
Outsourced innovation in SMES: a field study of R&D units in Spain

Jose Albors-Garrigós*

Universidad Politécnica de Valencia,
Valencia, Spain
E-mail: jalbors@doe.upv.es
*Corresponding author

Noemi Zabaleta Etxebarria

Universidad de Mondragon,
Mondragon, Spain
E-mail: nzabaleta@eps.mondragon.edu

Jose Luis Hervas-Oliver

Universidad Politécnica de Valencia,
Valencia, Spain
E-mail: joheroll@doe.upv.es

Jaione Ganzarain Epelde

Universidad de Mondragon,
Mondragon, Spain
E-mail: jganzarain@eps.mondragon.edu

Abstract: SME innovation strategy and motivation has become one of the most challenging subjects of innovation policy. New innovation models proposed recently have captured the attention of policy makers. However, these models seem for the most part to be applicable to medium-sized or large enterprises. The objective of this paper is to analyse the open innovation model in the case of outsourced cooperative R&D in SMEs. Although the driving forces for outsourcing innovation in SMEs are in some respects similar to those for large firms, others are linked to lack of resources, but both have in common the pursuit of efficiency in R&D and technology transfer.

This paper is based on an empirical study of open innovation in SMEs and proposes a model for analysing the critical elements which influence performance and strategic alignment between R&D performers and their partners (in most cases, SMEs).

Keywords: open innovation; OI; small and medium enterprises; SMEs; outsourced innovation.

Reference to this paper should be made as follows: Albors-Garrigós, J., Etxebarria, N.Z., Hervas-Oliver, J.L. and Epelde, J.G. (2011) 'Outsourced innovation in SMES: a field study of R&D units in Spain', *Int. J. Technology Management*, Vol. 55, Nos. 1/2, pp.138–155.

Biographical notes: Jose Albors-Garrigós is a Professor of the Universidad Politécnica de Valencia, Spain. He received his MBA and PhD in Industrial Engineering from the Universidad Politécnica de Madrid. He has 30 years international experience in engineering. He has published a number of articles in various journals such as the *Journal of Technology Transfer, Production, Planning and Control, Entrepreneurship and Regional Development, Management Research News* and *European Regional Studies*. His current research focuses on innovation and technology management. He teaches technology and innovation management to undergraduate and PhD students and carries out consultancy on technology management.

Noemi Zabaleta Etxebarria is a Professor of the Engineering Faculty of the Mondragon University in the Basque Country, Spain. She received her PhD in 'R&D Strategies, Technology Transfer and Innovation'. Her current research focuses on project management and technology transfer. She earned the Project Management Professional credential from the Project Management Institute and she carries out consultancy on this area.

Jose Luis Hervás-Oliver obtained his PhD in 2004 and is currently an Assistant Professor at the Management Department at the Polytechnic University of Valencia, Spain. His research interests are in the areas of strategic management, clusters and SMEs, and especially in med low technology industries. His contributions are published in *Entrepreneurship and Regional Development, Journal of Technology Transfer, International Journal of Technology Management, International Journal of Learning and Intellectual Capital, Journal of Intellectual Capital*, among others.

Jaione Ganzarain Epelde is a Professor of the Engineering Faculty of Mondragon University in the Basque Country, Spain. She received her PhD in 'Entrepreneurial Universities'. She is supervising several researches on technology transfer between research centres and companies, competitive intelligence and technology watch. Her current research focuses on innovation management, institutional entrepreneurship, innovation systems and regional prospective. She teaches innovation and prospective to MBA and executives.

1 Introduction and objectives

The requirements and competitive challenges of a globalised economy have led to the emergence of new models of innovation such as open innovation (OI). In general, these models have been presented and discussed as models suitable only for large multinational firms, as most small and medium enterprises (SMEs) cannot invest the necessary elements to become a pacesetter company in their class (Herstad et al., 2008). The major constraints that SMEs face include: restricted financial resources, a lack of personnel and time, little or no experience and limited confidence in implementing new systems (Storey, 1994). Nevertheless, the application of this model of OI offers substantial advantages in the case of SMEs working in networks or clusters.

The Basque Regional Government promoted the R&D units programme as part of their innovation public policies in order to meet the innovation needs of its SMEs regional population. It was considered an alternative policy to the existing research

technology organisation (RTO) model. The expectation was that these units could align more closely their innovation and R&D strategy with that of the served firms and the innovation processes would be more efficient (Jaureguizar, 1994). This programme was initiated during the mid-1980s and has grown to 22 units. Their primary mission was defined as 'serving the industry organisations (basically SMEs) in the medium- and long-term, as well as developing and valuing their technological capabilities'. There are actually 22 R&D units operational which assist 92 SME firms. These units subcontract R&D activities in a continuous basis with their mother firms with whom have constituted either an industry association, a cooperative or a formal society or have rather informal ties. The system has been assembled as an OI system.

The objective of this paper is to analyse the OI model as applied in the case of these R&D outsourced units. This paper will examine input and output dependent variables that affect the efficiency of these units. Other context variables such as industry environment have also been taken into account in the model. This research aims at filling a gap in the literature of the application of the OI model to SMEs.

This paper has been organised as follows: firstly, a state of the art has been provided in order to analyse which variables may play a relevant role in the OI model. Secondly, the hypotheses will be proposed along with the constructs which support them. Thirdly, the research study and methodology will be described as well as the results of the study. Finally, conclusions are drawn as well as recommendations for practitioners and policy makers.

2 State of the art

OI refers to an emergent model of innovation in which firms draw on research and development that may lie outside their own boundaries (Chesbrough, 2003). Following, the paper will intend discussing the OI processes and body of innovation research, identifying the significant variables which seem to be relevant in a SME environment.

2.1 New innovation modes

The requirements and competitive challenges of a globalised economy have resulted in the need to open up the innovation process agenda (Gassman, 2006). Consequently, new models of innovation have emerged: user innovation and integration in product development (Von Hippel, 1986) as a consequence of the implication of lead users which facilitated the creation of a new school of thought (Von Hippel, 2005); OI (Chesbrough, 2003; Von Hippel and Von Krogh, 2003) as a paradigm that assumes that firms should use external ideas as well as internal ideas to innovate, so the boundaries between a firm and its environment have become more permeable; external commercialisation of technology (Lichtenthaler, 2005; Perkmann and Walsh, 2007) and outsourcing and collaboration in R&D with engineering firms and public or private R&D institutions (Lichtenthaler, 2008).

In general, these models have been presented and discussed as suitable for large multinational firms. Nevertheless, as previously stated, the application of this model offers substantial advantages for the SMEs working in networks or clusters.

2.2 Influence of technology transfer processes

Technology transfer has been defined as ‘intentional, goal-oriented interaction between two or more social entities, during which the pool of technological knowledge remains stable or increases through the *transfer* of one or more components of *technology*’ (Autio and Laamanen, 1995). The literature stresses the important role of technology transfer in successful innovation (Albors et al., 2005). Moreover, and as applicable in this case, three elements are basic for a successful technology transfer system (Sexton and Barrett, 2004): organisational direction and capability, inter-organisational management communication and knowledge characteristics of technology which will be discussed following. Improving the interface between R&D and production is essential to progress changing and competitive environments (Gorschek et al., 2006).

There are numerous studies highlighting the benefits of transferring technology properly, considering it a critical factor at a regional or cluster level (Albino et al., 1999) as well as transferring it from public to private entities (Franza and Grant, 2006).

Various authors have analysed the stages, within the innovation process, in which technology transfer is planned and the new technology is validated and used in the organisation (Gilbert and Cordey-Hayes, 1996), others have recommended certain methodology (Gorschek et al., 2006; Szulanski, 2000). The aim of this paper is to explain how firms can work at the lowest level of technology transfer. This is an area undeveloped so far (Stock and Tatikonda, 2000), but significant if one takes into account the many processes that fail or do not reach the desired levels of satisfaction. Consequently, we can conclude that two factors concerning technology transfer should be taken into account: management and leadership of the technology transfer project and the relationship between participants.

2.3 Organisational factors influencing technology transfer and innovation

There is a significant relationship between organisational variables and technology innovation and transfer, especially taking into account firm interaction (Rebentisch and Ferretti, 1995). To define the type of organisation that participates in a technology transfer project, a number of variables must be considered which can be classified in three types: those pertaining to the environment or context of the firm, those concerned with the strategy of the firm, and those related with the organisational structure and personnel policies of the firm (Boulter and Bendell, 2002).

Traditionally, industry environment or context, strategy and structure have been the variables frequently used to rank organisations (Miles and Snow, 1978; Miller and Friesen, 1984). Different environments give rise to different types of organisations; working in a particular environment can influence the type of technology acquired and used, as well as the strategy pursued. Miller proposed the environment as one of the possible forces that shape organisations; thus, the environment is the force that determines the strategy and structure, a theory also endorsed by Burns and Stalker (1961) and Lawrence and Lorsch (1967) and later revised by Sine et al. (2006) in the case of emerging new ventures. Likewise, organisations need to adopt the structure that fits their situational factors, or contingencies such as strategy and size, because this leads to higher organisational performance as confirmed by Donaldson (2001).

As stated above, the environment affects the organisation (Albino et al., 1999; Burns and Stalker, 1961; Lawrence and Lorsch, 1967), which in turn has an effect on the organisation's knowledge processing and process performance (Tang et al., 2006). Therefore, it is important to have a flexible organisational structure which will facilitate technology and knowledge transfer (Rebentisch and Ferretti, 1995).

In their seminal work, Burns and Stalker (1961) identified two management models: mechanistic and organic. Organic organisational form, characterised by a lack of formally defined tasks and an emphasis on horizontal as opposed to vertical coordination was considered the archetype structure for firms operating in turbulent environments. Following that line, Lawrence and Lorsch (1967) developed their contingent theory confirmed later by Donaldson (2001). Moreover, Jassawalla and Sashittal (1998) define two alternative structures: '*pronoia*' and '*paranoia*', relating to organic and mechanistic systems respectively. They note that '*paranoia*' environments tend to slow down technology transfer; in contrast, '*pronoic*' organisations activate the process. Stock and Tatikonda (2000) point out that organic units are more efficient and effective in processing higher levels of information than mechanistic units.

2.4 *Factors linked to innovation strategy*

An innovation strategy represents the plan that guides the decisions of a firm on the development and use of novel technological innovative capabilities. This strategy covers six major areas:

- a selecting the pioneering posture
- b determining the number of products to be introduced to the market
- c choosing the extent of a venture's use of internal and external R&D sources
- d deciding the level of R&D spending
- e selecting the combination (portfolio) of research projects
- f the firm's IPR approach (Zahra, 1996).

Walker and Ellis (2000) suggest that when developing an R&D strategy, it is important to consider the variables which affect the nature of technology transfer. The current models and innovation strategies implemented by firms are influenced not only by their formal strategies, but also by their industrial context and skills (Miller and Blais, 1993).

There are innovation strategy classifications analysed by different authors such as Walker and Ellis (2000) and Miller and Blais (1993), among others, which analyse different innovation modes. A seminal categorisation was proposed by Freeman and Soete (1997) who identified six firm innovation strategies: offensive, defensive, imitative, dependent (from others), traditional (conservative) and opportunist (or reactive). These definitions are self-explicative and what will differentiate one strategy from another will be the firm's goals and the degree of familiarity with its new products markets and technologies. There will be environmental factors such as market complexity and stability, competitiveness and context diversity which will interact contingently with certain firm variables such as organisation, age size or ownership in this course (Friedman et al., 2008).

2.5 Factors related with innovation management and leadership

A relevant ingredient in an innovation or technology transfer project is coordination, understood as having a structured plan at the time of implementing a new innovative technology in the organisation and according to the existing needs at each moment.

Szulanski (2000) suggests that poor coordination is an additional complication in the process. The author advocates that before implementing a transfer process, the practice should be documented, creating process maps or flow diagrams. Drawing up the scope of the technology transfer, selecting the time required and establishing the participants' obligations are required to start the process. Walker and Ellis (2000) also place importance on this aspect, considering important a detailed and formalised planning at the time of implementing the technology. Malik (2002) also supports a documented process or the existence of appropriate resources which can contribute to the project success or failure.

A number of authors have identified different roles that can be helpful for incorporating technology transfer within the organisation. The need for a manager or person who leads the technology transfer project is a significant issue.

As regards leaders, one of the most distinguished profiles is the 'champion', who is the person responsible for carrying out all the stages and taking risks and is therefore key to the progress of the project (Lane, 1999; De la Garza and Mitropoulos, 1991; Rebentisch and Ferretti, 1995). Leadership also has a fundamental role in the process of technology adoption and diffusion (Albors et al., 2006).

However, the role most often referred to is the 'gatekeeper', as the nexus between technology and organisation (see Allen, 1977; Cohen and Levinthal, 1990; De la Garza and Mitropoulos, 1991; Rebentisch and Ferretti, 1995; Walker and Ellis, 2000).

2.6 Relationship between the firm and the R&D executor

All innovation projects have diverse priorities; these differences in priorities are greater in the case of cooperating organisations. Here, the priority of the project plays a relevant role. Having shared goals and outlining them is another essential aspect in innovation and technology transfer (Walker and Ellis, 2000; Studt, 2004).

The match between the objectives of the partners involved is a relevant feature and organisational culture plays a vital role (Bowen and Kumar, 1993). Moreover, Kirk and Pollard (2002) and Szulanski (2000), also point to cultural barriers as one of the key points in technology transfer. Franza and Grant (2006) emphasise a 'transfer culture' as a driving force for committing to involvement in the process. On the other hand, Cummings and Teng (2003) argue that differences in the organisational culture can significantly influence the process. Finally, Sung and Gibson (2005) point out the 'distance' variable – both geographical and cultural – and stresses that the latter is more relevant than the former. Being closer physically may or may not increase cultural proximity and vice versa.

There are often differences between the needs of the user and what is actually transferred that must be taken into account. The designers are not trained in communication or in the skills that are essential to meet user needs or do not have the resources to engage users in requirements and specifications. Furthermore, the users want to be able to use the products in a simple way and cannot see the point in learning the skills beyond those necessary for their immediate needs (Von Hippel, 1986).

Another imperative aspect in this section is cooperation, i.e., to work together towards a common goal. Franza and Grant (2006) highlight the importance of this feature for overcoming differences in achieving a successful technology transfer. In organisational interactions, cooperation becomes imperative for problem solving. Cummings and Teng (2003) propose a list of activities such as visits, presentations and the exchange of documents between the parties that promote cooperation. And finally, Bozeman (2000) and Szulanski (2000) also consider the exchange of people as an essential aspect in technology transfer support and effectiveness. Another aspect that can enhance cooperation is a good relationship between the parties, where trust and motivation of people become a key variable in technology transfer (Jassawalla and Sashittal, 1998; Malik, 2002).

2.7 Factors concomitant to absorptive capacity

Despite the governance of the previously discussed variables (i.e., environment, strategy, organisation, structure, etc.) and bearing in mind that technology transfer is a relevant phase and output of the innovation process, organisations could not assimilate, convey and apply the external knowledge successfully without greater absorptive capacity (Lin et al., 2004).

Organisations do not differ only in their technological expertise, but also in their ability to absorb and assimilate new technologies (Bessant and Rush, 1995). The ‘absorptive capacity’ is a classical term which was first described by Cohen and Levinthal (1990). The ability to evaluate and use external knowledge depends on a previous knowledge level, and at the same time, this knowledge level depends on the R&D investment (Malik, 2002). Previous knowledge confers an ability to recognise the value of new information, assimilate that information and apply it for commercial purposes. The absorptive capacity has also been labelled as ‘receptivity’ by some authors (Gilbert and Cordey-Hayes, 1996). According to these authors, it is a critical factor in technology transfer.

More recently, Zahra and George (2002) reconceptualised absorptive capacity as a set of organisational routines and processes by which firms acquire, assimilate, transform and exploit knowledge. They also suggest that these four organisational capabilities build on each other to yield absorptive capacity, a ‘dynamic capability that influences the firm’s ability to create and deploy the knowledge necessary to build other organisational capabilities’. Zahra and George further differentiate two types of absorptive capacity – potential and realised – where the former consists of acquisition and assimilation and the latter of transformation and exploitation. In this study, we focus on potential absorptive capacity by defining it as a set of interrelated organisational capabilities of acquiring, disseminating and assimilating external knowledge.

To summarise, absorptive capacity has been characterised as one of the most relevant concepts in technology innovation and transfer (Chen, 2004; Teasley et al., 1996; Kirk and Pollard, 2002; Bozeman, 2000).

2.8 Factors related with performance

Finally, our analysis needs to consider the innovation output or performance. Innovation yield is today considered a central question relating to performance achievement in firms (Hidalgo and Albors-Garrigós, 2008). This field, including the definition and

measurement of innovation, has been dealt with by a number of authors. In the case of benchmarking, it takes into account the number of patents, new activities, new products or processes, new spin-off firms, scientific publications per person, etc. (i.e., Cordero, 1990; Bloch, 2007; Adams et al., 2006; etc.). Coombs et al. (1996) carried out a comprehensive literature review in this respect. In our case, we have followed Arundel (Arundel, 2007; Arundel and Hollanders, 2005) and its European Innovation Survey indicators.

3 Proposal of hypotheses and OI model

Based on the above, the research hypotheses are formulated below. Here, it should be noted that the conclusions reached from the interviews demonstrate that the R&D units had different goals in terms of their final results; while some are more concerned with innovation excellence, others are more focused on economic performance. This observation supports the first hypothesis:

References	Hypothesis 1
Burns and Stalker (1961), Miles and Snow (1978), Miller and Friesen (1984), Jassawalla and Sashittal (1998), Donaldson (2001) and Stock and Tatikonda (2000)	According to industry environment, strategy, structure, absorptive capacity and technology transfer, R&D units can be classified in clusters which achieve different innovation and turnover performances.

As considered above, within the organisational approach, organisation structure and human resources policies have a significant role in the innovation intensity level. Accordingly, the following hypothesis is proposed:

References	Hypothesis 2
Burns and Stalker (1961), Lawrence and Lorsch (1967), Ginn and Rubenstein (1986), Jassawalla and Sashittal (1998) and Stock and Tatikonda (2000)	The more organic an R&D unit is, the higher their innovation performance.

Innovation has been associated with a number of advantages for the organisation. Some of them are endorsed by research work carried out over recent decades which demonstrates a positive relationship between innovation and organisational performance. Nevertheless, looking at the different strategies followed by the R&D units, the following hypothesis can be proposed:

References	Hypothesis 3
Armour and Teece (1978), Pavitt (1984) and Galanakis (2006)	Considering the output results, innovation is not related to turnover.

Bearing in mind that technology transfer represents an intense and challenging relationship in an organisation (Malik, 2002), it requires management effort and resources for success at every stage. Taking into account the elements such as communication, coordination or cooperation (Stock and Tatikonda, 2000) analysed above, the fourth hypothesis is drawn up as follows:

References

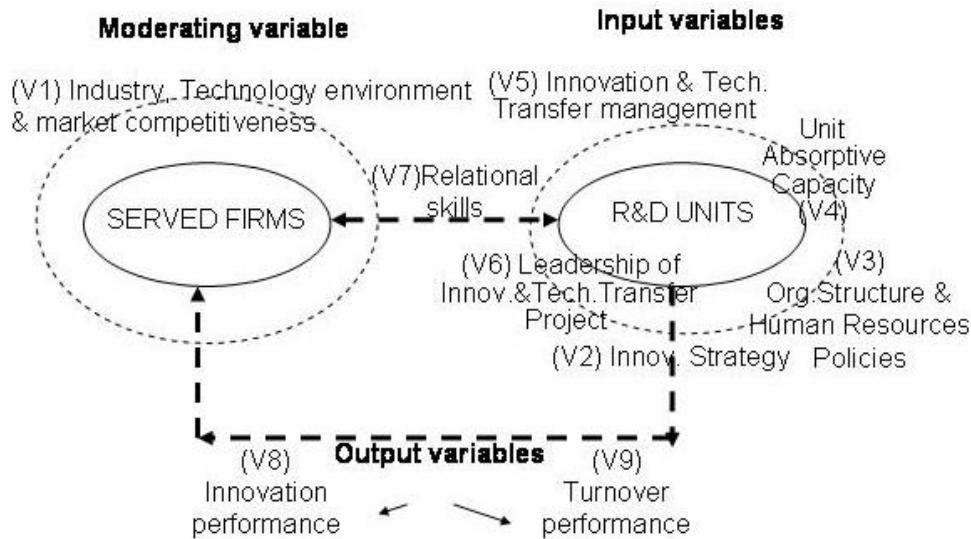
Allen (1977), Stock and Tatikonda (2000), Walker and Ellis (2000), Szulanski (2000), Kirk and Pollard (2002), Cummings and Teng (2003) and Franza and Grant (2006)

Hypothesis 4

The more attention paid to the technology transfer relationship factors, the unit will achieve higher innovation results.

Following this line of reasoning, in which environment, organisation, absorptive capacity and technology transfer are linked together and, in order to understand the relationships between the variables, Figure 1 shows the construct scheme which serves as a basis for the analysis.

Figure 1 Variables used to develop the taxonomy of R&D units



Finally, these hypotheses have been empirically tested in the R&D units. This paper proposes an empirical taxonomy of the Basque R&D units based on the field study carried out among the R&D organisations.

4 Research methodology, study and results

Taking into account the research objectives as well as the number and characteristics of the R&D organisations, the methodology was based on a questionnaire comprising some 100 questions covering three basic aspects of the R&D unit operation: organisational factors including market competitiveness, technology environment and partner absorptive capacity.

The research work was based on a questionnaire filled in by means of personal interviews carried out with the managers of 22 R&D units (representing 100% of the population) in the Basque Country. The majority of the questions were designed as closed questions. Each interview lasted between two and three hours. In order to obtain the

most reliable results possible, the interviewers ensured that the questions were properly understood and fully completed.

With the aim of simplifying the statistical analysis, a number of composite variables were built from the replies obtained. The key variables utilised for the analysis were as follows: industry technological environment and market competitiveness (V_1), innovation strategy (V_2), organisation structure and human resources policies (V_3), unit absorptive capacity (V_4), innovation and technology transfer management and leadership (V_5 and V_6) and relationship between participants during the process (V_7). Each of the variables was optimised and calculated through a combination of single variables.

As regards the output variables, turnover per employee (V_9) and innovation intensity (V_8) were selected. Innovation intensity was measured by the number of patents, new activities, new products, new spin-off firms and scientific publications per person in the last three years. Table 1 resumes the variables utilised and their composition.

Table 1 Construct variables

<i>Variable</i>	<i>Survey-related questions (items)</i>	<i>α cronbach</i>
V_1 Industry, technological environment and market competitiveness	Technology uncertainty, market competitiveness, technology life cycle (4)	0.8890
V_2 Innovation strategy	Motivation for the unit establishment, R&D activity, risk assumption policies, research freedom, pioneering, links with third party firms (9)	0.8379
V_3 Organisation structure and human resources policies	Hierarchy levels, organisation structure, staff stability, working groups, decision-making, personnel selection criteria, salary policies (6)	0.7052
V_4 Unit absorptive capacity	Staff education structure, training programmes, professional careers, external collaboration (6)	0.7589
V_5 Innovation and technology transfer management	Organisation management, coordination and communication with customers, common procedures with customers (4)	0.7899
V_6 Leadership of innovation and technology transfer project	Project management definition in both customer and unit (2)	0.7909
V_7 Relationship between participants during the process	Relevance and evaluation of technology surveillance between unit and firms (14)	0.8908
V_8 Innovation performance	Patents, licenses, spin-offs, new products or processes (4)	0.852
V_9 Unit performance	Turnover per employee (1)	

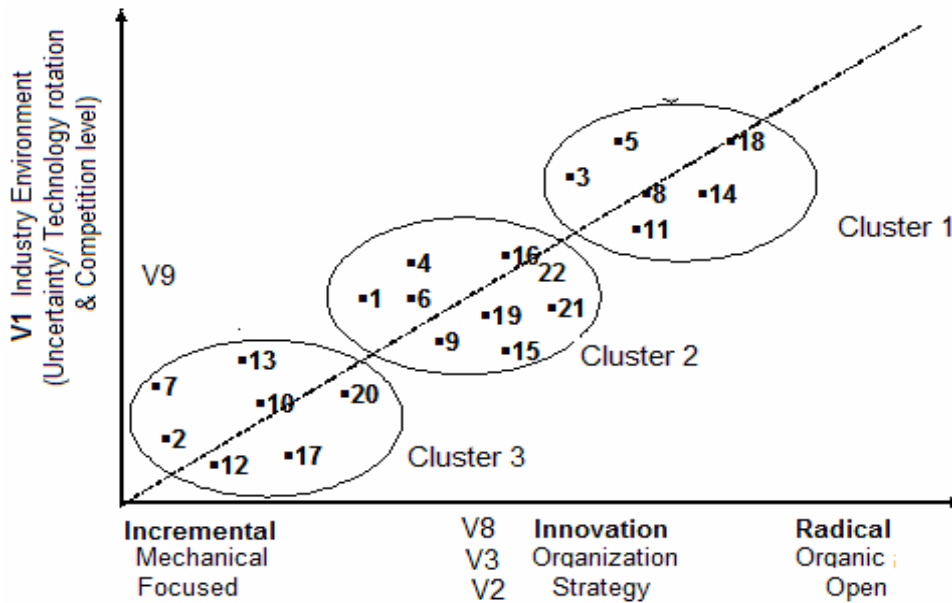
The data analysis was based on two steps. A cluster analysis permitted the classification of the R&D units and an ANOVA test was formulated in order to validate it.

Ward's method was followed given its acceptable performance as compared with other clustering methods (Milligan and Cooper, 1987). The clustering variables used were: V_1 , V_2 , V_3 , V_4 , V_5 , V_6 and V_7 . Three differentiated groups were found whose main characteristics were as follows:

- Cluster 1: It is made up of high intensity R&D units which focus their activity on R&D, rather than on engineering. This group comprises six R&D units operating in various high-tech areas and their technology rotation ratio is high. They are characterised by their operating in very dynamic markets that have a great deal of uncertainty and strong competition. With few exceptions, the vast majority of the most innovative partner firms are in this group (see Figure 2).

This dynamic environment drives R&D units to take risks researching technologies that have not yet found a position in the market. These organisations value positively the people who work in them and their personnel have higher salaries than those in the other clusters. Personnel training is a key element in these R&D units, language skills are valued and their structures are more flexible. These R&D units are more independent from their production partner companies and are permitted more autonomy to research in any field they find attractive. They also work for companies which are not formal partners¹ more than those in the other clusters do. They collaborate with geographically close companies, but are also interested in cooperating with international entities.

Figure 2 Classification of R&D units



- Cluster 2: It is composed of eight R&D units whose R&D activity concentrates on research and engineering with equal dedication. They compete in a less dynamic and uncertain industry environment than that of Cluster 1, but higher than that of Cluster 3 with a medium technology rotation ratio. They are characterised by maintaining a good market position but without risking too much in order to be leaders.

Their organisation structures are more rigid than in Cluster 1, but their employees also enjoy considerable freedom to take decisions, are provided with excellent

training and earn higher salaries than industry average. This cluster could be considered an intermediate cluster.

- Cluster 3: This cluster mainly contains sectors such as tooling machinery or automotive organisations. It contains seven R&D units operating in fairly stable industry environments and with a lower technology rotation ratio. Their R&D activities are more related to engineering and they do not perceive the need to employ PhD graduates in their staff. Except for some isolated cases, they have achieved a degree of stability in terms of their payroll. As a consequence of this stability, they have more rigid structures than are found in Clusters 1 and 2 in which the experience of the candidates and their CVs attain a significant relevance.

Collaboration with other organisations is not imperative in this group; only cooperation with other centres within the same region makes sense to them. At the same time, this group generally exhibits the highest turnover results (see Figure 2).

4.1 Cluster analysis

Table 2 reports the means of the variables used. The ANOVA results indicate that the main differences between the clusters (mean differences being statistically significant) lie in the innovation strategy pursued (V_2) and in the relationship between members within the innovation and technology transfer process (V_7). There is significance in the mean differences of all of variables except V_7 . Due to the small sample size of the sample, a duplication was carried out to find this data (Cohen, 2008).

Table 2 ANOVA test

	Cluster		Error		F	Sig.
	Mean square	DF	Mean square	DF	Media cuadrática	gl
V ₁	4.024	2	1.088	39	3.699	.034
V ₂	744.863	2	11.492	39	64.817	.000
V ₃	34.935	2	8.631	39	4.048	.025
V ₄	57.315	2	16.392	39	3.497	.040
V ₅	28.030	2	10.216	39	2.744	.077
V ₆	9.643	2	6.890	39	1.400	.259
V ₇	721.720	2	14.627	39	49.341	.000

Observing the results of V_2 ($p < 0.001$), it could be pointed out that each cluster carries out research in different activities; where Cluster 3 focuses on engineering and development activities, Cluster 1 does so on R&D, and Cluster 2 on R&D and engineering development equally.

Cluster 3 is focused more closely on its partner company needs; Cluster 2 is more internally driven, although it is open to the outside world; Cluster 1 has a significant external focus.

As regards the technology transfer process (V_7 , $p < 0.001$), the relationship between the R&D units and their partner firms is also progressive. Cluster 3 is aware of the value of keeping a close relationship with its partner firms and evaluating cultural, technological and strategy differences. Clusters 1 and 2, on the other hand, are not so

skilled in this respect. Cluster 1 is the most innovative, as shown in Table 2. Thus, it seems that the key to innovation dynamism is the process of technology transfer.

Moreover, it should be noted that organisational structure is more hierarchical and vertical in Cluster 3 and more horizontal and flexible in Cluster 1 while Cluster 2 holds an intermediate position.

When comparing innovation performance versus the R&D unit sales measured in turnover, Cluster 1 has the highest innovation performance and Cluster 3 has the highest turnover. Comparing these through an ANOVA test, the mean difference is significant (Table 3, $p < 0.05$). Those R&D units with higher turnover are not the most innovative. Moreover, the relationship (innovation performance versus turnover) is inversely proportional. This may be explained by the orientation of Cluster 3 R&D units. They are oriented towards their partner manufacturing plants, more focused on engineering and development and more centred on mature technologies. Consequently, they have less access to funds for promoting long-term R&D and are more dependent on their services turnover. These organisations are involved in day-to-day innovation problems; therefore, turnover is the main concern for their management.

Table 3 ANOVA of innovation output results

		<i>One way ANOVA</i>				
		<i>Sum of squares</i>	<i>DF</i>	<i>Mean square</i>	<i>Statistic F</i>	<i>Signif.</i>
<i>Innovation results</i>	Between groups	0.89776	2	0.44888	3.863	0.041*
	Within groups	2.09112	18	0.11617		
	<i>Total</i>	2.9889	20			
<i>Turnover per employee results (x 10⁶)</i>	Between groups	2,656.27	2	1,328.139	4.523	0.020*
	Within groups	5,281.81	18	293.47		
	<i>Total</i>	7,938.09	20			

Note: * $p < 0.05$

5 Conclusions

Traditionally, SMEs have not dealt suitably with the application of structured innovation models due to the restrictions in resources they have to face. Considering these conditions of context, OI models – models promoting the exchange of innovative applications and concepts among companies and entities – may be proposed as an appropriate reference for this type of company. This suggestion has guided this research, in which the main objective is a discussion of a cooperative R&D outsourcing scheme. The Basque R&D units are defined as organisations that have a goal of fostering technological innovation within their partner companies, basically SMEs and planning and carrying out R&D projects that can be implemented later in their manufacturing partner companies.

This paper analyses a number of influencing variables in the innovation and technology transfer process of OI such as organisation, industry environment, strategy,

structure, R&D policies and absorptive capacity, all of which affect the efficiency of these R&D units. Special attention has been paid to factors relating to the technology transfer process.

As regards the hypotheses proposed, the conclusions drawn from testing them are summarised below.

Firstly, the model developed reinforces the Burns and Stalker (1961) premise that the environment shapes the organisation strategy and structure, also supported by other authors such as Lawrence and Lorch (1967) or Miles and Snow (1978). Technology transfer plays a relevant role in the model, reconfirming the proposition of Stock and Tatikonda (2000) in that organic entities are more efficient and effective, processing higher levels of information than mechanistic entities. Hence, Hypothesis 1 is validated.

Secondly, according to the relationship between the variety of R&D units and their performance, it can be observed that Cluster 1 possesses the most organic organisation structure and the highest innovation performance. In contrast, Cluster 3 is basically mechanistic with the highest turnover. Depending on their strategy, R&D units in Cluster 2 have different performances due to its intermediate stand (Tables 1 and 2), so therefore, Hypotheses 2 and 3 can be validated.

Special attention has been paid to the factors related to technology transfer. The results show that importance placed by R&D units upon the technology transfer relationship factors promotes innovation performance. Cluster 1 units are aware of the relevance of cultural, strategic and technological differences and they are the most innovative. Therefore, Hypothesis 4 can be validated.

Using a contingency approach, different environments will require different strategies in order to achieve optimum performance. It appears that organisational structure and human resources policies are influenced by strategy, and hence, the more organic Clusters 1 and 2 R&D units are also more open to other non-member partner companies and have a higher technology level and a higher innovation performance. However, mechanistic Cluster 3 R&D units pay more attention to engineering and development activities since their technology rotation ratio is lower and they are more focused on turnover results as their day to day demands request.

Figure 2 shows how the different clusters are contingent on the environment, forming part of the technology rotation ratio of that environment. Simultaneously, technology transfer practices vary with organisational strategy. In view of this, the proposed construct may be validated.

The limitations of this paper result from the lack of detail at the project level by some academic schools (Stock and Tatikonda, 2000). Further phases of this research will focus on this gap. On the other hand, the contributions of this study must be interpreted with a degree of caution since the study has focused on the Basque context which may have certain characteristics that facilitated the success of the model. Finally, this study is limited by the number of factors utilised to classify the clusters; therefore, further analysis would provide more detail of R&D units as well as the complete vision of their partner firms.

It can also be concluded that OI models are applicable to SMEs. These outsourced R&D units behave in a contingent mode which adapts their strategy to that of their partner firms in their competitive and technology context on one hand and yet are perfectly able to perform adequately in their innovation tasks on the other. Thus, they outperform the classical RTO model (Rico-Castro, 2007).

For policy makers, the results of this paper provide a good example of an alternative method for providing SMEs with R&D outsourced services in a strategically focused approach. These R&D units prove to be more strategically aligned with their served firms and thus more focused on results than classical RTO, especially in turbulent environments. For this reason, further steps are needed for testing these results in other regions and contexts.

Acknowledgements

This paper has benefited greatly from the suggestions of the persons who answered the questionnaire. We would like to thank all the R&D unit managers for their helpful comments. We would like to thank, as well, the anonymous reviewers who have contributed with helpful comments to make this paper more readable and focused.

This paper has been partially supported by *ECO 2010:17318 (MICINN)*.

References

- Adams, R., Bessant, J. and Phelps, R. (2006) 'Innovation management measurement: a review', *International Journal of Management Reviews*, Vol. 8, No. 1, pp.21–47.
- Albino, V., Garavelli, A.C. and Schiuma, G. (1999) 'Knowledge transfer and inter-firm relationships in industrial districts: the role of the leader firm', *Technovation*, Vol. 19, No. 1, pp.53–63.
- Albors, J., Hervás, J.L. and Hidalgo, A. (2006) 'Analysing high technology diffusion and public transference programs', *Journal of Technology Transfer*, Vol. 31, pp.647–661.
- Albors, J., Sweeney, E. and Hidalgo, A. (2005) 'Transnational technology transfer networks for SMEs. A review of the state-of-the art and an analysis of the European IRC network', *Production Planning & Control*, Vol. 16, No. 4, pp.413–423.
- Allen, T.J. (1977) *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization*, The MIT Press, Cambridge, Mass.
- Armour, H.O. and Teece, D.J. (1978) 'Organizational-structure and economic performance – test of multi-divisional hypothesis', *Bell Journal of Economics*, Vol. 9, No. 1, pp.106–122.
- Arundel, A. (2007) 'Innovation survey indicators: what impact on innovation policy?', in *OECD, Science, Technology and Innovation Indicators in a Changing World: Responding to Policy Needs*, OECD, Paris, pp.49–64.
- Arundel, A. and Hollanders, H. (2005) *EXIS: An Exploratory Approach to Innovation Scoreboards*, MERIT, European Commission, Brussels.
- Autio, E. and Laamanen, T. (1995) 'Measurement and evaluation of technology transfer: review of technology transfer mechanisms and indicators', *International Journal of Technology Management*, Vol. 10, Nos. 7–8, p.643.
- Bessant, J. and Rush, H. (1995) 'Building bridges for innovation: the role of consultants in technology transfer', *Research Policy*, Vol. 24, pp.97–114.
- Bloch, C. (2007) 'Assessing recent developments in innovation measurement: the third edition of the Oslo Manual', *Science and Public Policy*, Vol. 34, No. 1, pp.23–34.
- Boulter, L. and Bendell, T. (2002) 'Managing the technology transfer process', Paper presented at the *Engineering Management Conference, IEEE International*, Vol. 2, pp.643–648.

- Bowen, J. and Kumar, U. (1993) 'Technology transfer: an expert system for adoption of innovation decisions', Paper presented at the *Canadian Conference on Electrical and Computer Engineering*.
- Bozeman, B. (2000) 'Technology transfer and public policy: a review of research and theory', *Research Policy*, Vol. 29, pp.627–655.
- Burns, T. and Stalker, G.M. (1961) *The Management of Innovation*, Oxford University Press.
- Chen, C.J. (2004) 'The effects of knowledge attribute, alliance characteristics, and absorptive capacity on knowledge transfer performance', *R&D Management*, Vol. 34, No. 3, pp.311–321.
- Chesbrough, H.W. (2003) 'The era of open innovation', *MIT Sloan Management Review*, Vol. 44, No. 3, pp.34–41.
- Cohen, J. (2008) 'Statistical power analysis', *Current Directions in Psychological Science*, Vol. 1, No. 3, pp.98–101.
- Cohen, W.M. and Levinthal, D.A. (1990) 'Absorptive-capacity – a new perspective on learning and innovation', *Administrative Science Quarterly*, Vol. 35, No. 1, pp.128–152.
- Coombs, R., Narandren, P. and Richards, A. (1996) 'A literature-based innovation output indicator', *Research Policy*, Vol. 25, No. 3, pp.403–413.
- Cordero, R. (1990) 'The measurement of innovation performance in the firm: an overview', *Research Policy*, Vol. 19, No. 2, pp.185–192.
- Cummings, J.L. and Teng, B.S. (2003) 'Transferring R and D knowledge: the key factors affecting knowledge transfer success', *Journal of Engineering and Technology Management – JETM*, Vol. 20, Nos. 1–2 SPEC, pp.39–68.
- Damanpour, F. and Gopalakrishnan, S. (1998) 'Theories of organizational structure and innovation adoption: the role of environmental change', *Journal of Engineering and Technology Management*, Vol. 15, No. 1, pp.1–24.
- De la Garza, J.M. and Mitropoulos, P. (1991) 'Technology-transfer (T2) model for expert systems', *Journal of Construction Engineering and Management*, Vol. 117, No. 4, pp.736–755.
- Donaldson, L. (2001) *The Contingency Theory of Organisations*, Sage Publ., Thousand Oaks, California.
- Franza, R.A. and Grant, K.P. (2006) 'Improving federal to private sector technology transfer', *Research-Technology Management*, Vol. 49, No. 3, pp.36–40.
- Freeman, C. and Soete, L. (1997) *The Economics of Industrial Innovation*, Free Press, London.
- Friedman, R.S., Roberts, D.M. and Linton, J.D. (2008) *Principle Concepts of Technology and Innovation Management: Critical Research Models*, IGI Publishing, PA.
- Galanakis, K. (2006) 'Innovation process. Make sense using systems thinking', *Technovation*, Vol. 26, No. 11, pp.1222–1232.
- Gassman, O. (2006) 'Open innovation. An agenda', *R&D Management*, Vol. 36, No. 3, pp.229–236.
- Gilbert, M. and Cordey-Hayes, M. (1996) 'Understanding the process of knowledge transfer to achieve successful technological Innovation', *Technovation*, Vol. 16, No. 6, pp.301–312.
- Ginn, M.E. and Rubinstein, A.H. (1986) 'The R&D production interface – a case study of new product commercialization', *Journal of Product Innovation Management*, Vol. 3, No. 3, pp.158–170.
- Gorschek, T., Wohlin, C., Garre, P. and Larsson, S. (2006) 'A model for technology transfer in practice', *IEEE Software*, Vol. 23, No. 6, pp.88–95.
- Herstad, S.J., Bloch, C., Ebersberger, B. and Van de Velde, E. (2008) 'Open innovation and globalization: theory evidence and implications', Project Final Report, VisioEra Net, European Commission, Brussels.
- Hidalgo, A. and Albors-Garrigós, J. (2008) 'Innovation management techniques and tools: a review from theory and practice', *R&D Management*, Vol. 38, No. 2, pp.113–127.

- Jassawalla, A.R. and Sashittal, H.C. (1998) 'Accelerating technology transfer: thinking about organizational pronoia', *Journal of Engineering and Technology Management*, Vol. 15, pp.153–177.
- Jaureguizar, J. (1994) 'Marco de la política tecnológica del Gobierno Vasco', Cuadernos de Sección, Ciencia y Tecnología, Eusko Ikaskuntza.
- Kirk, D. and Pollard, D. (2002) 'Systemic influences upon the operation of innovation and technology transfer intermediaries', *International Journal of Entrepreneurship and Innovation Management*, Vol. 2, Nos. 4–5, pp.424–437.
- Lane, J.P. (1999) 'Understanding technology transfer', *Assistive Technology*, No. 11, pp.5–19.
- Lawrence, P.R. and Lorsch, J.W. (1967) *Organization and Environment: Managing Differentiation and Integration*, Harvard University Press, Boston.
- Lichtenthaler, L. (2005) 'External commercialization of knowledge: review and research agenda', *International Journal of Management Reviews*, Vol. 7, No. 4, pp.231–255.
- Lichtenthaler, L. (2008) 'Open innovation in practice: an analysis of strategic approaches to technology transactions', *IEEE Transactions on Engineering Management*, Vol. 55, No. 1.
- Lin, C., Chang, S. and Chang, C.S. (2004) 'The impact of technology absorptive capacity on technology transfer performance', *International Journal of Technology Transfer and Commercialisation*, Vol. 3, No. 4, pp.384–409.
- Malik, K. (2002) 'Aiding the technology manager: a conceptual model for intra-firm technology transfer', *Technovation*, Vol. 22, No. 7, pp.427–436.
- Miles, R.E. and Snow, C. (1978) *Organizational Strategy, Structure and Process*, McGraw-Hill.
- Miller, D. and Friesen, P.H. (1984) *Organizations: A Quantum View*, Prentice Hall.
- Miller, R. and Blais, R.A. (1993) 'Modes of innovation in 6 industrial sectors', *IEEE Transactions on Engineering Management*, Vol. 40, No. 3, pp.264–273.
- Milligan, G.W. and Cooper, M.C. (1987) 'Methodology review: clustering methods', *Applied Psychological Measurement*, Vol. 11, pp.1–27.
- Pavitt, K. (1984) 'Sectoral patterns of technical change – towards a taxonomy and a theory', *Research Policy*, Vol. 13, No. 6, pp.343–373.
- Perkmann, M. and Walsh, K. (2007) 'University-industry relationships and open innovation: towards a research agenda', *International Journal of Management Reviews*, Vol. 9, No. 4, pp.259–280.
- Rebentisch, E.S. and Ferretti, M. (1995) 'A knowledge asset-based view of technology-transfer in international joint ventures', *Journal of Engineering and Technology Management*, Vol. 12, pp.1–25.
- Rico-Castro, M.P. (2007) 'Technology policy and its effects on the change of the R&D organizations: the case of the RTOs in the Basque Country (1980–1999)', PhD thesis, Universidad Complutense, Madrid, Spain.
- Sexton, M. and Barrett, P. (2004) 'The role of technology transfer in innovation within small construction firms', *Engineering, Construction and Architectural Management*, Vol. 11, No. 5, pp.342–348.
- Sine, W.D., Mitsuhashi, H. and Kirsch, D.A. (2006) 'Revisiting Burns and Stalker: formal structure and new venture performance in emerging economic sectors', *Academy of Management Journal*, Vol. 42, No. 1, pp.121–132.
- Stock, G.N. and Tatikonda, M.V. (2000) 'A typology of project-level technology transfer processes', *Journal of Operations Management*, Vol. 18, pp.719–737.
- Storey, D.J. (1994) *Understanding the Small Business Sector*, Routledge, London, UK.
- Studt, T. (2004) 'The 10 rules of technology transfer', *R&D Magazine*, Vol. 46, No. 2, pp.36–38.
- Sung, T.K. and Gibson, D.V. (2005) 'Knowledge and technology transfer grid: empirical assessment', *International Journal of Technology Management*, Vol. 29, Nos. 3–4, pp.216–230.

- Szulanski, G. (2000) 'The process of knowledge transfer: a diachronic analysis of stickiness', *Organizational Behavior and Human Decision Processes*, Vol. 82, No. 1, pp.9–27.
- Tang, F.C., Xi, Y.M. and Ma, J. (2006) 'Estimating the effect of organizational structure on knowledge transfer: a neural network approach', *Expert Systems with Applications*, Vol. 30, No. 4, pp.796–800.
- Teasley, R.W., Almeida, J.G. and Robinson, R.B.J. (1996) 'Managing technology transfer for value creation and competitive advantage: toward a contingency-based, information processing model', *IEEE*, Piscataway, NJ, USA and Vancouver, BC, Can, 18–20 August, pp.672–677.
- Von Hippel, E. (1986) 'Lead users: a source of novel product concepts', *Management Science*, Vol. 32, No. 7, pp.791–805.
- Von Hippel, E. (2005) *Democratizing Innovation*, MIT Press, Boston, MA.
- Von Hippel, E. and Von Krogh, G. (2003) 'Open source software and the private-collective innovation model: issues for organization science', *Organization Science*, Vol. 14, No. 2, pp.209–223.
- Walker, A. and Ellis, H. (2000) 'Technology transfer: strategy, management, process and inhibiting factors', *International Journal of Innovation Management*, Vol. 4, No. 1, pp.97–122.
- Zahra, S. (1996) 'Technology strategy and new venture performance: a study of corporate-sponsored and independent biotechnology ventures', *Journal of Business Venturing*, Vol. 11, No. 4, pp.289–321.
- Zahra, S. and George, G. (2002) 'Absorptive capacity: a review, reconceptualization, and extension', *Academy of Management Review*, Vol. 27, No. 2, pp.185–203.

Notes

- 1 With signed contracts