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What type of firm forges closer innovation linkages with Portuguese Universities?

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resumo

Utilizando dados baseados num inquérito extensivo às empresas localizadas em Portugal, analisamos quais as características das empresas que estão associadas ao estabelecimento de contactos com as universidades. Embora cerca de metade das empresas inquiridas afirmem que terão mantido algum tipo de contacto com as universidades no período 2001-2003, poucas (22%) consideraram as universidades como uma fonte importante de conhecimento e informação para as suas actividades de inovação. A nossa análise indica que a propensão das empresas em manterem ligações com as universidades é explicada pelas respectivas características, padrões regionais e sectoriais. Um resultado não ambíguo e estatisticamente robusto é que a proximidade é importante nas ligações entre empresa e universidade – as nossas estimativas revelam que as empresas têm maior probabilidade de contactar as universidades localizadas na sua vizinhança.

résumé / abstract

En utilisant des données d'une enquête aux entreprises localisées au Portugal, nous analysons les relations entreprises/université pour identifier les caractéristiques des sociétés qui maintiennent des relations avec l'université. Quoique presque la moitié des entreprises enquêtées affirment qu'elles ont eu des contacts avec les universités dans la période 2001-2003, seulement 22% considèrent les universités comme une source importante de connaissance et d'informations pour leurs activités d'innovation.

Notre analyse indique que la propension des entreprises au maintien de liaisons avec les universités est expliquée par les caractéristiques des sociétés et par des facteurs régionaux et sectoriels. Un résultat non ambigu et statistiquement robuste de notre analyse est que la proximité est importante pour les relations entreprises/université – nos estimations révèlent que les sociétés ont une plus grande probabilité de contacter les universités localisées dans leur voisinage.

Using large-scale survey data for firms located in Portugal, we analyze which firm characteristics are conducive to establishing contacts with universities. Although almost half of the firms surveyed stated they had established some contacts with universities in the period 2001-2003, only a few (22%) consider universities an important source of knowledge and information for their innovation activities. Our analysis indicates that the firms' propensity to draw on each of the Portuguese universities is explained by the characteristics of the different firms and their regional and industrial patterns. An unambiguous and statistically robust finding is that proximity matters highly in firms-universities linkages – our estimations reveal that firms are more likely to contacts universities located nearby.

JEL Codes: O38; C25

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1. Introduction

The importance of the traditional university is well documented in the literature (Geiger, 1993; Bok, 2003). Their primary mission is to engage in research and disseminate knowledge across both academic and student communities. They also contribute indirectly to technology transfer activities by providing highly educated and qualified personnel to industry (Carayannis *et al.*, 1998). According to Segal (1986), these universities not only provide a source of technical expertise for faculty members, but their students also acquire a wealth of codified and tacit knowledge through learning and living at the university.

While universities have a long-standing role in the system of innovation, it has nevertheless changed. The new role of universities as engines of local economic development (Feller, 1990) or magic beanstalks of invention and research (Miner *et al.*, 2001) places new demands on universities and raises question about the role of research universities in advanced economies. Many universities have restructured their research capabilities to be more responsive to local industry (Bercovitz and Feldmann, 2006) by, for example, setting up specialized research units, joint cooperative ventures or interdisciplinary projects that are more receptive to industrial needs. These specialized units may focus on revitalizing existing industries. In transferring technology, universities contribute to the stock of technologies that firms may draw on for innovation and economic growth.

Some however have raised the concern that universities are being asked to deviate from an historically successful role and that increased commercial influences may destroy the norms of open science that have promoted the national interest (Nelson, 2001). These same concerns may be raised at the regional level. Universities certainly add more to their local economies than the metrics of technology transfer are able to capture (Huffman and Quigley, 2002; Feldman and Desrochers, 2003). There are certainly many different modes of how universities interact with and enrich their local economies than by simply counting technology transfer indicators (LERU, 2006).

Firms should therefore be interested in forging links, perhaps even in collaborating with universities in order to capture timely new technological opportunities stemming from basic research (Mohnen and Hoareauc, 2003). Indeed, proximity to basic science is reported by Cohen (1995) to be one of the main determinants of innovation. Governments in their quest to maximize the social return of innovation should also be concerned with fostering such links between private firms and universities. Not all firms, though, are ready to seek such links and to be able to benefit from them (Veugelers and Cassiman, 2005). It would be interesting to know what profile of firm it takes, for instance, size, age, export and R&D intensity, foreign ownership, human capital (skill and education intensity), openness behaviour, region and industry, to seek close contacts and collaborate with centers of basic research.

The discussion of university-industry relationships, which entered the policy arena in the early 1980s, has become the property of both academics and the general public. An enormous number of contributions to academic writings and articles in the business and public press have come from policy makers in the last few years in a bid to explain, justify and regulate the interactions between universities and firms (Fontana *et al.*, 2004). At the European level, very few of these works have been supported by systematic data analysis. A large number of works have studied university-industry relationships from a qualitative point of view or by relying on a case study of a single university (Faulkner and Senker, 1995; Geuna *et al.*, 2004).

Using a large-scale database of firms located in Portugal, we aim to contribute to a better understanding of the quality and extent of firm-university links by examining the firms' propensity to establish (formal) contacts with universities. Similar studies in terms of the scope of analysis (e.g. Mohnen and Hoareauc, 2003) focus on the linkages between firms and universities considering this latter as an aggregate, homogenous entity. The present study overcomes such

limitation by econometrically evaluating the quality and extension of firm-university contacts with *all* and *each* of the Portuguese universities.

The paper is structured as follows. In the next section, a systematisation of the importance of Universities for firms learning and innovation is undertaken. In Section 3, we present some descriptive results regarding the contacts between firms located in Portugal and Universities. In the following section, the determinants of the firms' propensity to contact all and each of the Portuguese Universities is assessed using logit estimations. Finally, in Section 5 we conclude the study by highlighting the main results.

2. The importance of Universities in learning and innovation in firms

While universities have long served as a source of technological advances for industry, university-industry collaboration has intensified in recent years due to four interrelated factors (Bercovitz and Feldmann, 2006): the development of new, high-opportunity technology platforms such as computer science, molecular biology and material science; the more general growing scientific and technical content of all types of industrial production; the need for new sources of funding for academic research brought on by severe budgetary restrictions; and the prominence of government policies aimed at raising the economic returns of publicly funded research by stimulating university technology-transfer (Geuna, 1998).

However, technology-transfer is challenging as private firms and research universities have profoundly different missions and often display mutual distrust (Slaughter and Leslie, 1997). While universities are often regarded as holding important assets that could be leveraged for economic development, the presence of a local university may be necessary, but not sufficient, to guarantee that knowledge-based economic development takes place (Bercovitz and Feldmann, 2006).

Universities themselves are complex bureaucracies with their own rules, rewards and incentive structures (Clark, 2003). Moreover, in contrast to commercial firms with a relatively simple profit motive, universities have complex objective functions that involve a variety of educational and societal objectives as well as the interests of faculty members and the broader scientific community (Etzkowitz *et al.*, 2000).

The universities' relationships with firms are formed through a series of sequential transactions such as sponsored research and licenses (Mowery and Ziedonis, 1999; Siegel *et al.*, 1999; Feldman *et al.*, 2002; Thursby and Kemp, 2002), spin-off firms and the hiring of students. The core elements in university-industry relationships are transactions that occur through the mechanisms of sponsored research support (including participation and sponsorship of research centres), agreements to license university intellectual property, the hiring of research students, and new start-up firms.

Several macro-economic studies have indicated the importance of basic, scientific, research for technology, innovation and economic growth of nations (e.g. Griliches, 1998; Jaffe, 1989; Adams, 1990; Rosenberg and Nelson, 1994; Mansfield, 1995; Cohen *et al.*, 2002). At the micro level the technology management literature documents, mainly on the basis of specific case studies and detailed surveys at the firm-level, how scientific knowledge feeds into successful innovations (e.g. Allen, 1977; Tushman and Katz, 1980). Linking scientific knowledge is especially important for firms innovating in the fast developing technologies like biotechnology, information technology and new materials (Mowery, 1998; Zucker *et al.*, 1998; Cockburn and Henderson, 2000; Costa and Teixeira, 2005).

Especially in Europe, there seems to be a gap between high scientific performance on the one hand and industrial competitiveness on the other hand. This gap, mainly attributed to low levels of Industry Science Links, is known as the "European paradox" (EC, 2000). The evidence from the Community Innovation Survey for the EU shows that only a small fraction of innovative enterprises use science, i.e. universities and public research laboratories, as an important

information source in their innovation process – in the latest Eurostat-Community Innovation Survey CIS-III (1999-2000), of all reporting innovative EU firms (excl UK) 4.5% rated universities as important sources of information, while 68% indicated universities as not important at all (Veugelers and Cassiman, 2005). Furthermore, the survey shows that in 2000 less than 10% of innovative firms had cooperative agreements with universities. Similarly, Hall *et al.* (2001) report that in the United States the vast majority of research partnerships registered under the National Cooperative Research and Production Act do not include a university. Although the trend is increasing, only a modest 15% of all research partnerships involved a university.

There are few studies that consider the firm, rather than the university, as the focal actor. Prior research demonstrates significant variation in the firms' use of external resources (Laursen and Salter, 2004), organization of inter-firm R&D activity, and objectives in inter-firm R&D strategic partnerships (Sakakibara, 1997). Although the broad literature on strategic R&D alliances (e.g., Narula, 1999; Hagedoorn *et al.*, 2000; Caloghirou *et al.*, 2003; Elmuti *et al.*, 2005) mentions the importance of firm – university alliances, it does not specifically focus on the unique aspects of universities as research partners. As such, we have only a limited understanding of how university interactions fit within the firm's broader R&D strategy — and how firm strategy and organizational structure influence both the technology-transfer mechanisms employed by the firm and the relationship the firm ultimately maintains with the university.

Previous research has shown, however, that linking with external entities is a key element in successfully exploring strategies that emphasize the search for, discovery and development of new knowledge (March, 1991; Cockburn and Henderson, 1994; Von Hippel, 1998; Rosenkopf and Nerkar, 2001). Specifically, such interactions give the firm access to knowledge that differs from, but can complement, the firm's existing technology portfolio. It is the integration of this new knowledge that leads to path-breaking innovation. Academic researchers perform a great deal of cutting-edge research and universities are known sources of new knowledge (Rosenberg and Nelson, 1994). As such, we expect that pursuing university interactions to tap into such expertise is likely to be more highly valued by firms with innovation strategies that emphasize exploration rather than exploitation — the refinement, extension, and intelligent use of existing competencies (March, 1991; Levinthal and March, 1993).

What increases the propensity of firms to draw upon public research in general and universities in particular? In a regression analysis, Cohen *et al.* (2002) take size and age of the firm as the two explanatory variables. Larger firms and start-ups have a higher probability of benefiting from academic research.

Other studies (Schartinger *et al.*, 2001; Arundel and Geuna 2004) incorporate additional explanatory variables, such as level of R&D expenditure, degree of firms' innovativeness. A more recent study (Laursen and Salter, 2004) introduced the concept of 'open' search strategies of firms into this literature. Accordingly, search strategies play a central role in determining innovative performance (e.g., Katila and Ahuja, 2002). Laursen and Salter (2004) provide a proxy for assessing the degree to which the firm seeks to draw in new knowledge and to re-use that is, openness of a firm's search activities. The constructed variable is based on the number of different sources of external knowledge (e.g., clients, suppliers) that each firm draws upon in its innovative activities. Implicitly, it is assumed that the higher the number of external knowledge sources that a firm draws upon the more "open" it is its search strategy. With this variable the authors seek to introduce a degree of managerial choice into the debate about university–industry links. In this context, it is hypothesised that firms that adopt open search strategies have a higher probability of considering the knowledge produced by universities as important for their innovation activities.

As referred in the introductory part of the present paper, very few studies within firm-university linkages have been supported by systematic data analysis. The vast majority have studied such linkages from a qualitative point of view or by relying on case studies. Additionally, these studies tend to consider all universities in aggregate without distinguish the different type of universities

that exist in a given country, namely those that are more 'entrepreneurial led' from those more 'classical'.

In the next section we present descriptive and econometric analysis which permit to evaluate the quality and extension of firm-university contacts with *all* and *each* of the Portuguese universities. Moreover, we introduce in the econometric specification additional variables likely to explain the propensity of firms contacting universities, namely human capital and R&D intensity, which tend to reflect firms' absorption capabilities, and other firm structural variables, in concrete export intensity and foreign ownership. It is important to note that although in the descriptive part (Section 3.2) we refer to *all types* of contacts, including both formal and informal, in the estimation part (Section 4) only *formal* contacts (Protocols, partnerships, and projects; Consulting activities; Training provision for final year undergraduates; Seminars, conferences, publication, and alike) are taken into account as a non-negligible amount of firms could not precise the amount of informal contacts established with universities for the period in analysis. Informal contacts tend to be especially relevant when firms seek to access local tacit knowledge as they are based on personal contacts where social factors probably matter (Kallsen and Tornquist, 1994; Arundel and Geuna, 2004).

3. Contacts between firms located in Portugal and Universities. Some descriptive results

3.1 Methodology and the representativeness of the data

The empirical analysis is based on a direct survey to all (2852) firms located in Portugal listed in 24 Portuguese entrepreneurial associations covering all economic activities[1].

The questionnaire was implemented through telephone and fax contacts to all firms from the above mentioned list. The results provided in the present paper are based on the amount (1538) of valid questionnaires gathered from October 2004 up to the end of December 2005, reflecting a remarkable response rate (53.9%), well above several firm related surveys, some of which are compulsory – for instance, in the CIS III, the response rate was 45.8% in the case of Portugal (Bóia, 2003), and 41.7% for the U.K. (Stockdale, 2002).

When compared to the population, our respondent sample presents a relative bias towards manufacturing industry, particularly in industries such as 'Food products, beverage and tobacco' (7.9% of total respondents versus 1.6% of the total population), 'Textiles and leather' (8.6% versus 3.7%), and 'Coke and chemicals' (4.2% versus 0.2%). It is underrepresented in 'Electricity, gas and water supply, construction' (4.9% of total respondents versus 17.0% of the total population) and 'Wholesale and retail' (33.8% versus 52.1%).

In regional terms, our sample has a bias towards the Northern (37.2% of total respondents versus 31.3% of the total population) and the Lisbon and Tagus Valley (38.1% of total respondents versus 28.9% of the total population) regions, and presents a relatively poor coverage for regions such as the Alentejo, Algarve and Islands.

1 AECOPS – Assoc. Emp. Const. Civil e Obras Públicas; AEP – Associação Empresarial de Portugal – Indústria; comércio por grosso e a retalho; AFIA – Assoc. dos Fabricantes p/ a Ind. Automóvel; AIC – Assoc. Industrial de Cristalaria; AIMC – Assocação dos Industriais de Madeira do Centro; AIVE – Assoc. dos Industriais de Vidro para Embalagem; ANETIE – Assoc. Nac. das Emp. das Tecnologias de Informação e Electrónica; ANICP – Assoc. Nacional das Indústrias de Conservas de Peixe; ANIL – Assoc. Nac. Ind. de Lanifícios; ANIL – Assoc. Nacional dos Industriais de Lacticínios; ANIMEE – Assoc. Nac. dos Ind. de Material Eléctrico e Electrónico; ANIVE. – Associação Nacional das Ind. de Vestuário e Confecção; APCOR – Assoc. Port. dos Ind. de Cortiça; APIAM – Associação Port. dos Industriais de Águas Minerais Naturais e de Nascente; APIC – Assoc. Port. Ind. de Cortumes; APIEE – Asso. Port. dos Ind. de Engenharia Energética; APIFARMA – Associação Portuguesa da Indústria Farmacêutica; APIP – Assoc. Portuguesa da Indústria de Plásticos; Associação dos Industriais de Colas; Associação dos Indust. Port. de Iluminação; CEFAMOL – Associação Nacional da Ind. de Moldes; CELPA – Assoc. da Indústria Papeleira; TAGUSPARK; Markelink.

Table 1 – Characteristics of the respondent firms located in Portugal – industrial and regional distribution (%) compared to the population

	Population (INE, 2003)	Respondent sample (n=1538)
Industry		
Mining and quarrying	0.2	0.8
Food products, beverage and tobacco	1.6	7.9
Textiles and leather	3.7	8.6
Wood, pulp and publishing	2.4	3.0
Coke and chemicals	0.2	4.2
Rubber and other non-metallic	1.1	3.9
Basic metals and fabricated metal products	2.6	4.3
Machinery and equipment NEC	0.7	2.7
Electrical and optical equipment	0.3	3.4
Transport equipment	0.1	2.2
Manufacturing NEC and recycling	1.7	4.0
Electricity, gas and water supply, construction	17.0	4.9
Wholesale and retail	52.1	33.8
Transport and storage	4.3	4.1
Post and telecommunications, financial intermediation	2.7	1.8
Computer and related activities	0.5	3.6
Research and development & eng services	8.0	4.7
Social services and non-profit associations	0.9	2.0
Regions (NUTs II)		
North	31.3	37.2
Centre	22.5	19.5
Lisbon and Tagus Valley	28.9	38.1
Alentejo	7.9	2.3
Algarve	5.4	1.6
Islands (Madeira and the Azores)	4.0	1.3

Source: Authors' computation based on direct survey, October 2004-December 2005.

3.2. Database general description – firms' structural characteristics

Respondent firms have reasonable experience in business (on average, they have been in activity for 25.9 years), are of medium-to-small sized, employ on average 139 workers, are in their majority (87.3%) nationally owned and relatively inward oriented (they export on average 17.3% of their sales). Around 21.9% of the firms' total workforce has 12 or more years of

education and the percentage of engineers in the total workforce is 7.9%; the ratio of R&D on sales reaches a figure of 2.2%.

Similarly to Laursen and Salter (2004), the information and knowledge sources for innovation activities were assembly into six different items – internal, institutional, market – business networks, sector information, specialized information and other. In a Likert-scale, 0-1-2-3-4-5 (with 0 indicating that the firm does not used the listed source), firms indicated the degree of importance (1: low; 5: extremely important) of the listed source for their innovation activities. The distribution of firms (in percentage of the total number), according to the importance that they attributed to the listed sources is presented in Table 2. Following 'Internal', with 89.1%, 'Specialized information' includes the sources, namely 'Health and hygiene legislation' and 'Environmental norms and legislation', considered as highly important for more than eighty per cent of the respondent firms.

The number of firms which claim to draw from Universities in their innovative activities is quite high (75.4%). Nevertheless, it is still well below the scores for "business-networks" (88.7%) and "specialized information" (95.2%) sources. Despite this high percentage of firms, 'only' 21.5% of the firms indicate that the knowledge they draw from Universities is highly important – recall that this percentage is well below the figure (42.8%) that technology-based firms located in Portugal indicated (Costa and Teixeira, 2005). Nevertheless, among 'Institutional Sources', Universities are the most highly ranked source for the firms' innovation activities.

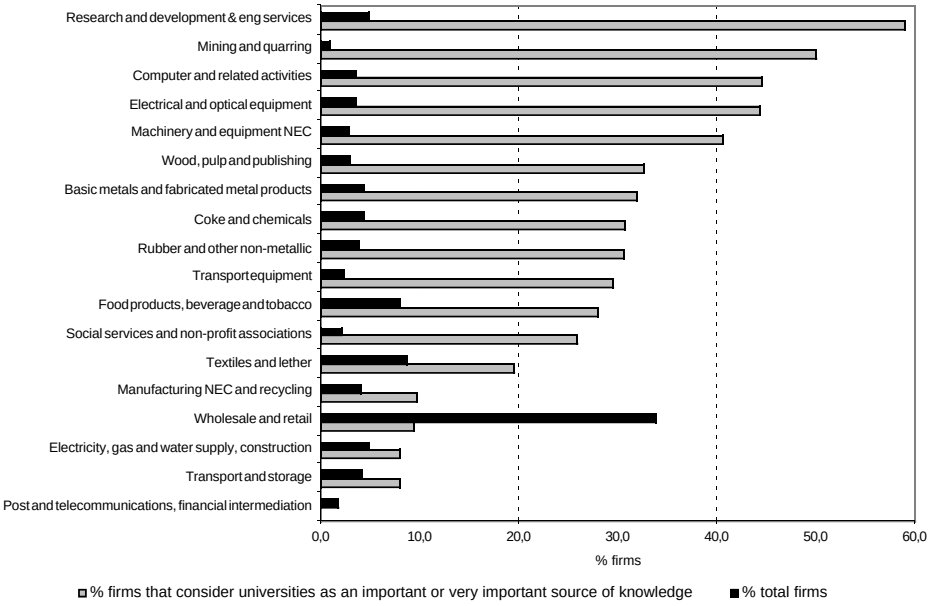
Table 2 – Characteristics of the respondent firms located in Portugal – industrial and regional distribution (%) compared to the population

Type	Source	% of firms			
		Not used	Low or very low	Medium	High and very high
Internal	Within the firm	0.1	0.5	10.3	89.1
Institutional	**Universities**	**24.6**	**37.9**	**16.0**	**21.5**
	Public R&D institutes	19.4	50.4	21.0	9.2
	Other governmental entities	19.7	59.2	15.2	5.9
	Private R&D institutes	25.4	33.6	24.8	16.1
Business networks	Clients	0.6	15.3	36.3	47.8
	Equipment suppliers	7.5	42.2	25.7	24.6
	Competitors	1.7	17.1	38.9	42.3
	Consultants	14.4	26.2	23.4	36.0
	R&D labs and firms	32.3	23.6	26.6	17.4
Sector information	Sector conferences and meetings	12.2	42.9	28.7	16.2
	Trade associations	6.3	51.0	31.6	11.1
	Technical and sector literature	18.0	26.3	18.5	37.2
	Fairs and events	7.2	17.1	21.6	54.2
Specialized information	Technical standards and norms	12.8	14.3	11.7	61.3
	Health and hygiene legislation	0.8	3.5	11.1	84.6
	Environment norms and legislation	0.7	3.4	9.6	86.3

Source: Authors' computation based on direct survey, October 2004-December 2005.

The importance attributed to universities as a source of knowledge and information for innovation activities varies considerably according to the industry. As we can see from Figure 1, in industries such as 'Research and Development & Engineering Services', and 'Mining and Quarrying', more than half of firms consider universities as a very important source for innovation-related activities. In contrast, over three quarters of the respondent firms belonging to industries such as 'Transport and Storage', 'Post and Telecommunications, Financial Intermediation', 'Manufacturing NEC and Recycling', and 'Electricity, Gas and Water Supply, Construction' claimed they did not use universities, or that they were not important, as a source of information and knowledge in innovation activities.

Figure 1 – Importance of Universities for innovation-related information and knowledge sources for firms located in Portugal by industry



Source: Authors' computation based on direct survey, October 2004-December 2005.

Through a simple descriptive analysis we find that both large and very large firm categories (employing 250 or more employees) are those that encompass a larger percentage of firms attributing high importance to universities as a source of innovation-related information and knowledge. Moreover, start-up (firms with 10 or less years in business) and non start-up firms seem to value universities similarly. In comparison to foreign-owned firms, the nationally-owned seem to draw much less on universities for their innovative activities (73.2% versus 90.7%, respectively, claim to use universities as sources of information for their innovation activities). Foreign-owned firms seem to attribute more importance to universities in this regard. Finally, around one quarter of firms located in the Northern and Central regions claimed that universities are an important or very important source of information and knowledge for their innovation-related activities. This contrast with the small importance attributed by firms located in the Alentejo and Islands.

Table 3 – Importance of Universities as a source of innovation-related information and knowledge for firms located in Portugal according to firm traits

	% of firms				
	Not used	Low or very low	Medium	High and very high	No. Firms (%Total)
Size (no. employees)					
Micro [1,10[	41,8	32,2	11,4	14,7	273 (17.8%)
Small [10, 50[	27,3	35,4	15,7	21,7	466 (30.4%)
Medium [50, 250[	19,1	41,8	17,7	21,4	593 (38.6%)
Large [250, 500[	11,2	37,3	17,9	33,6	134 (8.7%)
Very Large [500, …[	11,6	44,9	18,8	24,6	69 (4.5%)
Age (years in business)					
Start-ups (10 or less years)	27,5	34,1	16,8	21,6	334 (21.8%)
Non-start-ups	23,7	39,0	15,8	21,5	1201 (78.2%)
Capital ownership					
Nationally-owned	26,8	37,6	14,6	21,0	1341 (87.4%)
Foreign- owned	9,3	40,2	25,8	24,7	194 (12.6%)
Region					
North	24,5	37,8	14,7	23,1	572 (37.3%)
Centre	24,0	38,3	15,3	22,3	300 (19.5%)
Lisbon and Tagus Valley	24,0	36,9	18,7	20,4	583 (38.0%)
Alentejo	34,3	51,4	0,0	14,3	35 (2.3%)
Algarve	28,0	40,0	16,0	16,0	25 (1.6%)
Islands (Azores and Madeira)	29,8	40,1	14,7	15,4	20 (1.3%)
Total firms (average, %)	**24,6**	**37,9**	**16,0**	**21,5**	**100**
No. Firms	377	582	246	330	1535

Source: Authors' computation based on direct survey, October 2004-December 2005.

3.3. Database general description – contacts with universities

The oldest university, Universidade Coimbra, was created in the thirteen century receiving, with the implementation of the Republic in 1911, new legal status. Universidade de Lisboa and Universidade do Porto date back to the Republic period (1911). These three institutions are the most traditional and largest Portuguese universities (see Table 4). Although Porto university have always had a more technical and artistic tendency, the three mentioned universities are often regarded as the *'classical'* universities (Torgal, 2000).

During the late 1970s and the mid 1980s Portugal pursued a process of convergence that aimed at expanding and diversifying the tertiary system[2], especially by implementing the binary system (Universities and Polytechnics), promoting the private university system, and encouraging

2 Tertiary system includes all post-secondary education provided by universities, polytechnics, post-secondary colleges and other institutes.

institutional autonomy in the public sector (OECD, 2006). In the binary system the activities of universities would be teaching longer degrees, research and postgraduate education whereas the polytechnics would be devoted to shorter vocational degrees and professional training. This was regarded as a step towards more responsive higher education (Teixeira *et al.*, 2003).

With the Veiga Simão's reform (and the publication of the DL nº 402/73), the universities of Aveiro, Minho and Nova were created. Later, new public universities were established namely Algarve (1979), Açores (1980), and in the mid-eighties, Beira Interior (UBI), Madeira and Trás-os-Montes e Alto Douro (UTAD).

The Education System Act (Law 46/86) implemented in the mid-eighties defined the main objectives of higher education as teaching and research, cultural production and the development of entrepreneurial and scientific spirit and reflective thought (OECD, 1995). Here, the role of higher education institutions, namely universities, as providers of services to the outside community, particularly to industry was not however mentioned (OECD, 2006). Even though, within Portuguese public universities, Aveiro, Minho and Técnica Lisboa present a more industry-oriented perspective, with their 'mission statements' explicitly mentioning the aim of

Table 4 – Public Portuguese Universities plus Universidade Católica Portuguesa – students enrolled and year of foundation

University Profile	University	Student Enrolled 2005/2006	Year of foundation
Entrepreneurial-led	Universidade Aveiro	8902	1973
	Universidade Católica Portuguesa – Porto (1)	4200	1978
	Universidade Minho	15130	1973
	Universidade Técnica Lisboa	21708	1930
Classical	Universidade Coimbra	19890	1290 (1911*)
	Universidade Lisboa	18147	1911
	Universidade Porto	25370	1911
Research-led	Universidade Católica Portuguesa – Lisboa (1)	5354	1967 (1971*)
	Universidade Nova Lisboa	14677	1973
Regional-led	Universidade Algarve	3818	1979
	Universidade Beira Interior	5350	1986
	Universidade Évora	7500	1537
Not discriminated (included in 'others')	Universidade Aberta (2)	9171	1988
	Universidade Açores	2520	1980
	ISCTE – Instituto Superior Ciências Trabalho e Empresa	6000(3)	1972 (1990(4))
	Universidade Madeira	2551	1986
	Universidade de Trás-os-Montes e Alto Douro	6599	1986

Source: OCES (2006), Alunos inscritos no ano lectivo de 2005-2006, OCES/MCTES in http://www.oces.mctes.pt/?id_categoria=21&id_item=149810&pasta=23; year of foundation gathered from universities web page.
Note: (1) Private University classified as an institution of public interest – the total students enrolled in its four centres (Braga, Lisboa, Porto and Viseu) is 10102; (2) Distance learning public university; (3) approximate value; (4) Public non-integrated university; * Legal status.

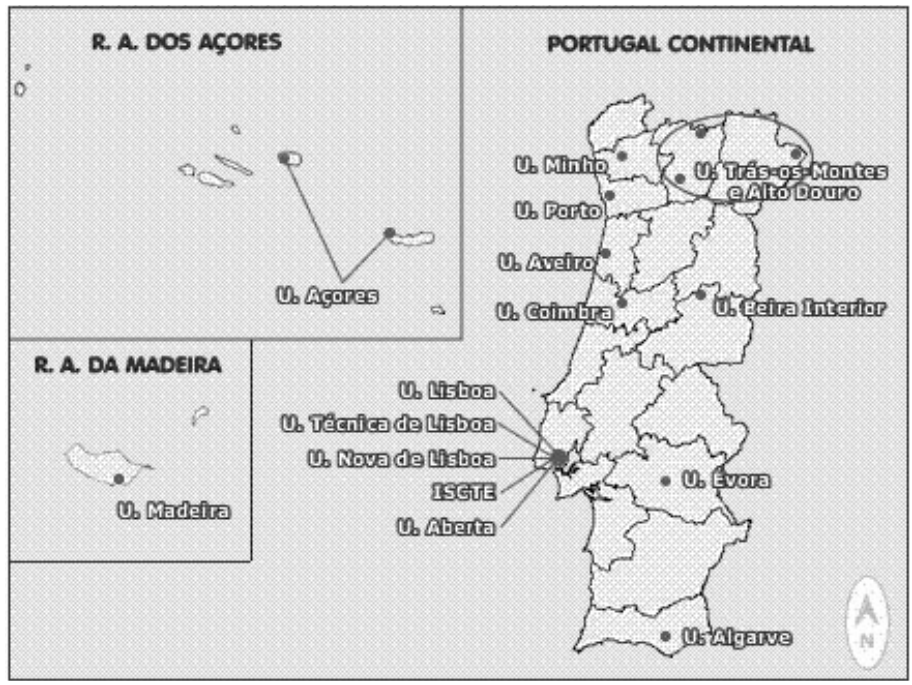
promoting university-firms linkages (Amorim, 2001). Etzkowitz (1983) has coined the phrase 'entrepreneurial universities' to describe the series of changes that reflect the more active role universities have taken in promoting direct and active transfer of academic research. In this vein, we might group these universities plus Universidade Católica Portuguesa (UCP) – Porto as *entrepreneurial-led universities*. This latter, one of the four regional centres of UCP, a private university with a public interest legal status, combines its educational function with a reasonable focus on business cooperation projects and services provision.

Universidade Nova Lisboa and (to a lesser extent) UCP-Lisboa are self-assumed[3] and increasingly acknowledged as *scientific-led* institutions. They put substantial emphasis on international scientific publication performance, being considerably oriented towards scientific knowledge development (Teixeira, 2006).

The youngest public universities – Algarve, Açores, UBI, Madeira, and UTAD – were created with an explicit government aim of promoting *regional development* (Torgal, 2002).

The next figure depicts the geographical distribution of the Portuguese public universities. Five out of the 15 public universities (including here also ISCTE) locate in the Lisbon area. Three universities, Minho, Porto and UTAD, belong to the North region sited respectively in the cities of Braga-Guimarães, Porto and Vila Real. In the Centre region are situated the universities of

Figure 2 – The location of Portuguese public universities



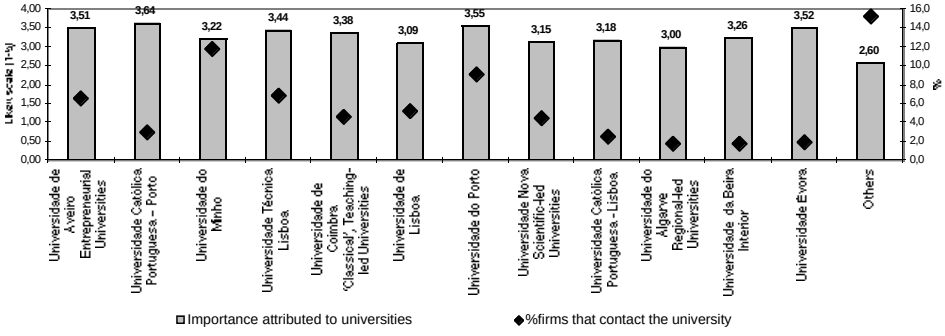
Source: Direcção Geral do Ensino Superior in http://www.pedagogicosensinosuperior.pt/PEDAGOGICO/REDE/Criação+de+Instituições/

3 See institutional presentation at these universities web pages (www.unl.pt/unl/nova and www.ucp.pt).

Aveiro, Coimbra and Beira Interior (Covilhã). University of Évora is situated in Alentejo whereas further south is located University of Algarve (Faro). Universidade Católica Portuguesa is geographically decentralized with two main sites, Porto and Lisbon. Finally, the universities of Açores and Madeira are situated in the islands, being the smallest (in terms of students enrolled) of the Portuguese public universities.

The University of Minho and University of Porto are the Portuguese universities with the highest amount of firms that claimed to have established some sort of contact (both informal and formal) with them during the period of 2001-2003, encompassing respectively 11.8% and 9.1% of total respondents. It is interesting to note that those firms that established some sort of contact with the University of Minho do not attribute as much importance to universities as a source of information and knowledge as those that established contacts with the University of Porto or that small minority which states to have contacts with the University of Algarve. Indeed, in a Likert scale (1- no or low importance … 5- extremely important), the University of Minho's corresponding average is 3.22 whereas the Universities of Porto's and Católica do Porto's are, respectively 3.55 and 3.64 (cf. Figure 3).

Figure 3 – Total contacts by university and the average relative importance attributed to universities as a source of information and knowledge by the corresponding firms



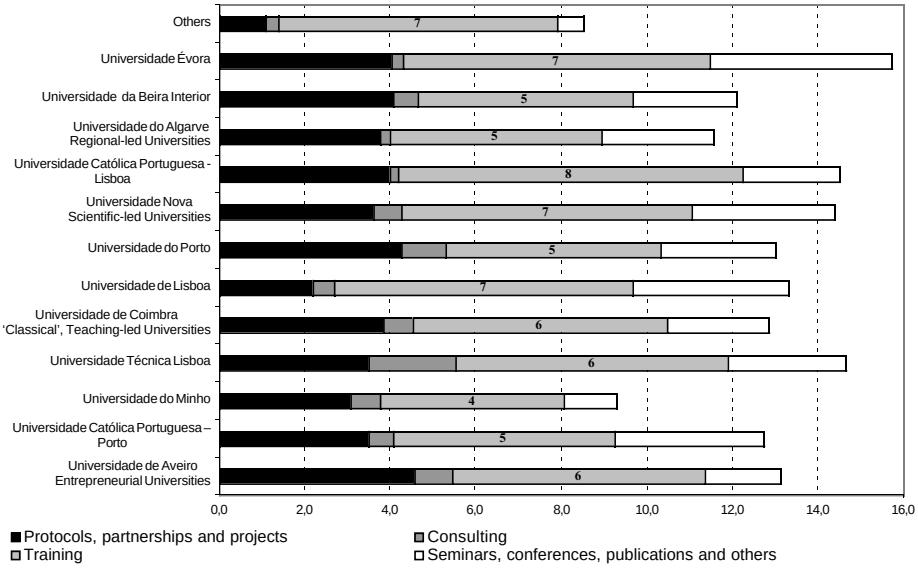
Source: Authors' computation based on direct survey, October 2004-December 2005.

Beside having been asked whether they had contacts with Universities, the firms were further inquired on the number and types – informal versus formal – of contacts that they had established with Universities in the three-year period in analysis (2001-2003). In relation to formal contacts, we divide them into four main groups (by decreasing order of commitment and knowledge content between firms and universities): Group 1 – Protocols, partnerships, and projects; Group 2 – Consulting activities; Group 3 – Training provision for final year undergraduates; Group 4 – Seminars, conferences, publication, and others.

Consulting activities are the least frequent type of formal contact (Figure 4). On average, firms that contacted in the period 2001-2003 the universities in analysis established 2 contacts of this type with the Técnica de Lisboa, and 1 with the Universities of Porto and Aveiro. This latter university is at the forefront of contacts involving Protocols, partnerships and projects with an average of almost five in the period under study. Summing up the most demanding type of contacts in terms of competencies and knowledge involved, that is, 'Protocols, partnerships, and projects' and 'Consulting', the Técnica de Lisboa, University of Aveiro, and University of Porto are the better positioned with an average of around five contacts per firm in the 2001-2003 period. We could thus assume that firms seem to recognize in these universities valid competencies, seeing them as important sources of knowledge for their innovative activities.

The most frequent type of contacts between firms located in Portugal and universities is training of final year undergraduates. To a great extent, firms located in Portugal are used as a locus for the first job market experience of future graduates – several even acknowledge that this type of contact is a one-way relation where universities/students have a more active role in searching for and maintaining this type of contact. The Católica (Lisboa), Évora, Lisboa, and Nova Universities seem to be the most active ones with an average of 7-8 training contacts from firms in 2001-2003.

Figure 4 – Type of formal contacts (average number) by university



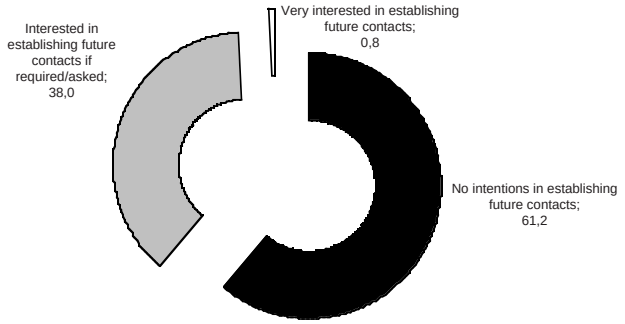
Source: Authors' computation based on direct survey, October 2004-December 2005.

In the least demanding type of contacts – attending seminars, conferences or reading/consulting publications – the Évora, Lisboa and Católica (Porto) Universities present the highest average, with approximately 4 contacts per firm in the period 2001-2003.

A truly disturbing finding is that although around 47% of the respondent firms state they had established (formal and informal) contacts with universities in the period 2001-2003, when asked whether they would be interested in establishing future contacts with these institutions, 61.2% claimed that they have no intentions in this respect and 38.0% revealed a moderate interest as they declared that they would establish contacts only if requested. Only 12 firms out of the 1521 that answered this question maintained they were highly interested in establishing future contacts with universities.

Such a disheartened scenario may reflect several issues. First, that firms located in Portugal do not consider (as expressed in Table 2) universities as critical sources of knowledge and information for their innovative activities, so they do not contact them at the outset. Second, having contacted universities, firms became disappointed with the outcomes of this relationship and realized that contacts were fruitless. Third, this situation may indicate relatively low innovative dynamics in firms located in Portugal, or at least some shortage of innovative dynamics requiring more fundamental and basic scientific knowledge.

Figure 5 – Interest in future contacts with universities (% total respondent firms)



Source: Authors' computation based on direct survey, October 2004-December 2005.

4. Determinants of the firms' propensity to contact *all* and *each* of the Portuguese Universities. An econometric analysis

4.1. Econometric specification and description of the variables

The aim here is to assess which are the main determinants of the firms' propensity to contact universities. The nature of the data observed relative to the dependent variable [Have contacted? (1) Yes; (0) No] dictates the choice of the estimation model. Conventional estimation techniques (e.g., multiple regression analysis), in the context of a discrete dependent variable, are not a valid option. First, the assumptions needed for hypothesis testing in conventional regression analysis are necessarily violated – it is unreasonable to assume, for instance, that the distribution of errors is normal. Second, in multiple regression analysis predicted values cannot be interpreted as probabilities – they are not constrained to fall in the interval between 0 and 1[4]. The approach used, therefore, will be to analyze each situation in the general framework of probabilistic models.

Prob (event j occurs) = Prob (Y = j) = F[relevant effects: parameters].

According to the literature (*cf.* Section 2) there are a set of factors, such as the firm's structural characteristics (age, size, export and R&D intensity, and foreign ownership), human capital intensity (firms' average skills and education), strategic firm traits such as openness to drawing on different sources of knowledge and information in their innovation activities, regional location and industry, gathered on a vector X, which might potentially explain the outcome, so that

$\Pr ob(Y = 1) = F(X,\beta)$ *and* $\Pr ob(Y = 0) = 1 - F(X,\beta)$.

The set of β parameters reflects the impact of changes in X on the likelihood of 'contacting'. The problem at this point is to devise a suitable model for the right-hand side of the equation. The requirement is for a model that will produce predictions that are consistent with the underlying theory. For a given vector of regressors, one would expect

$\lim_{\beta' X \to +\infty} \Pr ob(Y = 1) = 1$ *and* $\lim_{\beta' X \to +\infty} \Pr ob(Y = 1) = 0.$

4 The logistic regression model is also preferred to another conventional estimation technique, discriminant analysis. According to Hosmer and Lemeshow (1989), even when the assumptions required for discriminant analysis are satisfied, logistic regression still performs well.

Partly because of its mathematical convenience, the logistic distribution, $\Pr ob(Y=1) = \frac{1}{1+e^{-\beta' X}}$, has been used in many applications (Greene, 2000). Rearranged in terms of the log odds[5], this expression is the so-called *logit* model.
The probability model is a regression of the following kind:

$E(Y \setminus X) = 0[1 - F(\beta' X)]+1[F(\beta' X)] = F(\beta' X)$.

Whatever distribution is used, it is important to note that parameters of the model, like those of any non-linear regression model, are not necessarily the marginal effects.

In general, $\frac{\partial E(Y \setminus X)}{\partial X} = \frac{dF(\beta' X)}{d(\beta' X)} \beta = f(\beta' X)\beta$, where $f(.)$ is the density function that

corresponds to the cumulative distribution, $F(.)$.

For the logistic distribution, $\frac{d\Lambda(\beta' X)}{d(\beta' X)} = \frac{e^{\beta' X}}{(1+ e^{\beta' X})^2} = \Lambda(\beta' X)[1 - \Lambda(\beta' X)]$

Thus, in the *logit* model, $\frac{\partial E[Y \ X]}{\partial X} = \Lambda(\beta' X)[1 - \Lambda(\beta' X)]\beta$.

It is obvious that these values will vary with the values of X. In interpreting the estimated model, it would be useful to calculate this value at, say, the means of the regressors and, where necessary, other pertinent values. In the logistic regression, the parameters of the model are estimated using the maximum-likelihood method (ML). That is, the coefficients that make observed results most "likely" are selected, given the assumptions made about the error distribution.

The empirical assessment of the propensity to contact is based on the estimation of the following general logistic regression:

$$P(ContactUniv) = \frac{1}{1 + e^{-Z}}; \text{ with } Z = \underbrace{\beta_0 + \beta_1 Age + \beta_2 Size + \beta_3 ExpInt + \beta_4 R\ \&\ DInt + \beta_5 FOwnership}_{} + \underbrace{+ \beta_6 SkillInt + \beta_7 EducInt}_{} + \beta_8 Openness + \beta_4 \textbf{Region} + \beta_{10} \textbf{Industry} + \varepsilon_t$$

In order to have a more straightforward interpretation of the logistic coefficients, it is convenient to consider a rearrangement of the equation for the logistic model, in which the logistic model is rewritten in terms of the odds of an event occurring.

Writing the logistic model in terms of the odds, we obtain the *logit* model

$$\log\left(\frac{\Pr ob(ContactUniv)}{\Pr ob(Not\ ContactUniv)}\right) = \underbrace{\beta_0 + \beta_1 Age + \beta_2 Size + \beta_3 ExpInt + \beta_4 R\ \&\ DInt + \beta_5 FOwnership}_{} + \underbrace{+ \beta_6 SkillInt + \beta_7 EducInt}_{} + \beta_8 Openness + \beta_4 \textbf{Region} + \beta_{10} \textbf{Industry} + \varepsilon_t$$

The logistic coefficient can be interpreted as the change in the log odds associated with a one-unit change in the independent variable. Then, e raised to the power β_i is the factor by which the odds change when the i^{th} independent variable increases by one unit. If b_i is positive, this factor

5 The odds of an event occurring are defined as the ratio of the probability that it will occur to the probability that it will not.

will be greater than 1, which means that the odds are increased; if β_i is negative, the factor will be less than one, which means that the odds are decreased. When β_i is 0, the factor equals 1, which leaves the odds unchanged. In the case where the estimate of β_1 emerges as positive and significant for the conventional levels of statistical significance (that is, 1%, 5% or 10%), this means that, on average, all other factors being held constant, firms that are in business for a longer time have higher (log) odds of contacting universities.

The estimates of the βs are given in Table 6 below. In this table we present 13 different models. The first model ('All Univ') illustrates the estimated econometric specification relative to the firms' propensity to establish formal contacts with (*all*) universities. The remaining 12 models pertain to the propensity of firms located in Portugal to establish formal contacts with *each* Portuguese university.

In Table 5 some descriptive statistics of the variables involved in the estimation procedure as well their bivariate linear correlations estimates are presented. Around 46% of the firms surveyed claimed to have had formal contacts with universities in the period 2001-2003. These firms present an average age of approximately 26 years and an average size of 139 workers. Note that the youngest firm has been in business for one year whereas the oldest has been in business for almost three centuries (276 years). In terms of size, the smallest employs one worker whereas the

Table 5 – Descriptive statistics

		Mean	σ	Min	Max	1	2	3
	Formal contacts	0.458	0.498	0	1.00	0.089***	0.133***	0.219***
Structural firm characteristics	(1) Age	25.9	21.12	1	276	1	0.142***	0.079***
	(2) Size	139.1	360.65	1	6582		1	0.136***
	(3) Export Intensity	0.173	0.304	0	1.00			1
	(4) R&D Intensity	0.022	0.075	0	1.00			
	(5) Foreign ownership	0.127	0.334	0	1.00			
Human Capital	(6) Skill intensity	0.079	0.162	0	1.00			
	(7) Education intensity	0.219	0.256	0	1.00			
Strategic firm trait	(8) Openness (ln)	2.629	0.248	0	2.77			

Table 5 – Descriptive statistics (cont.)

		4	5	6	7	8
	Formal contacts	0.193***	0.193***	0.062**	0.151***	0.313***
Structural firm characteristics	(1) Age	-0.100***	-0.100***	0.014	-0.129***	0.042
	(2) Size	-0.059**	-0.059**	0.124***	-0.041	0.104***
	(3) Export Intensity	-0.058**	-0.058**	0.067***	-0.065**	0.221***
	(4) R&D Intensity	1	1	-0.056**	0.168***	0.070***
	(5) Foreign ownership			1	0.268***	0.128***
Human Capital	(6) Skill intensity				0.122***	0.156***
	(7) Education intensity				1	0.237***
Strategic firm trait	(8) Openness (ln)					1

Table 6 – Determinants of the firms' propensity to establish (formal) contacts with Portuguese Universities (ML estimation)

		All Univ.	U. Algarve	U. Aveiro	UBI
Structural firm characteristics	Age (ln)	0,08	-0,31	0,10	0,14
	Size (ln)	0,55***	0,48***	0,42***	0,38*
	Export Intensity	0,49*	0,38	-0,10	-0,95
	R&D Intensity	7,95***	2,32	2,64***	1,26
	Foreign ownership	-0,49***	-0,67	0,14	1,37**
Human Capital	Skill intensity	3,47***	1,80	3,26***	2,31
	Education intensity	1,27***	0,28	0,48	0,44
Strategic firm trait	Openness (ln)	1.81***	2,19	0.93	-0.19
Region	North	0,22	-0,61	0,93***	0,81
	Centre	0,53***	-0,33	2,31***	2,76***
	Alentejo	0.63	1,18	0,76	-15,87
	Algarve	1,78***	5,24***	-16,70	-14,65
	Islands	0,44	1,33	0,80	2,38
Industry	Mining and quarrying	1,09	-17,32	0,00	-16,36
	Food products, beverage and tobacco	0,60***	-0,05	-0,34	1,61**
	Textiles and leather	0,11	-17,26	-0,37	2,25**
	Wood, pulp and publishing	0,19	-17,16	1,36**	-15,97
	Coke and chemicals	0,71**	-0,04	0,08	1,77*
	Rubber and other non-metallic	0,85***	-0,58	-0,09	-17,01
	Basic metals and fabricated metal products	0,93***	-18,31	1,28***	0,07
	Machinery and equipment NEC	1,39***	0,52	1,05*	-16,45
	Electrical and optical equipment	0,46	-17,36	-0,22	-16,02
	Transport equipment	0,64	-17,68	0,36	-16,34
	Manufacturing NEC and recycling	-0,28	-16,98	0,02	-16,32
	Electricity, gas and water supply, construction	-0,56*	-0,54	-0,25	-16,20
	Transport and storage	-0,62	-17,67	0,07	-15,52
	Post and telecommunications, financial intermediation	-0,61	-17,23	-17,55	-15,67
	Computer and related activities	0,00	-18,79	0,11	0,65
	Research and development & eng services	1,37***	0,19	1,16**	2,77***
	Social services and non-profit associations	0,00	0,79	0,09	1,90
	Constant	-8,58***	-11,31***	-9,08***	-8,21***
	N	1528	1528	1528	1528
	Contacted	698	28	101	27
	Not contacted	830	1500	1427	1501
	Goodness of fit				
	Nagelkerke R Square	0.402	0.444	0.267	0.316
	% Corrected	73.9	98.6	93.6	98.2
	Hosmers and Lameshow Test	11.305	3.906	4.475	2.880
	(p-value)	(0.185)	(0.865)	(0.812)	(0.942)

U. Cat. Lisboa	U. Cat. Porto	U. Coimbra	U. Évora	U. Lisboa	U. Minho	U. Nova	U. Porto	U. Técnica Lisboa
-0,14	0,33	0,17	-0,34	0,38	0,02	0,25	-0,06	0,01
0,72***	0,34***	0,55***	0,69***	0,38***	0,36***	0,33***	0,49***	0,39***
-0,14	1,19*	0,43	-0,49	-0,03	0,17	0,71	0,86**	-0,13
0,83	1,41	2,15*	2,98*	2,35**	1,73	2,86***	1,03	1,30
0,35	-0,24	-1,22**	-0,73	-0,13	-0,14	0,43	-0,28	0,27
1,69	2,24*	4,18***	1,80	1,92***	3,28***	2,64***	3,69***	2,87***
1,14***	1,73**	1,41**	1,60*	2,43***	1,11**	1,21**	1,43***	0,12
0.91	-0.74	0.60	0.28	0.06	0.23	-0.60	0.77	-0.40
-2,27***	1,58***	-0,37	-0,67	-1,88***	2,91***	-1,47***	2,83***	-2,07***
-1,45*	0,39	2,69***	-0,74	-0,91**	1,10***	-1,70***	1,15***	-0,78**
-17,40	-16,50	0,15	3,79***	-0,78	-17,48	-0,87	-0,09	-1,33
-17,43	1,82	1,41	-16,06	-17,89	1,53	-17,88	-16,44	-18,25
0,27	0,62	0,33	0,30	-0,99	1,24	-0,92	0,64	-0,81
-16,60	2,16*	-0,21	1,26	0,91	-17,77	-17,57	-17,87	3,25***
0,00	2,18***	-0,89	2,23***	0,17	0,05	0,78	0,19	0,79
0,14	-18,33	-1,37	0,40	-1,00	1,54***	-0,48	-0,89*	-0,47
0,94	0,31	0,07	1,70	-0,11	0,36	0,84	-0,10	2,28***
-0,75	-0,13	1,73***	1,31	0,60	1,78***	0,28	1,24**	1,71***
-17,13	0,28	-0,33	-15,49	-17,74	2,74***	0,80	-0,09	0,56
-17,69	0,16	-0,23	-15,90	-0,46	1,38***	-17,86	1,20**	1,44***
0,41	-0,34	-1,22	2,11	-0,34	1,46***	0,52	0,84	2,05***
-17,66	-17,72	0,53	1,62	-1,15	0,35	-1,08	0,76	1,38**
-0,76	-17,93	-1,48	0,11	0,16	1,37***	-0,73	0,36	1,09
-16,78	-0,20	-1,54	-15,96	-0,44	-0,74	1,13	-0,30	0,02
-18,08	-0,01	0,74	0,37	-0,75	0,22	-0,90	0,85	0,25
-0,13	-16,79	-0,87	-15,56	-1,13	-0,93	-17,75	-17,83	-17,42
-18,13	-16,62	-17,41	-16,41	-18,43	-17,60	-17,88	-17,56	0,12
-0,45	0,50	0,51	0,21	0,22	0,41	0,79	1,34**	1,20**
0,42	1,98***	0,18	1,40	0,62	0,82	0,42	1,44***	1,66***
1,35	0,65	0,60	2,03*	0,60	0,72	0,89	0,31	1,25
-8,52***	-6,27***	-9,26***	-8,25***	-6,22***	-7,54***	-4,12***	-9,27***	-3,91***
1528	1528	1528	1528	1527	1528	1528	1528	1528
40	45	72	29	79	179	68	138	105
1488	1483	1456	1499	1448	1349	1460	1390	1423
0.305	0.302	0.344	0.337	0.297	0.412	0.258	0.349	0.316
97.4	97.1	95.9	98.4	94.8	89.3	95.4	92.1	93.1
1.836	6.035	7.439	3.127	2.607	10.396	6.893	9.525	8.209
(0.986)	(0.643)	(0.490)	(0.926)	(0.957)	(0.238)	(0.548)	(0.300)	(0.413)

largest employs 6582 workers. On average, the firms in the analysis export less than 20% of their total sales and 12.7% are majority-owned foreign affiliates. In our sample, workers with 12 or more years of schooling sum up to 40664, representing 19% of these firms' total workforce, which is below the percentage (26.8%) obtained in the *Quadros de Pessoal* referring to the year 2002 (DGEEP-MTSS, 2005). However, on average, in our sample, the ratio of 'top educated' workers to total workers amounts to 21.9%. As for 'top skills', that is engineers, our percentage is likely to be closer to the figure presented in the 2002 *Quadros de Pessoal* data. In our respondent sample, engineers totaled 11745 individuals, which represent 5.5% of the total workers employed by these same firms. In *Quadros de Pessoal* the corresponding percentage is 6.8% but it not only encompasses engineers but also other university graduates. On average, a respondent firm presents a ratio of engineers to total workers of 7.9%. In terms of R&D intensity, the firms under study stated that 2.2% of the total sales were expended in R&D related activities, which is well below the figure (5.1%) obtained for technology-intensive firms (Costa and Teixeira, 2005). Finally, the firms have relatively 'open' strategic behaviours in terms of searching for knowledge and information for their innovative activities – on average, a firm draws on 13 out of 15 external sources of knowledge and information.

In bivariate terms, estimates of the linear correlation coefficients indicate that firms that are in business for a longer time, are larger, more export, R&D and human capital intensive, and are (majority) foreign-owned tend to establish more formal contacts with universities.

4.2. Estimation results

The quality of adjustment of all models estimated is quite acceptable. According to Hosmer and Lemeshow's test, all specifications reveal a good fit[6]. Moreover, the percentage of correct predictions ranges between 73.9% ('All Univ') and 98.6% ('Algarve').

In line with previous studies (e.g. Veugelers and Cassiman, 2005), our results for all the universities as a whole ('All Univ') confirm the strong industry effect in industry science links, which tend to be agglomerated in specific science-based industries, most notably in 'Research and Development and Engineering Services'. Notwithstanding, industries such as 'Food, beverage and tobacco', 'Rubber and other non-metallic' and 'Basic and fabricated metal products', tends, in average, to present higher propensity for contacting universities than the default category ('Wholesale and retail'). In contrast, 'Electricity, gas and water supply, and construction' reveal a low propensity for drawing on universities as source of information and knowledge for their innovation activities.

Not surprisingly, we also find large firms to be more likely to have contacts with universities. Firm size may be related to the presence of the necessary resources to efficiently implement contacts with scientific institutions as part of the innovation strategy of the firm. In fact, the positive and significant estimates for human capital related variables and R&D intensity reflect the critical role of absorptive capacity in firm-university links. Indeed, firms possessing higher levels of absorptive capabilities (that is, higher human capital and R&D intensities), are, all other factors being held constant, more likely to contact universities.

Furthermore, although in the descriptive and exploratory analysis, foreign owned firms were more associated with higher levels of university contacts, controlling for industry, region and other firm structural and strategic variables likely to influence the propensity of contacts, reveal lower likelihood for being actively involved in industry science links in Portugal.

In regional terms, firms located in Central and, somehow surprisingly, Algarve regions, *ceteris paribus* disclose higher propensities for contacting universities.

6 This test null hypothesis refers that the predicted values by the model are not significantly different from the observed values. Given that the p-value is not significant for standard values, this hypothesis is not rejected, leading us to the conclusion that the first model foresees the reality reasonably well.

The following table summarises the main characteristics of the firms that contact all and each of the Portuguese universities.

Universities that reveal to have the most demanding linkages with firms (i.e., consulting and project related contacts) – Técnica de Lisboa , Aveiro and Porto – are in average contacted by large and skill intensive firms belonging to industries such as 'R&D & Engineering service' and 'Basic and fabricated metal products'. Universities of Porto and Técnica are also contacted by firms from 'Coke and chemicals' and 'Computer and related activities'.

Table 7 – Characteristics of the firms that contact all and each of the Portuguese universities – overview of the main results obtained through the econometric specifications (continua)

University Profile	University	Structural traits	Human capital	Region	Industry
Entrepreneurial Universities	Universidade de Aveiro	Larger R&D intensive	Skill intensive	North Centre	Wood, pulp and publishing Basic and fabricated metal products Machinery and equipment nec R&D & Engineering services
	Universidade Católica Portuguesa – Porto	Larger Exporters	Skill intensive Education intensive	North	Mining and quarrying Food, beverage and tobacco R&D & Engineering services
	Universidade do Minho	Larger	Skill intensive Education intensive	North Centre	Textiles and leather Coke and chemicals Rubber and other non-metallic Basic and fabricated metal products Machinery and equipment nec Transport equipment
	Universidade Técnica Lisboa	Larger	Skill intensive	Lisbon and Tagus Valley	Mining and quarrying Wood, pulp and publishing Coke and chemicals Basic and fabricated metal products Machinery and equipment nec Electrical and optical equipment Computer and related activities R&D & Engineering services
'Classical', Teaching-led Universities	Universidade de Coimbra	Larger R&D intensive Nationally owned	Skill intensive Education intensive	Centre	Coke and chemicals
	Universidade de Lisboa	Larger R&D intensive	Skill intensive Education intensive	Lisbon and Tagus Valley	
	Universidade do Porto	Larger Exporters	Skill intensive Education intensive	North Centre	Coke and chemicals Basic and fabricated metal products Computer and related activities R&D & Engineering services

Table 7 – Characteristics of the firms that contact all and each of the Portuguese universities – overview of the main results obtained through the econometric specifications (continuação)

University Profile	University	Structural traits	Human capital	Region	Industry
Scientific-led Universities	Universidade Nova	Larger R&D intensive	Skill intensive Education intensive	Lisbon and Tagus Valley	
	Universidade Católica Portuguesa – Lisboa	Larger	Education intensive	Lisbon and Tagus Valley	
Regional-led	Universidade do Algarve	Larger		Algarve	
	Universidade da Beira Interior	Larger Foreign owned		Centre	Food, beverage and tobacco Textiles and leather Coke and chemicals R&D & Engineering services
	Universidade Évora	Larger R&D intensive	Education intensive	Alentejo	Food, beverage and tobacco Social services and non-profit associations

A clear-cut and statistically strong finding is that proximity matters a lot in firms-universities contacts. In fact, as we may observe in Tables 6 and 7, our results that everything remaining constant, in average, firms are more likely to contacts universities located nearby. For instance firms located in Algarve tend to contact to a larger extent the University of Algarve, whereas mostly firms from the Alentejo contact the University of Évora. Nova (Lisboa) and Técnica de Lisboa are contacted especially by firms from Lisbon and Tagus Valley. One interesting result is that Aveiro, Minho and Porto are those universities which have a broader spatially range being contacted by both Centre and North regions' firms.

The importance of proximity is thus highlighted in our results. Such fact may result from what the extensive literature on proximity related issues documents as the positive externalities associated with the spatial proximity to universities, which can be accessed by the firm through the spillover mechanism of human capital. As Varga (2000) shows, university graduates may be one of the most important channels for disseminating knowledge from academia to the local high-technology industry. In addition, other related externalities may result from close geographic proximity. For example, local proximity lowers the search costs for both firms and students. This may lead to some competitive advantage over similar firms, which are not located close to universities, especially when high skilled labor is a scarce resource and there is intense competition about high potentials.

5. Conclusions

It has been clear over the last decades that the innovation process is not the result of isolated agents. Interactions among various agents of the economy have been acknowledged to be at the core of the process (Monjonand and Waelbroeck, 2003). Rosenberg and Nelson (1994) argue that universities, and more generally science and academic research are an important factor in the development of major innovations. This view is confirmed by several empirical studies that reveal the importance of universities in the innovation process (Jaffe, 1989; Berman, 1990; Mansfield, 1995). For instance, Mansfield (1995) finds that 10% of the innovations under study could not have been developed without academic research, while Berman (1990) finds that direct industry funding of university research can be associated with subsequent increases in industry R&D expenditure.

Thus, in an innovation setting where 'no firm is an island', successful innovation partly depends on the ability of firms to acquire technical knowledge from external sources (Arundel and Geuna, 2004) and effectively include this knowledge in their innovation activities (Kline and Rosenberg, 1986; Freeman, 1987). Where firms go to obtain technical knowledge and how they obtain it will be influenced by firm-specific characteristics, such as their internal competences and sector of activity, and by the national and regional innovation system of the country in which they are located (Lundvall, 1992; Nelson, 1993). The latter includes the availability and quality of knowledge produced by other private firms and by the 'public science' infrastructure, namely universities.

Our results show that in Portugal, on the overall, the links between firms and the universities are weak, occasional and lack of sustainability. The universities in general do not seem to have innovation strategies and the local institutional – organizational representation of innovation support at the universities seems to be inadequate (LERU, 2006; OECD, 2006). Moreover, the interactive skills of the firms seems to be extremely weak, only large (whichever the university), R&D and human capital intensive firms systematically evidence higher propensity for drawing on universities as sources of information and knowledge for their innovation activities. This aspect might be to some extent related with the fact that universities pursue mainly fundamental research (Motohashi, 2005). Due to their mission, they do not supply industry with readymade new product technologies. University-firms linkages involve much more than technology purchases, typically requiring significant development activity on the firm side; for this reason, they tend to concentrate in large firms with their own adequate R&D resources. Overall the results seem to suggest that the low frequency of contacts with universities in Portugal may be related to an industry structure that is focused on non-science based industries, characterized by a high share of small and medium sized firms, whose portfolio of R&D strategies is limited.

Furthermore the results of this analysis support the view that relationships between firms and universities are characterized by a high degree of heterogeneity. To speak about university-industry relationships in a general way and develop policies on the basis of such generalization will lead to unintended intersectoral differences. Indeed, the various actors will react to these policies in different ways depending on their specific characteristics. In addition, it is extremely important to take into account that policies in support of collaboration between universities and firms should create incentives for both sets of actors to cooperate. Current policies are mainly directed to forcing universities into these types of relationships with no acknowledgement that without appropriate 'demand' little will be achieved. This paper provides strong evidence that, after controlling for firm size and other firm structural and strategic factors, the openness of firms to the external environment (and therefore their willingness to interact with it) is very important in explaining their probability of contacting with universities. Without willing partners satisfaction will not be achieved.

It is important to highlight here that, as in the case of India, documented by Bhattacharya and Arora (2004), firms and universities in Portugal seem to have different norms, and have different levels of evaluation criteria. Expectations from each other are also not clear in many cases resulting in linkages not translating into deeper levels. Firms located in Portugal tend to be skeptical of the research done in the university. Further, even if the technology they have felt is promising the resultant transfer has not taken place in many cases. In general, collaboration with industry is still only a peripheral concern of the university. Universities seem to be more comfortable with their role of knowledge generating institution. Indeed, despite recent research underscores the importance of universities in contributing to local economic development, leading edge research, high value jobs and innovation (Etzkowitz, 2002), as O'Shea *et al.* (2005: 1005) recognize in the case of the USA, "…unfortunately, for many institutions, efforts to make universities more entrepreneurial have not had sufficient impact". The present study reveals that this is also the case for Portugal…

A challenging and interesting pathway for further research in this area would be to investigate why some universities maintain and sustain closer links with firms, which might be the institutional-organizational factors that promote more entrepreneurial-led behaviours on behalf of universities. Such endeavour would obviously require a more in-depth study of each university.

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