previous ones. However some of them are worth mentioning. *Education Level of Employees*, *Education Level of Executives*, *Export Activity* and *Public Subsidies* usually show positive and significant coefficients. However, in the case of *Public Subsidies* such coefficients show correlation with the utilization of knowledge provider, rather than for causality, because some of the subsidies require the firm to cooperate in order to be eligible for the aid. Finally, when *Foreign* firms are distinguished, no significant effect is found.

RESULT 4: Other determinants that seem relevant have received little attention

4.1.2 Main studied obstacles for innovation that motivate using knowledge providers

There are other indicators dealing with the use of knowledge providers but they are not strict characteristics of the firm. These indicators analyze the effect of the main obstacles for innovation on the utilization of knowledge providers. Therefore they were grouped as indicators dealing with the motives of the firm for using knowledge providers to overcome these obstacles (11 articles). These obstacles are studied using discrete variables. Out of these indicators, *Cost* (57%) and *Risk* (43%) are the most often studied ones. These two obstacles positively affect the use of knowledge providers. *Cost* is the most significant one.

RESULT 5: Firms encountering more costs obstacles to innovate are more likely to use knowledge providers

4.2 Do firms benefit from using knowledge providers?

Examining the benefits for firms using knowledge providers or, in other words, discovering how knowledge providers impact industry is the most frequently studied topic in the literature. Sixty-

three percent of the articles from the review focus on it (39 articles). Likewise, in articles from T1, most studies address the joint impact of several types of knowledge providers (69%). In all cases the combined impact of utilizing universities and research institutes is studied. In a few of articles, the impact of these two knowledge providers is assessed together with the utilization of KIBS (13%). In the articles studying the impact of knowledge providers individually (31%), the impact from universities is the most frequently evaluated one (18%). The individual impact of using research institutes (two articles, 5%) or KIBS (three articles, 8%) is hardly studied. All in all, universities are studied in 35 articles (90%), research institutes in 30 articles (77%) and KIBS in seven articles (18%).

In these studies the **independent variables** are employed for tracking whether the firm had some kind of link with knowledge providers. In most cases, discrete variables are employed (87%). In the few cases where continuous variables are utilized (15%), the indicators refer to *the number of co-publications* or *the number of partners* (within the types of knowledge providers of interest to this research). The **databases** exploited are mostly from surveys like CIS, MIP, CBR or public agency surveys. CIS is the most frequently utilized source of data (13 articles, 33%). The most employed waves are those from 1998 – 2000 and 2002 – 2004.

Regarding the **sample of firms**, there are two values to consider: (i) *number of observations per firm* and (ii) the *number of firms* from the sample. About the *number of observations per firm*, as with T1 articles, most articles analyze a single observation of the same firm (79%). However the share of articles employing a single observation is considerably less than the share of articles from T1 as a result of a more frequent utilization of panel-data (18%). The number of observations per firm from the articles using panel-data ranges between two to five observations. In relation to the *number of firms* from the sample, again, there are two samples: (i) the total number of firms from the sample (N) and (ii) the total number of firms from the sample using knowledge providers (n). The value N varies from figures close to one hundred to over five thousand firms. On average the value of N is 1,949 firms. The value n is on average 46% of N. A percentage higher than for articles from T1 but not significantly higher. On average n is equal to 675 firms.

Finally, **dependent variables** (Yi) are indicators of impact. Up to 41 different impacts were assessed and 84 impact indicators analyzed in the sample of articles from T2. To simplify the analysis of the vast number of assessed impacts, they were grouped into three categories, following Barge-Gil and Modrego (2011). The first category is *Technical Impacts*. This category groups the studied technical outcomes of the utilization of knowledge providers, such as new products, new processes or patents. The second category is *Economic Impacts*. This category gathers the evaluated outcomes from the use of knowledge providers on the economic figures of the firm, such as sales, profits or productivity. The third category – *Investment Impacts* – collects those assessed impacts from using knowledge providers that change the resource allocation behavior of the firm, for example R&D or capital investments.

4.2.1 Main studied impacts out of the use of knowledge providers.

The most frequently assessed impacts are **Technical Impacts** (26 articles). These impacts are mainly studied using binary indicators (62%). The innovation results evaluated are mainly: *New or improved products* (42%), *R&D efficiency*[3] (27%), *New patents* (23%), *New or improved processes* (19%), and *Degree of novelty of the innovation*[4] (15%). The results are mostly positive (81%) and significant (46%). The results are mainly significant for *New or improved products, R&D efficiency* and *New patents*.

RESULT 6: Utilizing knowledge providers tends to have a positive impact on Technical Impacts

The second most frequently studied impacts in the literature are **Economic Impacts** (26 articles). The economic outcomes from using knowledge providers are assessed employing mainly continuous indicators (88%). The economic impacts most studied in the literature are *Innovation Sales*, *Sales* and *Employment*. For *Innovation Sales* (58%) the results are mostly positive (42%) and very significant (35%). Where the impact is found to be negative (five articles), it is significant in two articles (Tsai and Hsieh 2009; Tsai and Wang 2009). Both studies take place in Taiwan and analyze low- and medium-technology sectors from the same sample. In the case of *Sales* (19%) the results are non-significant (12%) except for two cases (Belderbos et al., 2004; MacPherson, 1997) where the results are positive and significant (8%). For *Employment*, the utilization of knowledge providers has a positive and highly significant impact (12%).

RESULT 7: Evidence on the impact of using knowledge providers upon economic impacts is mixed. Knowledge Providers seem to increase innovation sales rather than the amount of sales

The third most commonly studied impact of using knowledge providers is **Investment Impacts** (four articles). These impacts are assessed using only continuous indicators. The addressed impact is *R&D Expenditure*. The use of knowledge providers has a positive and highly significant impact. Georges et al. (2002) is one exception to this statement (negative/non-significant). The results are specific for biotechnology firms. Possibly because this is a sector that already dedicates a large amount of resources to R&D. Therefore the variations in *R&D Expenditure* are perhaps not significant enough to be shown in the analysis.

RESULT 9: Using knowledge providers has a positive impact on R&D Expenditure

4.3 Which firms receive a greater impact?

The added value of the articles classified as T3 is that they analyze firms' characteristics influencing the impact inflicted by knowledge providers. Only 29% of the sample was classified as T3 (18 articles). As mentioned before, this includes two types of articles, T3A and T3B. The articles aiming to find the determinants of the impact are the least frequent ones in the literature.

[3] For example the time required for achieving a new product or a new patent.

[4] Firm, Market, Country, World, High and Low

The number of studies from T3 is 64% of articles from T1 and 46% of articles from T2. Hence, it is possible to say that the characteristics of the firm that intensify the impact of knowledge providers are not studied enough. Also the articles from T3 address several types of impacts so generalization of results is limited. There are not a sufficient number of articles addressing the same impact. Therefore the results are to be handled as a synthesis of the review of articles from T3.

In contrast to the previous categories, in T3 most articles study knowledge providers separately from one another (61%). In these articles, the determinants of the impact of firms using universities are the most studied ones (33%). The other 28% study the determinants of the impact of firms using KIBS. The remaining 39% of articles from T3 study a combination of the determinants of the impact of utilizing different types of knowledge providers. Out of these articles, the determinants of the impact of firms using either universities or research institutes are the most studied ones (28%). The other two articles evaluate the determinants of the impact of firms using any type of knowledge provider within the scope of this research (11%).

The **databases** employed in the articles from T3 are mostly from independent surveys (nine articles, 50%). Other surveys like CIS (six articles, 33%) and CBR (three articles, 17%) were commonly exploited as well. About the **firm sample**, the *number of observations per firm* is equal to one observation for most studies (83%). Panel-data is only employed in three articles. These articles use one, two and five observations per firm. About the *number of firms*, the number of firms from the sample (N) is on average 1,686 firms. The subsample of firms using knowledge providers is in average 598 firms. The subsample *n* is about 44% of *N*.

RESULT 10: The determinants of the impact of knowledge provider are in need of further research

4.3.1 Main studied determinants of the impact of knowledge providers

The ***Size*** of the firm is the most frequently studied determinant of the impact of knowledge providers (eight articles). It was evaluated on 26 different occasions using mainly three types of indicators (Size, Size^2 and Log of Size). Seventy-seven percent of the evaluations were done using continuous indicators. In all cases the indicators refer to the *Number of Employees*. *Sales* are never employed as an indicator. In 61% of the evaluations (eight articles), the *Size* is found to be non-significant. In the remaining 35% (three articles), the impact of knowledge providers and the *Size* of the firm seem to have an inverse correlation (Nieto and Santamaria, 2010; 2010; Mole et al., 2008; Sherwood and Covin, 2008). These results can be evidence that the impact of knowledge providers is greater for smaller firms. In only 4% of the evaluations (Robson and Bennett, 2000) was *Size* positive and significant for the impact of the use of knowledge providers.

RESULT 11: The impact of knowledge providers seems to be higher for smaller firms

R&D Activity is the second most studied determinant of the impact of utilizing knowledge providers (eight articles). It was evaluated on 21 occasions using five different types of indicators (R&D Expenditure / Sales, R&D Employees / Employees, R&D Expenditure / Employees, R&D Activity and R&D Experience). On 76% of the occasions, the employed indicators are continuous. In 38% of the evaluations (four articles), the results are non-significant. Twenty-nine percent of the evaluations (four articles) are positive and significant. Significant and negative results are found on 33% of the occasions (Robson and Bennett, 2000; Vega-Jurado et al., 2008).

RESULT 12: The impact of knowledge providers seems to be lower in intensive R&D firms

The third most studied determinant is the ***Sector*** of the firm (eight articles). It was evaluated on 39 occasions (due to sectoral comparisons). Discrete and binary variables are used in all articles. In 44% of the evaluations (five articles), the results were positive and significant. The non-significant results accounted for the 38% of the evaluations (five articles). The significant and negative results were found in the 18% of the evaluations (two articles). Out of the analysis of the results it is possible to say that firms from higher technological levels using knowledge providers seem to get a lower impact.

RESULT 13: The impact of knowledge providers seems to be lower for higher technological sectors

Some more determinants were studied. In most cases they were studied in a single article, so it is not possible to extract any conclusion or assessment out of them. Also the number of characteristics of the firms assessed is considerably lower in T3 studies than the number of characteristics studied in articles from T1. Therefore, the study of the determinants of the impact of knowledge providers is in need of further research in order to generalize results and there are still several more characteristics still to be assessed.

5. Discussion and Conclusions

It is possible to make some statements about two main topics: (i) how the scientific community has studied the impact of the use of knowledge providers and (ii) the main results found in the previous empirical literature. About the first topic, the analysis focused on research questions addressed, existing biases in terms of type of knowledge provider analyzed, countries and industries, and methodological issues.

First, most studies have centered their attention in proving the existence of technical or economic impacts (but not so much of intangible impact) or in the characteristics of firms using knowledge providers. Only a reduced number of articles have focused on the determinants of the impacts of using knowledge providers.

Second, a very important drawback from the empirical literature is that in almost all articles the assessment is done without making a distinction between the different knowledge providers being used by the firms. Therefore it is not possible to say which firms benefit the most from using each

type of source. This is a very important matter for both managers and policy makers. On one hand, managers are in need of assistance regarding the selection of the most suitable partner out the available ones. On the other hand, as the 'one size fits all' approach has proved unsuccessful (Tödtling and Trippl, 2005), policy makers require guidance about (i) the complementarity or substitutability of different knowledge providers and (ii) the most appropriate choices according to which firms profile they are addressing.

Third, studies have mainly focused on manufacturing industries in developed countries. Very few studies address the services sector independently, despite its growing importance in modern economies. In addition, most studies are concerned with European countries (possibly due to their interest in impact assessment) and, to a lesser extent, USA, Canada and some Asian countries, such as Taiwan, China and Korea. Thus, no evidence was found concerning the impact of the use of knowledge providers for firms from developing countries.

Fourth, it should be highlighted that the great majority of studies are very weak from a methodological point of view. More precisely, they do not account for issues of selectivity and endogeneity. Usually samples are selected in some way: by including only innovative firms (in type I and type II studies) or firms using knowledge providers (in type III). This sample selection could be a source of bias in the coefficients obtained. In addition, endogeneity is rarely taken into account when assessing the existence of impact. One could suspect that endogeneity problems exist. Firms using knowledge providers would usually obtain different economic or technical results despite the fact that they had utilized knowledge providers because some unobserved factors, such as managerial ability, could both influence the utilization of knowledge providers and the results from innovation processes. If so, coefficients would be biased again. Endogeneity has only been accounted for in over 6% of the studies. Considering the issues stated before and despite the fact that only the most robust empirical facts are reported, caution is suggested when interpreting the results from the review of the literature.

On one hand, the evidence regarding the impact of the use of knowledge providers upon technical and economic impact is quite mixed. Different samples, methodologies and background of the studies could explain this contradictory evidence, although no specific pattern has been found. Further research employing standardized methodologies is required. In these circumstances, the increasing availability of CIS-type surveys will contribute to the development of a more comparable set of studies. The additionality effect on Internal R&D Expenditure of the use of knowledge providers is the most reliable fact regarding the existence of impact. However, lack of availability of panel data, for proper taking into account of the dynamics, makes it advisable to take this result with some caution.

On the other hand, the evidence has been more stable concerning the characteristics of firms working in favor of the use and impact of knowledge providers. Theoretically, it is possible to distinguish four types of firms (see table 4): (I) firms more likely to use and obtaining a higher impact, (II) firms less likely to use and obtaining a lower impact, (III) firms more likely to use and

obtaining a lower impact, and (IV) firms less likely to use and obtaining a higher impact. As shown in table 4, larger, more R&D intensive and higher tech firms are more likely to use knowledge providers but the impact they achieve out of using knowledge providers is lower. On the other hand, smaller, less R&D intensive and lower tech firms are less likely to use knowledge providers but they achieve a higher impact out their utilization. This apparent contradiction has been explained by Barge-Gil (2010b, p.582) for the case of general cooperation (not restricted to knowledge providers) combining absorptive capacity and need-effect arguments, usually found in the literature. The consequence of such a fact is that barriers exist for using knowledge providers and that these barriers affect those firms potentially benefiting the most. In the case of knowledge providers one additional interpretation could be provided (Vega-Jurado et al, 2008): larger and more R&D intensive firms use knowledge providers for more standardized and less innovative activities.

Finally, the above review gives guidance for future lines of research. One important line of work is to compare achieved impacts, and their determinants, resulting from the use of different types of knowledge providers across different profiles of firms. This analysis would be very useful for both managers and policy makers. Another question in need of an answer is how firms decide to start using knowledge providers. Knowing more about such a decision and the barriers involved would be useful for designing suitable policy measures. Finally, a stronger and more robust body of knowledge is still to be built in the questions already addressed by the scientific community. A strong recommendation would be to employ as much as possible rigorous methodologies as in other fields of economics and management research.

Table 4 - Summary of firms' determinants

IMPACT OF USING KNOWLEDGE PROVIDERS	UTILIZATION OF KNOWLEDGE PROVIDERS	
	POSITIVE	NEGATIVE
POSITIVE	[I]	[III] Size (Smaller firms) R&D Intensity (Lower) Sector (Lower Tech)
NEGATIVE	[IV] Size (Larger firms) R&D Intensity (Higher) Sector (Higher Tech)	[II]

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7. Appendix

7.1 List of articles from the Literature Review

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