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External knowledge sourcing in the Spanish archaeological sector: Mapping the emergent stage of a business activity

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Abstract: Recent studies of innovation highlight the importance of external knowledge sourcing. Existing empirical works are based on national surveys and specific industries. The present study contributes to the analysis of strategies for sourcing external knowledge, based on a specific case study and moment in time: the Spanish archaeological sector and its emergence as a new business activity. Our results show that external knowledge sourcing involves diverse mechanisms, agents and two main strategies: cooperation and knowledge acquisition. In an expanding knowledge-based sector emerging in an uncertain context and whose sources of knowledge are scattered, innovation strategy should focus on the search for external knowledge –cooperation and acquisition strategies-, rather than on internal sources.

Keywords: External knowledge sourcing; uncertainty; interaction mechanisms; innovation; archaeological sector.

Fuentes de conocimiento externo en el sector arqueológico español: Mapeo de la fase emergente en una actividad empresarial

Resumen: Estudios recientes señalan la importancia de las fuentes externas de conocimiento como estrategia para innovar. La evidencia empírica se fundamenta en encuestas nacionales y en industrias específicas. El presente estudio contribuye al análisis de las estrategias de incorporación de conocimiento externo mediante un caso de estudio y en un momento concreto: el sector arqueológico español y su emergencia como nueva actividad económica. Los resultados muestran que las fuentes de conocimiento externo implican diversos mecanismos, agentes y dos estrategias principalmente: cooperar y adquirir conocimiento. En un sector en expansión, basado en el conocimiento, que surge en un contexto incierto y cuyas fuentes de conocimiento están dispersas, el foco de la innovación puede encontrarse en las estrategias de búsqueda de conocimiento externo -cooperación y adquisición-, más que en fuentes internas.

Palabras clave: Fuentes de conocimiento externo; incertidumbre; mecanismos de interacción; innovación; sector arqueológico.

1. INTRODUCTION

External knowledge sourcing as a strategic priority for firms is a popular research topic since firms have become involved in the full process of discovery, production and distribution of knowledge to innovate (Faems et al., 2005; Lin and Wu, 2010; Phillips et al., 2000). Firms need to interact with other agents, organizations and institutions to innovate because learning from external sources increases access to new ideas, knowledge and practices, and complementary technologies that increase the firm's adaptation, cost sharing and risk spreading capabilities, and speed up the development of innovations (Bierly and Daly, 2007; De Faria et al., 2010). External knowledge sourcing is becoming a critical factor in the generation of innovations in the current highly competitive and uncertain environments (Dittrich and Duysters, 2007). This uncertainty is related to the sourcing of new sectoral knowledge, which requires the development of specific procedures, practices and know-how.

Several studies address these issues to try to explain the reason why external knowledge sourcing is so essential for innovation and organizational learning. In the search for knowledge for innovation, the multiple actors, mechanisms and practices used by firms to try to extend their organizational boundaries have been identified (Laursen and Salter, 2006). Most of this work focuses on the manufacturing sector as a whole (Vega-Jurado et al., 2009b), or particular sub-sectors, such as electronic and electrical equipment (Mason et al., 2004), which are part of a large, high-tech industry with well-defined rules. Less attention has been paid to the service sectors (Caloghirou et al., 2004) and emerging/relatively new economic activities such as biotechnology (Carayannopoulos and Auster, 2010).

We contribute to this work by analysing the external knowledge sourcing strategies exploited by a new emergent knowledge based service sector: the archaeological sector. We investigate the strategies and mechanisms applied, and influence of the interactions among the agents involved in archaeological sector innovations. The archaeological sector represents an interesting study case in being a particular case in which uncertainty is inherent in its constitutive institutional rules, new field activities and nascent professional boundaries. Specifically, the Spanish archaeological activity constitutes a paradigmatic case study because it is a novel knowledge based service that has emerged as the result of a legislative change, which introduced the principle of the "developer pays". This means that any private or public construction activity has to include a heritage impact assessment, and consequent corrective measures. This legislation was introduced in the context of a construction boom in Spain which promoted the emergence and growth of a new sectoral activity related to heritage management or commercial archaeology. Firms and professionals involved in commercial archaeology developed their practices and procedures under a complex institutional setting, without previous experience, and in a context of high services demand conditions.

Based on a sample of 273 archaeological firms in Spain during 2006-2008, we investigate how the agents involved and the mechanisms used in the interactions shape firms' innovation strategies. The selected period is contemporaneous with the boom in archaeological services related to intensive construction sector activity.

The rest of the paper is organized as follows. Section 2 provides a review of the literature on the importance of knowledge incorporation practices for innovation, and the agents and mechanisms involved in this process. Section 3 presents the background to the Spanish archaeological sector and a comparison with international cases. Section 4 describes the dataset, sample, variables and statistical models used in this work, and Section 5 describes the results. Section 6 provides a discussion and conclusions.

2. LITERATURE REVIEW

2.1. External knowledge sourcing as an innovation strategy

The private sector generally and private firms in particular are faced by uncertainty and risk in the process of innovation. In order to deal these uncertainties and minimize their potential adverse effects, they develop strategies to acquire external knowledge in order to improve their competencies. They search for new knowledge bases and skills that complement their own resources (García-Granero et al., 2014), allow the sharing of costs and risks, and the management of environmental pressures (Hagedoorn, 1993). In some circumstances, these activities become especially important, for instance, in conditions of rapid technological development and widely dispersed knowledge sources such as the emergent stage of a business activity (Eisenhardt and Schoonhoven, 1996). In this situation, single firms do not possess all the capabilities required to achieve good performance and/or to survive; for this reason they try to cooperate with other agents, such as competitors,

suppliers, researchers, public administrations, etc., involved in the new activities as part of an innovation process. These potential partners should be working towards the same targets and under similar conditions. Thus, external knowledge practices that seek to reduce the inherent ambiguity associated with novel products or markets act as a stimulus for firms to interact. Following this logic, the acquisition of resources and skills that are not internally available are boosted by external knowledge sources (Powell et al., 1996).

In addition, approaches that highlight the importance of external knowledge sourcing illuminate the role played by organizational learning beyond a utilitarian strategy aimed at reducing costs, accessing new knowledge, and gaining competitive advantage. The most frequent reasons for exploiting external knowledge involve risk sharing, obtaining access to new markets and technologies, speeding up the introduction of new products, and pooling new or complementary organizational skills (Hamel, 1991; Dodgson, 1993).

Various studies focus on identifying the ideal conditions to promote particular external search strategies, mostly in relation to large, high-technology industries. For example, Beckman et al. (2004) find that market uncertainty reinforced networking activity in a sample of the 300 largest services and industrial firms. Mason et al. (2004) find that accessing knowledge via greater network openness can be particularly advantageous for fast-changing industries. Conversely, Toedtling et al. (2012) study the Austrian information and communication technology sector and argue that, in global knowledge networks, local and regional relationships still matter for innovation. Other authors like Valmaseda-Andia et al. (2015) have found that benefits obtained by companies through interaction with public research organizations.

Although the service sector includes heterogeneous activities, there is agreement on the importance of external knowledge sourcing to increase the firm's added value and organizational learning processes. Studies of the innovation process in the services sector began in the early 1990s (Miles, 1994). In addition to the discussion about the characteristics of innovation in this sector, various researchers emphasize the importance of co-creation initiatives for service innovation (Rubalcaba et al., 2012) and highlighted the need to take account of the multidimensionality of these processes, which might include consumer/user participation (den Hertog et al., 2010). Among the empirical, Chang et al. (2012) discuss various service firms' knowledge sourcing strategies, trajectories, joint appropriation mechanisms and agents, and provide a comparison based on the responses of services firms to the Taiwan Innovation Survey. Moreover, various studies show that external knowledge sourcing, via technology adoption and knowledge interaction has a positive impact on innovation performance (Elche-Hortelano, 2011).

2.2. Unpacking external knowledge sourcing: strategies, mechanisms and agents

Knowledge as a source of innovation highlights the importance of developing a firm strategy related to accessing new ideas, know-how, practices and technology. Vega-Jurado et al. (2009a) classify firms' strategies for the acquisition of knowledge according to three categories of innovative activity. The first one relies on the organization's internal resources and capacities for innovation based on its R&D activities. This is generally described as a "make" strategy. Although we acknowledge its relevance, we do not examine this strategy in the present paper because it does not involve external agents. The other two strategies identified are "purchasing or acquisition" and "cooperation", based on external knowledge sources that the firm accesses in the search for valuable knowledge or skills to supplement their internal capabilities.

The decision to purchase, buy or acquire implies the incorporation in the innovation process of goods, tools or inputs in the form of materials and components, outsourcing of R&D, and patent licensing. A strategy of cooperation involves partnerships with other companies, agents and institutions. The fundamental difference between "acquire" and "cooperate" is that while purchase (or acquisition) involves a unilateral relationship (money is exchanged for R&D results), cooperation implies that each of the parties contributes to the relationship by providing and receiving valuable knowledge (Croisier, 1998).

Scholars have proposed various interaction mechanisms (how practices, technologies and rules are produced) related to innovation strategies based on external knowledge sourcing. For example, Vega-Jurado et al. (2009a) discuss cooperation based on the criterion of power disequilibrium in equity-based mechanisms (joint ventures) and contractual agreements. Along similar lines, Powell et al. (1996) state that alliances take on many forms, ranging from R&D partnerships, to equity joint ventures, to collaborative or manufacturing partnerships, to complex co-marketing arrangements. Other scholars, such as Phillips et al. (2000), understand cooperative mechanisms as an "inter-organizational relationship that is negotiated

in an ongoing communicative process and that relies on neither market nor hierarchical mechanisms of control". These authors identify mechanisms based on market equality characteristics such as consortia, alliances, joint ventures, roundtables, networks and associations.

Although there is no comprehensive classification of the "acquiring" strategy, Vega-Jurado et al. (2009b) distinguish various mechanisms including outsourcing of R&D, technology licensing, and the acquisition of knowledge embodied in machinery and equipment, which includes purchase of machinery and equipment as innovation inputs.

Regarding the agents involved in the interaction mechanisms, there are many types of eligible partners: firms (clients, suppliers, competitors); private organizations (consultants, laboratories); and public organizations (universities, public research centres) (OECD, 2006; Tether and Tajar, 2008). The literature generally agrees on the importance of all these external partners in the search for innovative ideas (see e.g. Sánchez-González and Herrera, 2010; Powell, 1990).

3. THE ARCHAEOLOGICAL SECTOR: BIRTH AND DEVELOPMENT

Historically, the archaeology business sector emerged as the result of a European agreement, the Valetta Convention (COE, 1992), which introduced the basic principles of developer-funder preventive archaeology in order to protect and manage heritage assets. The huge destruction of heritage was associated with a growing and accelerated modernization process. Prior to the Convention, archaeological activity was restricted to research. Following international guidelines, each country must protect its heritage by developing legislative processes and adapting institutions to ensure correct management and compliance with standards.

Although each country is responsible for implementing its own rules, two main management models can be identified. Some countries have adopted "public management models", in which cases a public administration runs and manages the entire process of protecting the archaeological heritage. Others follow a "mixed management model", based on a system whereby public institutions monitor, control and supervise the archaeological actions delegated to the private sector. This mixed model has led to a new business knowledge based activity: commercial archaeology.

Countries that have adopted the public management model have enacted legislation on heritage protection, and implemented public structures and resources for the management of their archaeological heritage. Such countries include Denmark, Estonia, Czech Republic, France, Finland and Greece. In other contexts where significant demand for archaeological services developed over a very short time, it was impossible for public administrations to develop their own structures to support archaeological activity and responsibility was delegated to private organizations. Under this system, conservation and promotion of heritage resources are linked to the need to mitigate the effects of rapid incremental construction on this heritage. This has resulted in construction and archaeological protection growing in parallel, and the development of a new professional and business service activity. Those countries where commercial archaeology has become a large and growing business are the USA, the UK, Ireland and Australia (Aitchison, 2009).

In the case of Spain, commercial archaeology is an emergent business activity that has been ongoing for only 20 years. It exhibited extraordinary development after the 1990s as a result of a normative process based on the need to protect and manage archaeological heritage. This includes the publication of the Historical Heritage Law 1985 (and other laws related to land use and the environment), which established a set of requirements for the management of archaeological heritage. In particular, it requires that any activity in the territory should be licensed and includes previous submission of an archaeological impact report. In addition, Spanish archaeological management is a responsibility of regional governments, which means that the regional heritage department is responsible for developing regional archaeological heritage laws and management models. For this reason, there are 17 different archaeological management models in Spain (one for each NUTS2 region), resulting in a complex regional and national institutional environment.

The development of this business activity is also the result of a second reason; related to the construction sector boom in Spain (involving public and private organizations) during the last decade of the twentieth century, which resulted in an exponential increase in the demand for archaeological impact reports. In addition, the electric power generation, transport and distribution sectors have established new facilities and are subject to the same legal framework. All these factors resulted in the creation of numerous archaeological firms, and a vigorous labour market in the 1990s to deal with this new, extremely complex and ambiguous environment, and respond to an increasing demand from developers. The outcome is a very active

and complex sectoral innovation system (Parga-Dans et al., 2012). This new sector offers various specialized services related to the archaeological heritage management value chain (documentation, intervention, enhancement, consultancy and dissemination activities) under the supervision of the public administration and international legal requirements (Parga-Dans, 2011).

4. DATA AND METHODOLOGY

4.1. Data

The absence of previous studies and the recent phenomenon of archaeological activity render access to information difficult. To compensate for the absence of official sources of data on the Spanish archaeological labour market, and lack of consensus over professional definition (e.g. degree courses in archaeology were not available in Spain until recently), we conducted an in-depth data collection process. It involved three stages:

First, we set up an *expert panel* in heritage management to define the boundaries of the sector. The panel included five scientists and three accredited practitioners. The panellists were recommended by researchers, public administrations and other practitioners. They participated in several discussions to define the sector's general characteristics and processes, they identified the firms operating in the sector, and they worked collaboratively on the design and validation of a firm questionnaire. The discussions helped to delimit the sample, develop the survey, and define the scope of the interview protocol.

Second, we collected qualitative information from *interviews* with 107 informants in order to obtain a context of interpretation. We interviewed scholars, specialists and practitioners from firms (archaeological services, their clients), research bodies, universities and public administrations. The interview protocol was based on open-ended questions addressing aspects related to the evolution of the activity, structural data, innovation processes and strategic relations with stakeholders. This background provided the qualitative context of the study and provided an understanding of the archaeological process, and some definition of the agents and external knowledge sources employed in this article.

Third, we designed a *survey* to gather quantitative information. This stage included the following activities:

- The sample: we created a list of Spanish archaeological companies. These actions resulted in a total of 273 firms registered in 2009 as archaeological firms. To date, no public or private institution has carried out such a task. Hence, the identification of firms was complex and we conducted different activities to identify data sources:
  - Since archaeology is an activity controlled in part by the public sector, we expected the 17 regional institutions responsible for to have an archaeological companies register. Most of these lists were incomplete, out of date, or not available;
  - we consulted professional associations, but their information was incomplete because professionals participate on a voluntary basis;
  - we searched company databases , but found that the relevant companies were assigned to different NACE codes (European Communities, 2008), such as: 71:12 "Engineering activities and related technical consultancy"; 72.20 "Research and experimental development on social sciences and humanities"; 74.90 "Other professional, scientific and technical activities;
  - we eventually identified companies using the snowballing technique where identified informants and participants referred us to other firms and individuals.
- The questionnaire. To develop our survey instruments we drew on two large-scale surveys—the Spanish Survey on Technological Innovation in Business1, and the EU's Community Innovation Survey (CIS)2. The questionnaire was structured in several interrelated sections, covering aspects related to sector and firm characterizations, interaction mechanisms for incorporating and producing knowledge - both formal and informal, and types of agents with which firms interact. Demographic data (e.g. number of employees, qualification and experience, and turnover) were also collected.
- The survey was administered on the web in order to simplify procedures and to reach all the companies; each firm responded to its own questionnaire. This method is deemed reliable and inexpensive for covering a large geographic area. In a second stage, we surveyed those that had not responded to the questionnaire by telephone to increase the response rate.

The resulting database consisted of 217 out of 273 firms which is a high response rate (around 80%). The information provided was used to address the research question and analyse the archaeological sector including interactions - both formal and informal -with external agents. The succeeding sections describe the agents and the interaction mechanisms operating in the archaeological sector identified through the interviews and used to construct the variables for the empirical analysis.

4.2. The agents

Archaeological activity involves various different agents in addition to the archaeological firms and their competitors, which include other firms and freelancers with specific knowledge of different historical periods, and cultures that inhabited the Iberian Peninsula. The diversity of cultures and their uneven distribution across the Spanish territory have led to specializations among archaeologists working in different Spanish regions.

Based on our interviews we identified other firms involved in the innovation process. First, suppliers of technical and scientific analysis and exploration equipment and materials, which include companies providing such services as software, computer engineering, topography, photography, 3D, etc. The other major group of firms is clients, which are firms involved in the construction, production and distribution of electricity, engineering, etc. and are obliged to deliver archaeological impact reports before starting any works. Other involved companies include firms that restore monuments, provide environmental services, architects, etc., which all work in the same field, but are neither competitors nor suppliers.

Other important agents include universities and research centres involving archaeology, art or history groups, specialists in the artefacts identified in excavations, in identification and delimitation of heritage elements, documentary studies (inventory and cataloguing of findings), and bibliographies, equipment and methodologies used for impact evaluations (magnetic prospecting system, geo-spatial technologies, Terrestrial Laser Scanning, etc.). These specialists use various materials, and chemical and biological laboratories to identify or characterize the findings, to date them, etc. There are researchers responsible for methodological aspects using advanced infrastructure and equipment.

Professional associations have emerged to respond to the demand for archaeology professionals, and have contributed by designing protocols and methodologies, and pricing different types of services. Also important are public administrations which are simultaneously supervisor and client. Public administrations have responsibility for developing heritage management regulations, supervising archaeological projects and issuing permissions for construction work. They are important archaeological service users in relation to public construction works.

4.3. The mechanisms

Our expert panel and information obtained from our semi-structured interviews provided a comprehensive account of the interaction mechanisms used by the above agents:

Joint actions: refers to (mostly large) projects involving several entities (businesses, universities, research centres, etc.) acting with a public or private framework to produce archaeological impact reports; participants contribute knowledge, capacity, workers, and equipment.

Technical assistance: comprises the hiring of services to assist projects that are already underway where there is a need for specific and specialized archaeological knowledge or experience.

Joint publications: the scientific and technical knowledge outcome of an archaeological activity interesting and useful to the entire sector including firms, researchers, museums and public administrations. Publication of the results of archaeological activity is encouraged, as is contribution by all those who participated. Activities are often disseminated in scientific journals which possibly explain the large proportion of business archaeologists with doctoral degrees who are interested in continuing to do research.

Outsourcing of design and marketing services: includes the design and elaboration of service catalogues, the organization of diffusion activities such as editing of company reports, organization of workshops, events with stakeholders, attendance at fairs and conferences that combine marketing services, business development and diffusion of activities.

Acquisition of materials and capital goods: includes the acquisition of products, machinery, equipment, hardware, computer software and other capital goods required for the conduct of archaeological projects and complementary activities.

Human capital training: includes training to improve skills of firms' staff.

Development of technical and methodological guidelines: since the sector is emerging, there are no already existing protocols. Various actors (firms, administrations, researchers, etc.) collaborate to codify technical and methodological practices related to archaeological activity, codes of ethics, etc.

R&D public funds: while joint actions refer to cooperation in archaeological projects or contracts, this also includes activities related to the generation and application of scientific knowledge developed in the framework of public programmes funding R&D and innovation activities (R&D projects, personnel exchange, PhD programmes).

4.4. Analysis of survey data

The information from the survey was used to develop factor analysis and regression analysis. The factor analysis groups the above mentioned mechanisms used by firms to search for external knowledge. Factor analysis identifies the minimum number of dimensions to explain the maximum amount of information (Hair et al., 1998) and is useful to understand the external knowledge underlying sourcing strategies measuring various interaction mechanisms. We conducted a principal components analysis with a Varimax rotation (with Kaiser Normalization) of factor dimensions, and extraction of factors at the 1.0 or greater eigenvalue level. Regression analysis (ordinary least squares - OLS) shows how the agents involved in an interaction shape each of the external knowledge sourcing strategies identified by the factor analysis. The factor analysis results constitute the dependent variables for the regression analysis calculated as factor scores for the respective dimensions (Bozeman and Gaughan, 2011). Since factor scores are normal distributed variables we can employ OLS regressions to solve the empirical models. Having defined our external knowledge sourcing strategies, we then define seven dichotomous dummies which are our independent variables, one for each type of agent defined. These variables take the value 1 if the firm has collaborated with this agent and 0 otherwise. The specific agents considered as inter-organizational collaborators are competitors, suppliers, other firms, universities, research institutions, professional associations and public administrations.

Firm level analyses require variables for firm characteristics. We include three variables to control for: firm age, size and turnover. We define firm age as the number of years since the firm began its activity, to the 2010 (year of data collection). In cases where firms failed to this information in their questionnaire responses, we constructed this variable based on information from the online databases, such as the Iberian Balance Sheet Analysis System (SABI). Firm size includes the number of founder members and employees on indefinite contracts in 2008. Both age and size present skewed distributions. We checked their normality by applying a Kolmogorov-Smirnov test. Given the significant result (p-value <0.05) we decided to use the log transformation of the variables in the analysis. We explored the variable normalization of the transformed variable applying a QQ-plot graph. Finally, firm *turnover* refers to the amount of money earned by the firm in 2008. The initial variable had 18 categories (from less than €10,000 to more than €500,000), which we regrouped into 3 categories: less than €100,000, €100,000 to €500,000, and over €500,000. Annex I includes the correlation matrix for the independent variables used in the regression model. The values are very low, except for the relationship between size and turnover (0.662). To clarify this relationship, we have calculated the tolerance statistics values indicating whether there is a strong linear relationship between two independent variables. All the tolerance statistic values are much higher than 0.2, suggesting no risk of multicolinearity problems in the regression model.

5. RESULTS

5.1. Describing the Spanish archaeological sector

Descriptive statistics results (Table I) show that archaeological firms are characterized by their young age - less than 10 years on average (75% aged less than 12 years), and small size. In relation to size, 86% of our surveyed archaeological companies had ten or fewer employees (including founder member) in 2008, with an average of 5.75 workers. The categories for the variable turnover are better balanced: 39.2% of the companies earned less than €100,000 in 2008, 33.2% earned between €100,000 and €500,000 and the remaining 27.6% earned more than €500,000. A characteristic specific to this sector is the high level of education of workers: 71% of employees have a university degree of which 16.2% is a doctorate.

According to Eisenhardt and Schoonhoven (1996) or Powell et al. (1996), as a new business activity, the actors and organizations involved had to make decisions under uncertainty conditions, and develop completely new archaeological management procedures. This institutional complexity has led to strong links among agents, which, in turn, increases the possibilities and constraints for firms offering archaeological services. Archaeological services firms can be considered very interactive, with 82.9% of the sample having collaborated under both formal (79%) and informal agreements (only 37 companies stated that they had not engaged in collaboration). Table II shows the heterogeneity among types of agents involved with archaeological firms and the interaction mechanisms employed.

Table I. Descriptive statistics

Categorical variables				
Competitors	105 (48.4%)			
Suppliers	45 (20.7%)			
Other firms	87 (40.1%)			
Universities	94 (43.3%)			
Research institutions	41 (18.9%)			
Associations	30 (13.8%)			
Public administrations	60 (27.6%)			
Joint actions	123 (56.7%)			
Technical assistance	118 (54.4%)			
Joint publications	89 (41.0%)			
Outsourcing of design and marketing services	43 (19.8%)			
Acquisition of materials and capital goods	49 (22.6%)			
Human capital training	33 (15.2%)			
Development of technical and methodological guidelines	28 (12.9%)			
R&D public funds	17 (7.8%)			
Turnover				
<€100,000	39.2%			
€100,000 and €500,000	33.2%			
>€500,000	27.6%			
Quantitative variables	**Mean**	**S.D.**	**Min.**	**Max.**
Age	9.63	5.74	2	36
Size	5.75	7.04	1	46

Among types of mechanism, joint actions and technical assistance are the most common interaction types. In contrast with den Hertog et al. (2010) that stated the importance of clients for knowledge networks in services, the archaeological firms interactions usually involve competitors and other firms. They also include universities in order to achieve the critical mass required to undertake a major project, or to incorporate the necessary knowledge, skills and expertise. Only 7.8% of firms referred to the importance of financial resources through public funding of R&D, as a mechanism for interaction. Thus, we do not include it in the next empirical analysis.

Firms in other fields are the preferred agents for acquiring materials and capital goods, for outsourcing design and marketing services, and for developing technical and methodological guidelines.

Conversely to high-tech industries which engage in global knowledge networks (Mason et al., 2004), national universities and competitors are the most frequent partners for joint publications and human capital training. Since this is an emergent sector, some universities are introducing in their archaeology degree courses, topics related to archaeology management and teaching skills in the technologies used at different stages of the process of archaeological intervention. Before the emergence of this business sector, archaeology was a specialist subject in a history degree. The university professors interviewed said that companies come to them for analysis of materials found during prospecting, or to seek advice or literature on how to document findings.

Public administrations are important as both clients and supervisors. Firms interact with public administrations to develop guidelines and joint publications, and conduct R&D activities; in the first and second case in relation to their supervisor role, and in the third case to obtain funding. In line with Valmaseda-Andia et al. (2015), we found that archaeological firms greatly benefit from public agents' interactions.

Table II. Interaction mechanisms of archaeological firms by type of agent

	Joint actions	Technical assistance	Joint publications	Outsourcing of design and marketing services	Acquisition of materials and capital goods	Human capital training	Development of technical and methodological guidelines	R&D public funds	Total
Competitors	**83 (67.5%)**	**70 (59.3%)**	54 (60.7%)	**28 (65.1%)**	30 (61.2%)	19 (57.6%)	**17 (60.7%)**	7 (41.2%)	**105 (48.4%)**
Suppliers	31 (25.2%)	33 (28.0%)	24 (27.0%)	19 (44.2%)	29 (59.2%)	16 (48.5%)	7 (25.0%)	9 (52.9%)	45 (20.7%)
Other firms	61 (49.6%)	**70 (59.3%)**	41 (46.1%)	**28 (65.1%)**	**33 (67.3%)**	22 (66.7%)	**16 (57.1%)**	11 (64.7%)	87 (40.1%)
Universities	71 (57.7%)	63 (53.4%)	**62 (69.7%)**	22 (51.2%)	26 (53.1%)	**24 (72.7%)**	11 (39.3%)	**9 (52.9%)**	**94 (43.3%)**
Research institutions	33 (26.8%)	34 (28.8%)	28 (31.5%)	11 (25.6%)	14 (28.6%)	12 (36.4%)	11 (39.3%)	8 (47.1%)	41 (18.9%)
Professional associations	24 (19.5%)	25 (21.2%)	20 (22.5%)	13 (30.2%)	11 (22.4%)	6 (18.2%)	11 (39.3%)	4 (23.5%)	30 (13.8%)
Public administrations	46 (37.4%)	48 (40.7%)	42 (47.2%)	16 (37.2%)	21 (42.9%)	14 (42.4%)	**15 (53.6%)**	8 (47.1%)	60 (27.6%)
Total	**123 (56.7%)**	**118 (54.4%)**	89 (41.0%)	43 (19.8%)	49 (22.6%)	33 (15.2%)	28 (12.9%)	17 (7.8%)	217

Note: The highest percentage in each collaboration mechanism is in bold. Total percentages, column and row, are calculated over total. Percentages do not sum 100% because one firm can choose more than one collaboration mechanism and agent.

5.2. External knowledge sourcing strategies in the archaeological sector

Data reduction by means of factor analysis allows identification of the main external knowledge sourcing strategies in the archaeological sector based on the various interaction mechanisms (Table III). The data reveal two dimensions and, as customary, they are named according to the variable loadings to the extent of ±.50, as greater "acquisition" and "cooperation" strategies. Cronbach's alpha for both factors is 0.5. Although some authors argue that this is low (Hair *et al.*, 1998), according to Bowling (2002), an alpha of 0.5 or higher is considered as a sign of acceptable internal consistency. The complexity of the sector does not allow clear differentiation of all the interaction mechanisms included in factor analysis. For example, the mechanisms "Development of technical and methodological guidelines" and "Acquisition of materials and capital goods" cannot reasonably be assigned to an acquisition or a cooperation strategy because they involve both types of innovation strategy. For example, the case of "acquisition of materials and capital goods" can be interpreted as an acquisition mechanism where archaeological firms may cooperate over the purchase of expensive equipment.

Table III. Factor analysis for interaction mechanisms

	Acquisition	Cooperation
Training of personnel	0.819	-0.055
Outsourcing of design and marketing services	0.633	0.122
Technical assistance	0.473	0.389
Development of technical and methodological guidelines	0.375	0.268
Joint actions	-0.119	0.838
Joint publications	0.239	0.594
Acquisition of materials and capital goods	0.426	0.517

Method: Principal Components Analysis. Rotation: Varimax with Kaiser Normalization

After identifying the main external knowledge sourcing strategies in this sector, the results of the regression models are presented in Table IV, which analyses how the interactions among different agents shape the strategy selected. Before interpreting the results, we run goodness-of-fit models to demonstrate the adequacy of the independent variables to predict the dependent variables (the results are significant for both R-squared changes). The strategies show an adjusted R-squared of 18.4% for acquisition and 37.1% for cooperation, which reflects the proportion of variance in the dependent variables that is explained by the independent variables. In general, the interaction with other agents has a positive influence on the external knowledge sourcing strategies, that is, most results show positive values. Only the interaction between archaeological enterprises and universities has a negative sign for acquisition strategy, but the coefficient is not significant. Depending on the agent involved in the interaction, the selected external knowledge sourcing strategy differs. The interaction with other non-archaeological firms is based on the respective acquisition strategy. However, archaeological firms' interactions with competitors, universities, associations and public administrations are based on a cooperation strategy while interactions with suppliers imply use of both types of strategy, although acquisition is dominant. The results for the control variables are not significant, but the age of the firm negatively influences both strategies. In line with theoretical argumentation of uncertainty when knowledge base is dispersed, this means that young firms are more likely to innovate using these interaction mechanisms (Eisenhardt and Schoonhoven, 1996). The effect of size and turnover works in different directions according to the selected strategy. Deepening the line pointed by Vega-Jurado et al. (2009a), about the different mechanisms adopted under power disequilibrium situations, we found that larger companies are more likely to employ acquisition strategies while smaller ones are more likely to base their external knowledge sourcing on cooperation, although neither is significant.

6. DISCUSSION AND CONCLUSIONS

Several current studies address the reason why external knowledge sourcing is so essential for innovation (Faems et al., 2005; Lin and Wu, 2010). However, most of this work focuses on the manufacturing and high-technological industries (Vega-Jurado et al., 2009b). Our analysis was aimed at establishing a roadmap of external knowledge sourcing strategies used by archaeological firms, an emergent knowledge-based service, taking account of both the agents involved in the interaction and the types of mechanisms used in the strategies for innovation in this new sector.

The emergent stage of the commercial archaeology sector in Spain means all the agents involved (companies, universities, governments, professional associations) interact through

Table IV. OLS regression results for external knowledge sourcing strategies in archaeological sector

	Acquisition strategy			Cooperation strategy		
	Coefficient	Standard Error	Sig.	Coefficient	Standard Error	Sig.
Agents						
Competitors	0,061	0,152		0,662	0,125	***
Other firms	0,46	0,16	***	0,236	0,132	
Suppliers	0,627	0,185	***	0,38	0,152	**
Universities	-0,037	0,16		0,496	0,131	***
Research institutions	0,299	0,202		0,17	0,166	
Associations	0,189	0,216		0,415	0,178	**
Public administrations	0,221	0,174		0,395	0,143	***
Firms' characteristics						
Age (ln)	-0,068	0,132		-0,015	0,108	
Size (ln)	0,046	0,115		-0,09	0,095	
Turnover	0,095	0,145		-0,041	0,119	
Constant	-0,499	0,32		-0,67	0,263	**
n	172			172		
R2	0,232			0,408		
Adjust R2	0,184		***	0,371		***

** p-value<0.05; *** p-value<0.01

various mechanisms in order to satisfy a new and growing demand and to establish protocols and methodologies to supply the necessary rigorous services. The process is one of collective and innovative learning as demonstrated by research on other sectors such as architecture, engineering and construction (Boland et al., 2007). However, we found evidence of specific mechanisms and dynamics in the archaeological sector. For example, R&D public funds and programmes do not have the same importance as in other knowledge service activities. It might be that R&D funding programmes are usually oriented to science based manufacturing sectors, but not non-technological activities or emergent cultural services provided by very small firms (Asheim et al., 2007).

In relation to the agents involved in the interaction, firms distinguish between two innovation strategies: acquisition or cooperation. Conversely to general conclusions about service sector (den Hertog, 2010), archaeological firms mainly cooperate with competitors, universities and public administrations, and exploit acquisition strategies with other firms. A singularity of the sector is that companies cooperate significantly with competitors; this is due to the conditions of demand for services (increased demand and need for a rapid response), and also to the requirement for specific knowledge related to each different project and the complementarity between the different knowledge base specializations of companies. Commercial archaeology is characterized by its humanities related knowledge base which, in many cases, is oriented to public goals and retains its value when it is shared (Olmos-Peñuela and Castro-Martinez, 2014), rather than the development of common protocols, guidelines and strategies for the entire sector.

On the other hand, public administrations are important agents for cooperation (García-Carpintero et al., 2014). This is the case in other regulated sectors, such as environment or energy, but within the archaeological sector, public administrations play multiple roles. Besides being the authority that approves the archaeological impact reports, it cooperates with other agents, monitors their activities, and acts as the client in the performance of public works.

To conclude, in a service sector with high absorption capacity (Vega-Jurado et al., 2009b), emerging in contexts of uncertainty with unclear boundaries, external knowledge sourcing enables the fostering and acceleration of learning processes (Powell et al., 1996). Specifically, these

emergent and entrepreneurial contexts demand inclusive policy strategies involving organizations sharing their expertise and resources, and collective resolution of common problems. External knowledge sourcing can be a source of innovation based on the generation of new practices, rules, processes and technologies, which transcend particular external knowledge practice. These strategies develop important know-how as a way to develop new solutions to complex problems. External knowledge sourcing can be important steps in the process of new knowledge creation and can become a basis for innovation.

The main limitation of this study is the lack of longitudinal data to capture the current economic crisis context. Future analyses will explore the evolution of the archaeological sector, taking into account the radically changed situation in Spain and following the bursting of the construction bubble. Spanish archaeological firms emerged from a very particular context: a construction boom and consequent high-demand for one of its main services – reporting archaeological impact. Nevertheless, the activities conducted during the construction boom resulted in the discovery of many archaeological materials and new knowledge which need to be characterized, studied and disseminated, all activities that are undertaken by archaeological sector companies.

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8. NOTES

1 http://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176755&menu=ultiDatos&idp=1254735576669

2 http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey

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APPENDIX I. Non parametric correlation matrix

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1 Competitors	1	0.149*	0.005	0.084	0.074	0.04	0.082	-0.051	-0.051	-0.139
2 Other firms		1	0.277**	0.139*	0.11	0.244**	0.167*	0.088	0.179*	0.094
3 Suppliers			1	0.195**	0.102	0.092	0.141*	0.049	0.261**	0.131
4 Universities				1	0.291**	0.189**	0.208**	0.055	0.249**	0.304**
5 Research institutions					1	0.216**	0.333**	0.038	0.233**	0.106
6 Associations						1	0.170*	-0.018	0.202**	0.119
7 Public administrations							1	-0.007	0.14	0.048
8 Age								1	0.201**	0.260**
9 Size									1	0.662**
10 Turnover										1

* p-value<0.1; ** p-value<0.05