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WHAT TYPE OF INNOVATIVE FIRMS ACQUIRE KNOWLEDGE INTENSIVE SERVICES AND FROM WHICH SUPPLIERS? *

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ABSTRACT: Knowledge intensive services (KIS) and, in particular, R&D services contribute significantly to innovation in firms. The objective of this paper is to find out which characteristics of firms explain the acquisition of R&D services and to analyse whether there are differences depending on the typology of the supplier (universities, technology centres and consulting firms). Three main conclusions emerge from the econometric estimations. Firstly, the results show that size and age matter in the decision to buy R&D services, but these characteristics of firms do not have any particular influence in the decision to choose a specific supplier. Secondly, our results are consistent with the relevance that the literature gives to human capital in absorbing external knowledge. The variables used to control for human skills have a positive effect on the decision to buy R&D services. On the contrary, the estimates of other variables that capture internal knowledge base suggest that there is a substitution process between internal R&D activities and acquiring R&D services. Thirdly, innovation policy has a significant influence on the decision to acquire R&D services.

JEL Codes: L84, O32, L24
Keywords: Knowledge intensive services; R&D services; universities; technology centres; consulting firms; innovation policy

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1. INTRODUCTION

Knowledge intensive services (KIS) can be considered as vectors of information and knowledge. They act as drivers of knowledge dynamics in multilevel contexts (Strambach, 2008) and participate actively in the development and commercialization of new products, processes and services. The relevance of KIS comes from their interaction with other firms: their outputs are used as inputs for other productive activities. For this reason, KIS have significant potential for contributing to innovation through knowledge spillovers.

The role of KIS as producers and disseminators of knowledge has been studied in some investigations (Triplett and Bosworth, 2003). In fact, there is a growing body of research (Aslesen and Isaksen, 2007; Doloreux *et al*., 2010) devoted to analyzing their role in the process of generating and diffusing knowledge geographically and among firms.

However, less is known about what the main determinants are of decisions by firms to outsource KIS to different types of suppliers. In fact there is little empirical research either on outsourcing in general or specifically about the outsourcing of KIS (Antonietti and Cainelli, 2008). This work aims to fill this gap through an empirical analysis based on a sample of innovative firms in a region (Valencian Community) in Spain.

KIS are heterogeneous in two senses: (i) because of the content of the service; (ii) because of the type of service provider. Regarding their characteristics, KIS include a variety of types of services, from marketing to legal services through consultancy, engineering and technical analysis. So the relationships established with other firms are also diverse and with varying degrees of orientation towards innovation (Corrocher *et al*., 2009). Some classifications (Miles *et al*., 1995) distinguish the P-KIS (purely professional) from the T-KIS (with a technological base). In the latter case, the most important of these are R&D services. In this paper we will focus our attention on those KIS which have a greater knowledge and innovation content: R&D services that are included in the sector knowledge-intensive high-tech services in the Eurostat classification of KIS.

As regards the different suppliers, the impact of R&D services on the competitiveness of client firms depends mainly on the type and intensity of the relationship established between the organization providing the KIS and user companies. The extensive study by Howells (2006) highlights the wide variety of organizations that mediate with the companies. Given the different nature of each type of supplier/customer relationship, it is necessary to analyze each organization providing services specifically. In this paper we analyze three types of suppliers: universities, technology centres and consulting firms.

We have structured the paper as follows. After this introduction, in the next section, we review the literature and we propose the main hypotheses of the research. In section 3 we explain the sources of data and the variables used. The fourth section presents the techniques of analysis applied and the main results of the study. The paper ends with a section for conclusions.

2. ACQUISITION OF KNOWLEDGE INTENSIVE SERVICES

Although there are different definitions of KIS (Den Hertog, 2000; Tovoinen, 2006), there is no universally accepted definition. From the various concepts can be drawn two key features of KIS (Miles, 2005). Firstly, they are services that are addressed to companies and public organizations, i.e. not produced for private consumption. Secondly, as expressed by the term "knowledge intensive", organizations providing these services develop complex operations in which human capital plays an essential role.

KIS can perform various tasks in the innovation process (facilitators, intermediaries or sources of innovation) incorporating knowledge-intensive inputs to production processes in other firms. Firstly, KIS provide intermediate inputs through, for instance, consulting or training. This allows user firms to obtain knowledge-based solutions (Castellacci, 2008). Thus, KIS act as co-producers of innovation. In this sense, one could speak of co-innovation, in which client companies participate together with the organization providing the service (Wood, 2004). Secondly, KIS act as an interface between the knowledge base available in the whole economy and their own customers. In other words, KIS operate as catalysts in innovation systems (Castellacci, 2008).

More specifically and according to the characteristics of the organization providing the services, KIS, and particularly R&D services, may play three types of functions: (i) *facilitate* the innovation process that is taking place within the client companies; (ii) act as *carriers of innovation* that is taking place in other settings and channel it to their client firms; (iii) be a *source of innovation*, launching and implementing an innovation process within firms (Den Hertog, 2000).

The dynamics of KIS knowledge transfer have been described by Strambach (2008), who not only underlines the key role played by knowledge-related resources but also highlights the capacities and skills that are required by the client companies. The provision of knowledge to user firms requires a complex and intense interaction between service providers and enterprise customers. Both parties collaborate on interactive learning allowing their expertise to adapt to specific customer needs (Muller and Zenker, 2001). The literature has emphasized the dual need and complementarity between, on the one hand, external knowledge provided by a specific supplier of KIS, especially high-tech services and, on the other hand, the resources and capabilities of enterprise customers (Tether and Tajar, 2008).

For this reason and in order to identify the variables involved in the acquisition of R&D services it is essential to carry out a double analysis. Firstly, to identify what characteristics of firms increase their likelihood of acquiring such services. Secondly, to examine how these characteristics can be different depending on the supplier organization.

Regarding the latter, in recent years there has been a reconsideration of the role of universities in the context of national innovation systems. In opposition to the old conception of universities as "ivory towers", these institutions are increasingly considered as tools for economic development focusing on knowledge (Mowery and Sampat, 2005). In fact, especially in certain contexts (Gertler, 2010), universities operate as a key player in the innovation process through the provision of R&D services. For their part, technology centres are organizations dedicated to the provision of technological innovation and development for firms and industries. Firstly, they are responsible for disseminating the knowledge gained through research among their customers and, secondly, they assist firms in applying knowledge to production activity.

In this way technology centres act as strategic business partners through the provision of knowledge intensive services (Mas-Verdú, 2007; Barge-Gil and Modrego-Rico, 2008; Albors-Garrigues *et al*., 2010).

With regard to consulting firms, from a certain perspective these organizations can be seen as the epitome of knowledge-based companies, their main asset being the experience and expertise of their staff (Engwall and Kipping, 2002). The consultant is faced with an significant range of problems that require a broad set of solutions based on a wide and varied knowledge base that has been validated empirically (Creplet *et al*., 2001).

Determinants of the acquisition of R&D services

Several studies have suggested various reasons for the external acquisition of services and collaboration with other organizations in general (Belderbos *et al.,* 2004; Muscio, 2007; Zhang and Li, 2010). Broadly, absorption capacity has been widely associated with both the possibility of collaboration with other organizations and with the potential to generate innovations. According to Cohen and Levintal (1989) absorption capacity is related to the ability of the company to identify, assimilate and exploit knowledge in the environment.

From the existing literature three types of factors can be identified that influence the acquisition of R&D services: (1) A first group is related to firm-specific characteristics: age, size, degree of internationalization and sector. (2) The second group of determinants is linked to the internal knowledge base of the company that affects its ability to identify, assimilate and use external knowledge (Cohen and Levintal, 1989 and 1990). This specifically refers to the R&D activities and their organization in the firm. (3) The third factor is the role that technology policy can play in increasing the absorptive capacity of enterprises. While this capability is primarily an internal function, it may be reinforced by the institutional environment and, specifically, by a technology policy that grants tax incentives or financial subsidies designed to encourage internal R&D.

a) Firm characteristics

Size and age

In the case of the size and the age of the firm, the effect of these variables is ambiguous. More specifically, the relationship between absorptive capacity and firm size appears imprecise. On the one hand, it is arguable that the greater agility of smaller firms (Liao *et al*., 2003), in terms of simpler and less bureaucratic organizational structures, facilitates their ability to access external sources. But, on the other hand, the availability of resources, both organizational (routine, systematic decision-making processes, etc.) and R&D is associated with larger firms (Mowery *et al*., 1996). This latter argument would sustain a greater capacity of larger firms to absorb external innovations and services.

The association between firm age and other variables has been examined by different studies (Fariñas and Moreno, 2000; Mata and Portugal, 2004), but the results have not been clear-cut (Coad *et al*., 2010). It might be pointed out that strengthening the absorptive capacity of an enterprise is connected with the accumulation of knowledge, which is more likely in those companies which have existed for longer (Rao and Drazin, 2002).

Exports

Firms that export tend to be more intensive in capital and innovation than non-exporters (Bernard *et al*., 2005) due to the higher levels of efficiency required by competition in international markets. As the global environment has become increasingly competitive, internationalization strategies have also become more complex (Buckley and Ghauri, 2004). Among other things, and towards the adoption of an international strategy, companies must decide how much of their activities are conducted within the company and in which areas they should seek collaboration with other organizations (Pearce and Robbins, 2008).

In short, international business potential depends not only on relationships with customers and suppliers but also connections with organizations and intermediary organizations. Export activity is associated with access to a wide range of intermediary organizations and institutions acting as "bridges" to connect businesses with external sources of knowledge and innovation.

Sector

The level of difficulty in accessing technological and scientific knowledge is different in each sector. The concept of technological opportunity reflects these differences between industries. Firms which operate in sectors with high technological opportunities present more frequent access to external knowledge (Warner, 2003). Thus, in principle, in those sectors with high innovation intensity, firms would be more oriented towards exploring and exploiting external knowledge resources. Since firms operating in high technology sectors are characterized by developing R&D, these companies would have a greater tendency to use external resources with high technological content (Grimpe and Sofka, 2009).

However, the argument can be constructed in reverse: those firms operating in low-technology sectors could try to compensate for this deficit through the external acquisition of R&D services offered by technology centres, universities or consulting firms. In short, the influence of sector on the likelihood of acquiring KIS appears ambiguous.

b) Internal knowledge base

Knowledge is cumulative. Thus the existence of an internal knowledge base can contribute decisively to increasing capacity for the acquisition and assimilation of external resources. The internal level of knowledge depends on two interrelated factors (Veugelers, 1997; Muscio, 2007). The first is connected to R&D understood in a broad sense (availability of R&D, previous experience in conducting research projects, budgets for R&D). The second factor is the availability of human resources with a high educational level. An internal structure with qualified personnel strengthens the firm's ability to absorb and exploit external knowledge.

R&D expenditures over sales have often been used as the equivalent of absorptive capacity (Volberda *et al*., 2010). This is positively related to both innovation and collaboration with external organizations (Negassi, 2004; Fabrizio, 2009). However, due to differences in how firms of different characteristics manage R&D, such

relationships might not be so obvious unless we incorporate other variables that measure human capital and, especially, education levels of staff dedicated to R&D.

c) Innovation policy

The absorption capacity of a firm is primarily a function of their internal knowledge. But this capacity can be enhanced by their institutional environment and, specifically, by technology policy. Traditionally, the legitimacy of such policies has been based on evidence of market failure. Additionally, systemic failures, such as capability failures, institutional rigidities or network and coordination problems also justify technology policy. These failures are often associated with disadvantages in size, limited resources and problems between actors in the innovation system, especially in the field of R&D (Chaminade and Vang, 2008). The recognition of these failures together with the different behaviour of regional innovation systems have lead to the increasing participation of regional governments in the design and implementation of innovation policies.

Innovation policy, at a central and regional level, aims to stimulate firms to invest in R&D and to strengthen the ability of firms to absorb and use knowledge generated externally both through the so-called "soft" factors (institutions) as well as "hard" factors (fiscal incentives and R&D subsidies). Thus, these incentives are aimed at encouraging both internal R&D and the ability of companies to take advantage of research spillovers.

3. DATA AND VARIABLES

In order to analyse the typology of firms that acquire R&D services and to examine possible differences depending on the supplier (universities, technological centres and consulting firms) we use data from a survey conducted in 2007 of firms from the Valencian Community in Spain. The Valencian Community is a region with low absorptive capacity (Azagra-Caro *et al*., 2009). Its main industrial features of interest for our study are: (i) scarcity of qualified personnel, even in firms in knowledge-intensive sectors; (ii) mostly incremental innovation in the form of the acquisition of machinery and equipment, with low R&D expenditure; and (iii) low-tech profile of its

economic structure, with a high proportion of microfirms in services and traditional manufactures.

There is a policy emphasis on enhancing technology transfer, but specially adapted to the aforementioned characteristics of the industrial fabric. The instrument chosen was the creation of a strong network of technology institutes in the early 1980s; most of them being founded as industry-based associations of firms. These technology centres have their own legal status as private, non-profit associations with an independent management (Mas-Verdú, 2007).

There have also been pioneering actions regarding the creation of technology transfer offices, spin-off incubators and other channels of interaction directly placed in universities (Azagra-Caro, 2007). A close look at the relationship between universities and firms shows their relevance. A report for the Valencian R&D Council (ACCID, 2005), showed: (i) that 3% of the sales of Valencian firms were due to product innovations that could not have been developed without academic research; and (ii) that Valencian firms tend to contract out to universities for low-tech, short-term oriented R&D.

The survey used in this paper, that was carried out by the Valencian Government, has a similar structure and content to that of the Community Innovation Survey, and also includes some complementary questions on the performance of innovation activities, human resources, acquisition of R&D services and R&D public support programs. The information in the survey was obtained through direct interviews with managers of firms.

A total number of 988 Valencian firms carried out R&D and innovation activities during the period 2004-2006. From this whole population of innovative firms, the survey provides information for 256 firms, all of them engaged in internal R&D activities.[2]

[2] Given that the decision to acquire R&D services could be related to a previous decision to carry out internal R&D (Piga and Vivarelli, 2004) we only use firms undertaking internal R&D and, hence, avoid possible problems of sample selection.

Given that the main objective of this paper is to determine which characteristics of firms explain the acquisition of R&D services and to analyse whether there are differences in these characteristics depending of the typology of the supplier, we use a binary dependent variable (acquisition of R&D services) in a logit estimation (Table 1 presents the descriptive statistics for the variables used in the present analysis).

TABLE 1

The proportion of innovative firms that have acquired R&D services (dv_rdserv) is 60.5% of the total sample. Distinguishing between the three types of supplier, 36.7% of the total firms had bought R&D services from technological centres (dv_tc) and 25.3% and 22.6% respectively from firms (dv_firm) and universities (dv_uni). Some firms resort to more than one specific supplier to cover their needs for R&D services. These percentages are quite low and only 12.5% of firms buy services simultaneously from technological centres and firms, 10.9% from technological centres and universities and 9.7% from universities and firms. Finally, a very small proportion, 5.4% of the firms, acquires R&D services from the three types of supplier.

To analyse the determinants of the acquisition of R&D services and whether there are differences depending of the typology of the supplier, following a review of the literature three groups of independent variables were proposed.

The first group of variables correspond to the main characteristics of the firms. These variables are size (lworkers), age, propensity to export (dv_exp)[3] and sector. Specifically to control for sector, two binary variables have been included, one for the high and medium-high technology manufacturing industries (Man_mht) following the OECD classification, and the other for high-technology services (Serv_ht) in accordance with the Eurostat classification.

The second group of variables is related to the internal knowledge base and the main R&D characteristics of the firms, including their R&D personnel. Six variables have been used. The first two capture the effort in R&D, measured by R&D expenditures

[3] The survey does not provide information on the amount of exports and therefore the only variable to control for openness to foreign markets is the propensity to export.

over sales (R&D effort) and the organisation of R&D activities, with a binary variable for the existence of an R&D department (Dptrd). With these two variables the purpose is to analyse whether there is complementarity or a substitution process between own R&D and the acquisition of R&D services.

Complementarily, two variables allow human resources devoted to R&D to be controlled for, the number of researchers (Respers) and the number of R&D technicians (Restech). The level of human skills determines not only the ability of the firms to carry out internal R&D but also their absorptive capacity with regard to external knowledge and therefore their propensity to acquire R&D services.

In addition, we examine whether the level and the characteristics of the innovative activities of the firms, whether they are more oriented to technological product innovation or to process innovations, influences the acquisition of R&D services or the selection of the supplier. Two variables, the percentage of innovation expenditure devoted to new products (Newproduct) and that devoted to new processes (Newprocess), have been included.

Finally, the third group of variables captures innovation policy. Two main instruments have been considered, fiscal incentives (dv_tax) and R&D subsidies (dv_sub), with the use of binary variables in both cases. In Spain, central and regional governments have responsibilities in technology and innovation policy. The fiscal incentives for R&D activities are designed and implemented by the central government and are mainly devoted to increasing private R&D expenditure. In addition they seek to improve the interrelation between the agents of the innovation system, particularly between firms and universities. Public R&D subsidies to firms are granted by central and regional governments and in both cases they usually offer better conditions to firms when their R&D projects are carried out subcontracting R&D activities or in cooperation with other firms or institutions –universities or technological centres-.

Apart from these two main instruments, in the Valencian Community, the creation and promotion of a supply of innovation support services has a central role in innovation policy. The regional government has supported the creation of a network of technological centres that provide firms with infrastructures and services for their

innovative activities (Mas-Verdú, 2007). Most of these centres are sector-oriented particularly in low technology sectors, such as agro-food industries, textiles, footwear and the ceramic tile industry. To control for this policy a dummy variable (Sector_ct) for the firms in these sectors has been included in some of the estimations.

4. METHODOLOGICAL ISSUES AND RESULTS

As previously presented, and given that the main variable of interest, acquisition of R&D services, is dichotomous, we make use of a logit model to obtain our results. We estimate the following specification:

$$Prob(external\ R\&D\ acquisition=1)^t_i = c + \alpha(firms'\ structural\ characteristics)_i + \beta(firms'\ R\&D\ characteristics)_i + \gamma(innovation\ policy)_i + \varepsilon_i \quad (1)$$

The dependent variable is a dummy variable which equals one if the firm acquires R&D services, and zero otherwise. The subscript *i* refers to the unit of analysis, firms in our case, while the superscript *t* refers to the type of supplier of these R&D services: firms, universities or technological centres.[4] The three main categories of independent variables are described in detail above and ε_i is an error term. As is well known, the estimation of a logit model (see Greene, 2002 for more technical details) is preferable to an OLS estimation when the dependent variable is binary, in order to make sure that the predicted probabilities rely on the [0,1] interval and also to ensure that we obtain positive variance estimates. The use of the logistic distribution $\text{Prob}(Y=1) = \frac{e^{\beta' x}}{1+e^{\beta' x}}$ allows, by maximum likelihood, our specification of interest to be estimated.

Note that the estimation of our logit model, in principle, does not suffer from possible problems of sample selection because all firms in our sample perform internal R&D activities. Moreover, the possibility of using lagged values for some of our explanatory variables, particularly for R&D expenditures and for the main instruments of

[4] As explained previously, we conduct an initial estimation where the dependent variable is a dummy variable indicating whether the firm buys R&D services regardless of the supplier those services are acquired from.

technology policy – subsidies and fiscal incentives -, allows us to tackle, at least partially, the possible problem of endogeneity with some of the explanatory variables.

Two types of estimation of the logit model have been carried out. Firstly, we analyse the aggregate decision to acquire R&D services (dv_rdserv). Secondly, we analyse the decision to buy these services from a particular agent, that is, from firms (dv_firm), universities (dv_uni) or technological centres (dv_tc).

The results of the estimation for the acquisition of R&D services, without distinguishing between suppliers (see Table 2), show that innovative firms that use the market more frequently to acquire knowledge are mainly mature and small. Therefore, they are firms that have accumulated knowledge and also have good information on the characteristics of the supply of R&D services. In addition, and although the literature is not conclusive on the effects of size, our results suggest that small firms are more likely to buy these services from outside than bigger firms which have a greater capacity to provide these services internally. The estimations show that they do not belong to high-technology services, which indicates that these firms have less need to buy KIS than firms in the other sectors. Regarding the sector, and although some studies (Grimpe and Sofka, 2009) have found different patterns in different industries, the results show that buying KIS is not specifically relevant for manufacturing firms included in the high and medium-high technology sectors.

TABLE 2

The results corresponding to the R&D characteristics of the firms and their human skills point towards two conclusions. Firstly, the acquisition of external knowledge is particularly relevant for firms that do not have an R&D department, showing that it is very likely that they are firms that do not carry out R&D systematically. In addition, the parameter corresponding to the effort in R&D is not significant. Both results point towards a process of substitution between increasing own R&D efforts and buying R&D services. Nevertheless, the results also show the importance of human capital (García-Quevedo *et al*., 2011) and that a certain absorptive capacity is necessary, measured by the numbers of R&D technicians and researchers, to take the decision to acquire R&D services. In particular, R&D technicians seem to have an important role in

the interaction required between the supplier and the client. The results also show that the acquisition of R&D services is more related to innovative activities with the purpose of achieving product innovations rather than process innovations.

Public policy is relevant in the decision to acquire R&D services, a result consistent with previous analysis (Piga and Vivarelli, 2004). Three indicators of technological policy are included in the estimations, R&D subsidies, fiscal incentives and the existence of technological centres promoted by the regional government in some specific sectors. The results show that R&D subsidies, that frequently have the aim of increasing relationships between the different agents of the regional innovation system, have a positive effect on decisions to buy R&D services.

The results corresponding to the estimations distinguishing between the three main suppliers of R&D services (universities, technological centres and consulting firms) show some differences when compared with the general estimation and also between them (see Table 2). The results point out that there is no specific characteristic of firms that explains the selection of one specific supplier. While size and age are important in explaining the general decision to acquire external R&D, they are not significant in the decision about the specific supplier. Neither is belonging to high and medium-high technology manufacturing sectors significant, as in the general estimation.

Nevertheless, in the case of high technology services, the three estimations by suppliers exhibit some differences that show that, in particular, firms in these sectors are less likely to buy R&D services from universities and technological centres, while in the case of consulting firms belonging to these sectors is not significant. The parameter measuring the openness to foreign markets is significant only in the estimation for the services provided by technological centres. This result is consistent with previous analyses (García-Quevedo and Mas-Verdú, 2008) and shows that the services supplied by these organisations, with the support of public policy, seem to be particularly in accordance with the necessities of the firms trying to compete in foreign markets.

The results regarding the R&D characteristics of the firms, R&D department and R&D effort, confirm those obtained in the general estimation, showing that all types of innovative firms use R&D services from the three different types of supplier and there

is no specific positive relationship for firms that make a greater effort in R&D. The results for the variables that measure human skills also reinforce the importance of having absorptive capacity for the acquisition of R&D services from some specific suppliers, and, in particular, from universities (García-Quevedo *et al*., 2011). Firms with a greater presence of R&D technicians and researchers are more likely to use R&D services from universities. This result is related to the high technological content that the services provided by academic institutions usually have. In contrast, in the case of technological centres, neither of these two variables is significant, which seems to indicate that the supply of services from these centres is better adapted to all kinds of firms.

Finally, the results reinforce the conclusion that technological policy plays a significant role in the acquisition of R&D services and show that some specific instruments are especially related to the selection of one specific supplier. Technology policy favours the acquisition of services from academic institutions and technological centres while it has no impact in the case of consulting firms. In particular, in the case of universities, the parameter corresponding to fiscal incentives is positive and significant while in the case of technological centres, subsidies and the creation, with the support of the regional government, of a technological infrastructure for some specific sectors, explain a greater use of their services.

Robustness checks

To check the robustness of our results, we have taken into account three main aspects of the process of acquiring R&D services that could affect the reliability of the results. Specifically, we analyse whether the decision to buy external R&D is taken in two stages, the potential complementarity between the different suppliers, and the variables that influence the amount of external R&D services acquired.

Firstly, an important aspect to be aware of in our empirical framework is the possibility that the decision to acquire R&D activities could be taken in two stages. It could be the case that the firm first decides to buy R&D services and then it decides which institution to address itself to in order to obtain those services (universities, technological centres or other firms). If that is the case, when analysing the decision to externalise to a

specific provider, for instance to technological centres, the estimation could suffer from sample selection due to the fact that the number of firms that have decided not to externalise could be what it is because they decided not to acquire R&D services or not to acquire R&D services from technological centres but from other firms or universities. Not taking this characteristic of the process into account could lead to an erroneous interpretation of the results.

To avoid this problem we have performed a two-step Heckman procedure where we explain the probability of acquiring services from a particular supplier controlling for the initial probability of deciding, or not, to acquire R&D services. The two-step Heckman procedure provides us with the estimation of the Mills ratio, which informs about the existence of possible selection bias in our estimates. The two-step Heckman procedure results indicate that the Mills ratio is not significant and it seems that there is no evidence of selection bias. Hence, the logit estimates for each type of provider are not biased. [5]

Secondly, another aspect that could affect our logit estimation is the fact that decisions to buy R&D services from a specific supplier are taken independently, that is, if the decision is not influenced by the probability of acquiring from any of the other available providers. As some authors (Belderbos *et al*., 2004) have pointed out for the cooperation relationships in R&D, it is possible that there is, in the acquisition of R&D services, a potential complementarity between the different suppliers. To analyse this aspect we perform multivariate probit estimations for the possible combinations of externalization decisions that the firm can face when deciding to acquire R&D services (firm vs universities, firm vs technological centres and universities vs technological centres). The multivariate results will inform us as to whether the decisions are interrelated or not.[6]

The multivariate estimates (Table 3) show that the decision whether to acquire R&D activities from universities or from technological centres is independent, but there is no

[5] The Mills ratios obtained from the two-step Heckman procedure are (p-values in parenthesis): -0.6869 (0.360) for universities; -0.1359 (0.832) for firms and 0.9268 (0.360) for technological centres.

[6] The multivariate probit (because we assume normality of the error terms) estimation will provide us with ρ, a correlation parameter that will inform us about the covariation of the error terms of the two externalization decisions taken into account. If ρ=0 the probability of one decision is independent of the probability of the other decision.

such independence between the decisions about acquiring R&D services from universities or firms, or to acquire R&D services from technological centres or firms. Even taking into account these interrelations, the results are very consistent with those obtained in the univariate logit models estimated initially. In the three estimations the same variables as in the univariate model are significant. The only difference is that in the multinomial framework, R&D subsidies are a significant variable explaining the acquisition of R&D services from firms while in the univariate estimation they did not appear as a statistically significant variable, although they were very close. Therefore, these estimates not only confirm the logit results but also provide us with more information regarding the effects of interrelations between suppliers in firms' decisions about acquiring R&D services.

TABLE 3

Thirdly, the estimations have also been carried out using the amount of external R&D services as a dependent variable (Table 4). Although, in our framework, we have concentrated our results on the decision about externalising (or not) R&D services, it is convenient to take into account the quantity of R&D services bought. To carry out this analysis we have used a Tobit model. The justification for the Tobit regression technique is that the firms' percentage of R&D services externalised (to each type of provider) is bounded between zero and one and a sub-set of the sample may be accumulated into the 0 value (those firms that do not acquire R&D services).

TABLE 4

The results,[7] although similar to those obtained using the logit methodology, show some differences between the variables that explain the decision to buy R&D services and those related to the amounts acquired. In particular, the most relevant differences are that in the estimation regarding the acquisition of external services from firms, the variable corresponding to innovation expenditure on new processes is significant and that in the case of buying R&D services from technological centres, human capital, measured by researchers, is now significant. This result suggests that firms that have

[7] In a similar way to the logit estimations, a multivariate Tobit model has been estimated to take into account a potential complementarity between the different suppliers, yielding the same results.

more intense relationships with technological centres need to have proper human skills to absorb this external knowledge.

5. CONCLUSIONS

KIS play a key role in the development and marketing of new products, processes and services. In particular, R&D services can be considered as drivers of knowledge and the organizations that provide these services develop complex operations where the generation and transmission of knowledge takes place through intensive producer/user interaction. In this sense such services perform two functions: (i) act as facilitators and sources of innovation for other sectors; (ii) carry innovation through knowledge transfer activities. Thus, R&D services play an intermediary role in the case of knowledge that is relevant to the productive activity: from tacit knowledge to scientific and technological knowledge in the strict sense.

While a part of research has considered KIS as crucial for economic development and has focused on their impact on the overall economy, less attention has been paid to providing empirical evidence about the reasons why companies make use of such services. Actually, a significant number of firms do make use of R&D services. Specifically, in our sample, 61% of the firms had used these services, technological centres being the most important supplier (37% of the firms) while 25% and 23% of the firms respectively had bought R&D services from consulting firms and universities.

Despite the frequent use of R&D services, as indicated above, there is little knowledge about the determinants of firms outsourcing R&D services in general and, in particular, the variables that explain the decision to select a specific supplier. Therefore, the main objective of this paper has been to analyse the main characteristics of firms, also taking into account the role of innovation policy, that explain the decision to acquire R&D services in general, and from three specific suppliers, universities, technological centres and consulting firms.

The main conclusions from the estimations regarding the decision to acquire R&D services are the following. Firstly, some specific characteristics of firms such as size and age, matter in the decision to buy, in general, R&D services but they do not have

any particular influence in the decision about choosing a specific supplier. Although the literature is not conclusive on the effects of size and age on outsourcing R&D services, our results point out that mature and small firms are more likely to use external R&D services.

Secondly, the results are consistent with the relevance that the literature gives to human capital in absorbing external knowledge. The two variables used to control for human skills, researchers and R&D technicians, have a positive effect on the decision to buy R&D services. This result is also obtained in the estimations regarding the acquisition of R&D services from universities and firms. In contrast, the estimates for the other two variables that capture internal knowledge base, R&D effort and having an R&D department or not, are not significant and negative respectively. This result suggests that there is a substitution process between internal R&D activities and acquiring R&D services, particularly for the most innovative firms that carry out R&D systematically and have proper infrastructures, an R&D department, for their R&D activities. This result holds even for buying R&D from universities, showing that academic institutions do not only direct their supply of R&D services towards firms with a high technological content.

Finally, the results of the estimations show that innovation policy has a significant influence on the decisions of firms to acquire R&D services. Public subsidies, both from the central and regional level, play a significant role in buying R&D services. The existence of a network of technology centres created with the support of the regional government also has a positive influence on the decisions of firms about acquiring R&D services.

To check the robustness of these results we have carried out some complementary estimations. Firstly, to control for the possibility that the decision to acquire R&D services could be taken in two stages, we have performed a two-step Heckman procedure. Secondly, a multivariate framework has been used to analyse whether the decision to buy R&D services from a specific supplier is independent of the probability of acquiring these services from other suppliers. Thirdly, we have carried out some Tobit estimations using the amount of R&D services bought as the dependent variable.

Although in the three cases, the results of the estimations hold, showing the robustness of the results, our analysis is not free of limitations. In particular, the database does not provide information on variables related to the sources of information about the innovation process or on ways of protecting information that could have helped us to understand more deeply the reasons that explain the acquisition of R&D services. In addition, it would have been convenient to have a larger database, with a panel data structure, to examine in more detail the process that a firm follows in taking the decision to acquire R&D services from a specific supplier. R&D services require a high level of interaction between the user and the supplier with the active participation of the client and it could be claimed that the most frequent procedure is that they decide to engage in acquiring external R&D activities jointly with the decision about choosing a specific supplier. Nevertheless, our database does not allow a conclusive answer to this hypothesis to be given. Knowing whether these decisions are simultaneous or consecutive would improve our understanding of the process of outsourcing R&D services and of the existence of possible information asymmetries concerning the services provided by the different types of supplier.

References

ACCID (2005). *Análisis de la contribución de la I+D universitaria al desarrollo económico de la Comunidad Valenciana.* In: Alto Consejo Consultivo en Investigación y Desarrollo de la Presidencia de la Generalitat Valenciana, Informe anual sobre el estado de la investigación, el desarrollo y la tecnología en la Comunidad Valenciana. Valencia, Generalitat Valenciana.

Albors-Garrigos, J., Zabaleta, N., & Ganzarain, J. (2010). New R&D management paradigms: rethinking research and technology organizations strategies in regions. *R&D Management* 40 (5), 435–454.

Antonietti, R., & Cainelli, G. (2008). Spatial agglomeration, technology and outsourcing of knowledge-intensive business services: empirical insights from Italy. *International Journal of Services Technology and Management*, 10 (2-4), 273-298.

Aslesen, H.W., & Isaksen, A. (2007). Knowledge-intensive business services and urban industrial development. *Service Industries Journal*, 27(3), 321-338.

Azagra-Caro, J.M., Fernández de Lucio, I., Perruchas, F., & Mattsson, P. (2009). What do patent examiner inserted citations indicate for a region with low absorptive capacity? *Scientometrics*, 80(2), 443–457.

Azagra-Caro, J.M. (2007). What type of faculty member interacts with what type of firm? Some reasons for the delocalisation of university-industry interaction. *Technovation,* 27, 704-715.

Barge-Gil, A., Modrego-Rico, A. (2008). Are technology institutes a satisfactory tool for public intervention in the area of technology? A neoclassical and evolutionary evaluation. *Environment and Planning C: Government and Policy*, 26, 808-823.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B., & Veugelers, R. (2004). Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organisation,* 22, 1237-1263.

Bernard, A. B., Bradford, J., Schott, K.P. (2005). Firms in International Trade. *Journal of Economic Perspectives*, 21 (3), 105-130.

Buckley, P.J., & Ghauri, P.N. (2004). Globalisation, Economic Geography and the Strategy of Multinational Enterprises. *Journal of International Business Studies*, 35 (2), 81-98.

Castellacci, F. (2008). Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. *Research Policy*, 37, 978-994.

Chaminade, C., & Vang, J. (2008). Globalisation of Knowledge Production and Regional Innovation Policy: Supporting Specialized Hubs in Developing Countries. *Research Policy*, 37 (10), 1684-97.

Coad, A., Segarra, A., & Teruel, M. (2010). *Like milk or wine: Does firm performance improve with age?* Working Paper XREAP2010-10.

Cohen, W., & Levinthal, D. (1989). Innovation and Learning: the Two Faces of R&D. *The Economic Journal,* 99, 569–596.

Cohen, W., & Levinthal, D. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly,* 35(1), 128-152.

Corrocher, N., Cusmano, L., & Morrison, A. (2009). Modes of innovation in knowledge-intensive business services: evidence from Lombardy. *Journal of Evolutionary Economics,* 19, 173-196.

Creplet, F., Dupouet, O., Kern, F., Mehmanpazir, B., & Munier, F. (2001). Consultants and experts in management consulting firms. *Research Policy*, 30, 1517-1535.

Den Hertog, P. (2000). Knowledge-intensive Business Services as co-producers of innovation. *International Journal of Innovation Management*, 4, 491-528.

Doloreux, D., Freel, M., & Shearmur, R. (eds.) (2010). *Knowledge-Intensive Business Services: Geography and Innovation.* Farnham: Ashgate.

Engwall, L., & Kipping, M. (2002). Introduction: Management consulting as a knowledge industry. In M. Kipping & L. Engwall (Eds.), *Management consulting: Emerging dynamics of a knowledge industry*: 1–16. Oxford, U.K.: Oxford University Press.

Fabrizio, K.R. (2009). Absorptive capacity and the search for innovation. *Research Policy,* 38(2), 255-267.

Fariñas, J., & Moreno, L. (2000). Firms' Growth, Size and Age: A Nonparametric Approach. *Review of Industrial Organization,* 17**,** 249–265.

García-Quevedo, J., & Mas-Verdú, F. (2008). Does only size matter in the use of knowledge intensive services. *Small Business Economics,* 31, 137-146.

García-Quevedo, J., Mas-Verdú, F., & Polo-Otero, J. (2011). R&D human resources in firms: What determines the educational level required? *Applied Economics Letters,* 18 (16), 1537-1540.

Gertler, M.S. (2010). Rules of the game: the place of institutions in regional economic change. *Regional Studies*, 44(1), 1-15.

Greene, W. H. (2002). *Econometric Analysis*, 5th Edition. Upper Saddler River, NJ: Prentice Hall.

Grimpe, C., & Sofka, W. (2009). Search patterns and absorptive capacity: low and high-technology sectors in Europe countries. *Research Policy*. 38, 495-506.

Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy,* 35, 715-728.

Liao, J., Welsch, H., & Stoica, M. (2003). Organizational Absorptive Capacity and Responsiveness: An Empirical Investigation of Growth-Oriented SMEs'. *Entrepreneurship: Theory & Practice*, 28 (1), 63-86.

Mas-Verdú, F. (2007). Services and innovation systems: European models of Technological Centres. *Service Business. An International Journal*, 1, 7–23.

Mata, J., & Portugal, P. (2004). Patterns of Entry, Post-Entry Growth and Survival: A Comparison between Domestic and Foreign Owned Firms. *Small Business Economics,* 22 (3-4), 283-298.

Miles, I. (2005). Knowledge-intensive business services: prospects and policies. *Foresight*, 7 (6), 39-63.

Miles, I., Kastrinos, N., Flanagan, K., Bilderbeek, R., den Hertog, P., Huntink, W., & Bouman, M. (1995). *Knowledge intensive business services: their roles as users, carriers and sources of innovation*. Report to DG13 SPRINT-EIMS, PREST, Manchester, March.

Mowery, D.C., & Sampat, B.N. (2005). Universities in national innovation systems. In J. Fagerberg, *et al*. (eds.) *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, 209-239.

Mowery, D.C., Oxley J., & Silverman, B.S. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal*, 17, 77-91.

Muller, E., & Zenker, A. (2001). Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems. *Research Policy,* 30, 1501–1516.

Muscio, A. (2007). The impact of absorptive capacity on SME's collaboration. *Economics of Innovation and New Technology,* 16, 653–668.

Negassi, S. (2004). R&D co-operation and innovation: A microeconometric study on French firms. *Research Policy.* 33, 365–384.

Pearce, J., & Robbins, K. (2008). Strategic transformation as the essential last step in the process of business turnaround. *Business Horizons*, 51, 121-130.

Piga, A., & Vivarelli, M. (2004). Internal and external R&D: A sample selection approach. *Oxford Bulletin of Economics and Statistics,* 66, 457-482.

Rao, H., & Drazin, R. (2002). Overcoming resource constraints on product innovation by recruiting talent from rivals: A study of the mutual fund industry, 1984–94. *Academy of Management Journal*, 45, 491-507.

Strambach, S. (2008). Knowledge-intensive Business Services (KIBS) as drivers of multilevel knowledge dynamics. *International Journal of Services and Technology Management*, 10, 152-174.

Tether, B.S., & Tajar, A. (2008). Beyond industry-university links: Sourcing knowledge for innovation from consultants, private research organizations and the public science-base. *Research Policy*, 37, 1079-1095.

Triplett, J.E., & Bosworth, B.P. (2003). Productivity Measurement Issues in Services Industries: Baumol's Disease has been cured. *Federal Reserve Bank of New-York Economic Policy Review,* 9, 23-33.

Veugelers, R. (1997). Internal R&D expenditures and external technology sourcing. *Research Policy,* 26, 303-315.

Volberda, H., Fos N., & Lyles, M.A. (2010). Absorbing the Concept of Absorptive Capacity: How to Realize Its Potential in the Organization Field. *Organization Science,* 21(4), 931-951.

Warner, A. (2003). Buying Versus Building Competence: Acquisition Patterns in the Information and Telecommunications Industry 1995-2000. *International Journal of Innovation Management,* 7 (4), 395-415.

Wood, P. (2004). Knowledge-intensive services and urban innovativeness. *Urban Studies*, 39: 993-1002.

Zhang, Y., & Li, H. (2010). Innovation search of new ventures in a technology cluster: the role of ties with service intermediaries. *Strategic Management Journal,* 31, 88–109.

Table 1. Descriptive statistics

Variable	Description	Observ.	Mean	Std. Dev	Min	Max
dv_rdserv	Dummy= 1 if the firm has acquired R&D services in 2006	256	0.605	0.490	0	1
dv_uni	Dummy= 1 if the firm has acquired R&D services from universities in 2006	256	0.226	0.419	0	1
dv_tc	Dummy= 1 if the firm has acquired R&D services from technological centres in 2006	256	0.367	0.483	0	1
dv_firm	Dummy= 1 if the firm has acquired R&D services from firms in 2006	256	0.254	0.436	0	1
lworkers	Number of workers in 2006 (in logarithms)	256	3.460	1.609	0	8.937
Age	Number of years that the firm has been operating	254	20.736	16.242	2	118
Serv_ht	Dummy= 1 if the firm is in a high technology service sector	256	0.102	0.303	0	1
Man_mht	Dummy= 1 if the firm is in a medium-high or high technology manufacturing sector	256	0.172	0.378	0	1
dv_exp	Dummy= 1 if the firm exports. 2006	256	0.555	0.498	0	1
R&D effort	R&D effort (total R&D expenditure over sales). Average 2004-2006	235	0.081	0.153	0	0.936
Dptrd	Dummy= 1 if the firm has an R&D department	251	0.677	0.468	0	1
Newprod	R&D expenditure on new products (in percentage over total). 2004-2006	238	54.71	34.10	0	100
Newprocess	R&D expenditure on new processes (in percentage over total). 2004-2006	238	5.08	14.83	0	100
Restech	Number of R&D technicians. 2006	256	2.891	5.498	0	74
Respers	Number of researchers. 2006	256	2.630	7.322	0	100
dv_tax	Dummy= 1 if the firm has benefitted from an R&D tax incentive in 2004 or 2005	256	0.176	0.381	0	1
dv_sub	Dummy= 1 if the firm has received a public R&D subsidy in 2004 or 2005	256	0.570	0.486	0	1
Sector_ct	Dummy= 1 if the firm operates in a sector where there is a technology centre sectoral-oriented (agro-food, textile, ceramics, leather and footwear)	256	0.219	0.414	0	1

Table 2. Acquisition of R&D services. Logit estimations.

VARIABLES	**dv_rdserv**	**dv_rdserv**	**dv_uni**	**dv_firm**	**dv_tc**	**dv_tc**
lworkers	**-0.272****	**-0.223***	-0.169	0.029	0.006	0.024
	(0.124)	**(0.121)**	(0.148)	(0.131)	(0.118)	(0.118)
Serv_ht	**-1.383****		**-1.761****	-0.896	**-1.208***	
	(0.580)		**(0.797)**	(0.702)	**(0.668)**	
Man_mht	-0.380		-0.714	-0.178	-0.394	
	(0.392)		(0.485)	(0.424)	(0.392)	
dv_exp	0.299	0.346	-0.465	0.503	**0.679****	**0.706****
	(0.318)	(0.315)	(0.390)	(0.361)	**(0.321)**	**(0.323)**
Age	**0.029****	**0.025****	0.002	-0.005	0.009	0.004
	(0.012)	**(0.012)**	(0.014)	(0.012)	(0.010)	(0.011)
R&D effort	0.011	0.013	-0.039	0.030	-0.081	-0.069
	(0.048)	(0.048)	(0.100)	(0.054)	(0.124)	(0.116)
Dptrd	**-0.715****	**-0.770****	-0.035	-0.402	-0.148	-0.166
	(0.339)	**(0.337)**	(0.386)	(0.349)	(0.323)	(0.324)
Newprod	**0.999****	**0.901****	**1.175****	**1.202****	0.373	0.261
	(0.463)	**(0.455)**	**(0.597)**	**(0.557)**	(0.475)	(0.474)
Newprocess	1.178	0.682	0.143	1.413	0.184	-0.638
	(1.221)	(1.265)	(1.469)	(1.196)	(1.150)	(1.215)
Restech	**0.140****	**0.119****	**0.067***	-0.009	0.040	0.032
	(0.062)	**(0.058)**	**(0.035)**	(0.038)	(0.030)	(0.030)
Respers	**0.053***	0.041	**0.059****	**0.042***	0.042	0.039
	(0.030)	(0.030)	**(0.023)**	**(0.023)**	(0.026)	(0.030)
dv_tax	0.365	0.393	**1.540*****	0.366	-0.264	-0.194
	(0.439)	(0.437)	**(0.432)**	(0.414)	(0.401)	(0.409)
dv_sub	**0.686****	**0.521***	0.247	0.558	**0.515***	0.403
	(0.308)	**(0.300)**	(0.376)	(0.350)	**(0.309)**	(0.311)
Sector_ct		0.643				**0.997****
		(0.421)				**(0.391)**
Constant	-0.330	-0.477	**-1.764****	**-2.328*****	**-1.603*****	**-1.754*****
	(0.526)	(0.514)	**(0.691)**	**(0.680)**	**(0.571)**	**(0.570)**
Observations	227	227	227	227	227	227
Chi-squared	36.94	33.21	34.91	18.27	23.05	25.48
pseudo-R-squared	0.12	0.11	0.14	0.07	0.08	0.09

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10

Table 3. Multivariate probit model

VARIABLES	**dv_uni**	**dv_firm**	**dv_tc**
lworkers	-0.098	0.002	-0.009
	(0.081)	(0.075)	(0.073)
Serv_ht	**-0.921****	-0.468	**-0.683***
	(0.423)	(0.387)	**(0.383)**
Man_mht	-0.401	-0.110	-0.216
	(0.274)	(0.251)	(0.235)
Dv_exp	-0.248	0.301	**0.450****
	(0.222)	(0.214)	**(0.196)**
Age	0.002	-0.000	0.005
	(0.007)	(0.007)	(0.007)
R&D effort	-0.014	0.021	-0.034
	(0.045)	(0.031)	(0.056)
Dptrd	-0.021	-0.279	-0.102
	(0.222)	(0.205)	(0.195)
Newprod	**0.626***	**0.700****	0.208
	(0.335)	**(0.321)**	(0.288)
Newprocess	0.104	0.900	0.134
	(0.817)	(0.711)	(0.709)
Restech	**0.039***	-0.002	0.024
	(0.020)	(0.020)	(0.018)
Respers	**0.034****	**0.026***	0.027
	(0.014)	**(0.015)**	(0.016)
dv_tax	**0.925*****	0.201	-0.150
	(0.252)	(0.250)	(0.245)
dv_sub	0.141	**0.350***	**0.309***
	(0.214)	**(0.205)**	**(0.187)**
Constant	**-1.052*****	**-1.392*****	**-0.954*****
	(0.378)	**(0.377)**	**(0.341)**
Atrho21	0.138		
	(0.123)		
Atrho31		**0.335*****	
		(0.115)	
Atrho32			**0.380*****
			(0.130)
Observations	227	227	227
Chi-squared	61.20	61.20	61.20

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10. Likelihood ratio test of rho21 = rho31 = rho32 = 0: chi2(3) = 17.7698 Prob > chi2 = 0.0005.

Table 4. Tobit estimations

VARIABLES	**Uni**	**Firm**	**TC**
lworkers	-0.126	-0.004	-0.072
	(0.098)	(0.089)	(0.103)
Serv_ht	**-0.932***	-0.296	**-1.060***
	(0.514)	(0.472)	**(0.593)**
Man_mht	-0.505	0.147	-0.340
	(0.329)	(0.296)	(0.348)
dv_exp	**-0.487***	**0.502***	**0.601****
	(0.268)	**(0.265)**	**(0.300)**
Age	0.007	0.001	0.011
	(0.009)	(0.008)	(0.009)
R&D effort	-0.022	0.037	-0.049
	(0.060)	(0.036)	(0.085)
Dptrd	-0.102	-0.283	-0.248
	(0.260)	(0.249)	(0.288)
Newprod	0.591	**0.808****	0.227
	(0.398)	**(0.399)**	(0.422)
Newprocess	-0.446	**1.456***	0.321
	(1.017)	**(0.878)**	(1.056)
Restech	**0.036***	0.004	0.026
	(0.018)	(0.023)	(0.022)
Respers	**0.031****	0.018	**0.027***
	(0.014)	(0.013)	**(0.016)**
dv_tax	**1.101*****	0.171	-0.388
	(0.325)	(0.295)	(0.353)
dv_sub	0.148	0.332	0.433
	(0.252)	(0.248)	(0.278)
Constant	**-1.039****	**-1.829*****	**-1.071****
	(0.487)	**(0.527)**	**(0.529)**
Sigma	**1.239*****	**1.254*****	**1.562*****
	(0.190)	**(0.179)**	**(0.215)**
Observations	227	227	227
Chi-squared	31.93	17.53	19.10
pseudo-R-squared	0.11	0.05	0.05

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10

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