7 Brokerage roles in academic patenting

An analysis of Italian inventors

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1 Introduction

Recent research on university–industry technology transfer has dedicated great attention to the theme of university patenting. In the past few years, European economists and other social scientists have identified a large number of so-called 'academic inventors', namely academic scientists who appear as designated inventors of patents whose assignee is not necessarily a university or a public research organization, but also the scientist himself or, most often, a business company (Geuna and Nesta 2006; Verspagen 2006).

Most patents signed by academic inventors are co-authored by other inventors, who may be either employees of the assignee or graduate students brought in by the academic inventors themselves.

The relationship between academic inventors and their co-inventors is of great interest. Do academic inventors play a peripheral or central role in knowledge diffusion? Do academic inventors entertain stable collaborations with their co-inventors, or is the interaction limited to short-lived projects (those that have produced the observed patents)? Does the answer change with the professional status of the co-inventors (who may be either academic scientists, industrial researchers, or students)?

Fieldwork by Murray (2004) suggests that academic scientists involved in entrepreneurial ventures bring useful social capital to the latter, which consists both of their personal networks of current and former students and of the 'cosmopolitan network of colleagues and co-authors'. Nicolaou and Birley (2003) provide a theoretical treatment of academic inventors' entrepreneurial networks.

Extensive data collected by Meyer *et al.* (2003) for Finland suggest that academic inventors in that country are more closely connected to large firms rather than start-up companies. This suggests that framing the analysis of academic inventors' social network within the analysis of entrepreneurship may be reductive.

At a quantitative level, Balconi *et al.* (2004) examined the overall 'networks of inventors' in Italy and found that academic inventors tend to occupy rather central positions, which suggests that their social capital is considerable also within the community of industrial researchers.

Here we combine the same kind of relational analysis on inventors' data with the results of a short questionnaire submitted to a subset of Italian academic inventors, and with data on their scientific publication record and CVs. Our objective is to explore in greater depth the personal relationships that academic inventors entertain with co-inventors with a different background and/or professional status. In order to do so, we adapt Gould and Fernandez's (1989) definitions of brokerage roles to our data, and illustrate some of our results with selected biographical information.

In Section 2 we provide a brief summary of the literature on academic inventors, and of the technical literature on the notion of 'brokerage' as applied to social network analysis. In Section 3 we describe our data and methodology. In Section 4 we present our quantitative results and biographical examples. Section 5 concludes.

2 Background literature

2.1 Academic inventorship

Research on university patenting in Europe has been very intense over the past decade. Besides the studies surveyed by Geuna and Nesta (2006) and Verspagen (2006), as recently as 2007–8 new research has been published on Germany (Czarnitzki *et al.* 2007), Norway (Iversen *et al.* 2007), Italy, France and Sweden (Lissoni *et al.* 2008). All the evidence so far produced suggests that European universities, despite not having as large patent portfolios as their US counterparts, do contribute remarkably to their countries' patenting record via their scientists' inventive efforts (Lissoni *et al.* 2008).

Most patents covering inventions by academic scientists, however, do not belong to universities but to business companies. Some of them derive from contract research or consulting, while others are the result of research partnerships between companies and universities, which share the IPRs over the research results. The institutional specificities of the European universities, in fact, are such that the latter have either little interest or little ability in bargaining hard both with their own staff and with companies in order to reclaim or to share the IPRs over academic inventions, when compared to the US public and (above all) private academic institutions.[2]

Present enquiries focus now on the technological characteristics, ownership pattern and the value of what have now become known as 'academic patents', that is patents whose inventors comprise at least an academic scientist, irrespective of the assignee. Crespi *et al.* (2006) find that inventors' own estimates of the economic value of their patents are not affected by the ownership of the patent, that is they find no evidence that, by retaining the property of their scientists' inventions, universities would do a better job than companies in turning patents into valuable assets.

Other lines of enquiry focus not so much on the patents, but on the inventors. The latter can be interviewed, their CVs or publications can be retrieved, and analyses can be performed on the determinants of their productivity, and on their mobility in space or across organizations. Recent investigations, in particular, have found that academic inventors are very productive scientists, whose productivity further increases after patenting (see Chapter 4, this volume).

Finally, patent data reclassified by inventors are a key source of relational data, which can cast light on processes of innovation diffusion and, when academic inventors are involved, university–industry links. Patents authored by two or more co-inventors, in fact, are instances of cooperation and knowledge exchange. Co-inventors of one or more patents can be safely presumed to know each other, and to have exchanged some information and, possibly, knowledge. One can build networks of inventors where the latter are represented nodes, and patents are ties between them. Balconi *et al.* (2004) build the network of Italian inventors from data on patent applications registered at the European Patent Office, from 1978 to 1999, and find that academic inventors tend to occupy rather central positions in the network. Lissoni and Sanditov (2007) find that the same results hold for France and Sweden.

Network analyses based purely on patent data, however, cannot say much on the qualitative aspects of the relationships between academic inventors and their co-inventors, for at least three reasons. First, we may wish to know more on the quality of the relationships established between inventors. Are they stable or occasional? Do they provide both parties with chances of scientific collaborations, or are they a mere vehicle for information exchanges (such as those on funding opportunities, jobs, etc.)?

Second, the identity of non-academic co-inventors of academic patents is not always clear; they may either be industrial researchers (most typically, members of the patent assignee's R&D staff), graduate students or former academic colleagues who are now retired or have left the university.

Last, we would like to know more about the nature of the relationship between the academic inventors and the patent assignee and its R&D staff. Do academic inventors provide a bridge between university and industry (that is, between cliques of academic scientists and industrial researchers)? Or do they also provide a bridge between different companies (that is, between industrial researchers)? Are academic inventors instrumental in introducing their students to business R&D staff members?

2.2 Brokerage

In order to answer these questions, it is necessary to collect information not only on the academic inventors and co-inventors, but also on the relationship between them (more on this in Section 3). A useful instrument to guide this data collection and the following analysis is the notion of 'brokerage', as derived from economic sociology and, in particular, from applications of social network analysis.

Such notion builds upon that of 'in-betweenness' across nodes in a network (Freeman 1979). In any network (either social or physical), any node *j* is said to stand in between two other nodes *i* and *z* if the shortest path between the *i* and *z*

passes through it. Measures of in-betweenness for node *j* will be therefore based upon counts of how many shortest paths between any pair of nodes in the network pass through it.

If we consider only *j*'s ego-network (i.e. the subset of the overall network that comprises only the nodes in direct contact with j), *j* will result to be in-between its ego-network nodes to the extent that the latter are no connected to each other by any direct tie, that is they reach one another only through *j*.

The peculiar role of in-between nodes is most evident in directed graphs, that is graphs where ties between nodes do not necessarily run both ways, but may also run in one direction only (for example, from *i* to *j* and from *j* to *z*). In social network analysis, directed graphs are used to portray information flows in a community of agents: in-between agents are the necessary intermediaries of information flows between many agents who could not otherwise reach each other (in our example, *i* can send information to *z* only through *j*). In-between agents can take advantage of their position in many ways, which have been the subject of much sociological investigation (Burt 2001).

In-between agents are even more relevant when the community of agents they belong to are fragmented across different affiliation groups, as happens when citizens of the same town belong to different religious or ethnic groups or (as in our case) researchers in a given technological field belong to different types of organizations (university and industry). In this case, they may find themselves in-between not only two other agents, but two entirely different groups of people, whose chances to communicate in the absence of the in-between nodes are very few. In our example, if *i* and *z* belong to different affiliation group, their link through *j* (who may belong either to the same group of *i* or *z*, or possibly to a third one) is especially important, since their different affiliation may make it especially hard to build alternative links.

Terms such as 'brokers' and 'gatekeepers' have for long been used in sociology and organization theory to identify actors who are in-between other actors from different affiliation groups. Within social network analysis, Gould and Fernandez (1989) have proposed a set of measures of various brokerage positions any node can take in its ego-network, which are now available on most software packages for social network analysis, such as *Ucinet* and *Pajek* (both used for this chapter).

- Node *j* is said to act as a broker between *i* and *z* whenever the latter belong to the same affiliation group, and this group is different from *j*'s.
- Node *j* acts as a gatekeeper when the information flow runs from *i* to *z*, and *j* and *z* belong to the same group, which is a different one from *i*'s (*j* is said to act as a representative of *z* whenever the information runs the opposite way).
- Node *j* acts as a coordinator when all three nodes belong to the same group, and as a liaison when each of them belongs to a different group.

The number of each type of brokerage positions taken by node *j* are then divided by the expected number of position the same node would take if its ego-network were a random one, so that standardized measures are obtained, which can be used to compare nodes with ego-networks of different size and group composition.

A number of papers have been produced, which makes use of Gould and Fernandez's methodology, and find that actors in brokerage positions enjoy strategic advantages in a number of activities, ranging from the political to the entrepreneurial (Taube 2004).

In what follows, we adapt Gould and Fernandez's measures to data on academic inventors. However, we do not make use of those measures to draw conclusion on the structural property of the networks academic inventors belong to, but only on the most salient individual characteristics associated to being in a brokerage position.

3 Data and methodology

Data used in this chapter results from the integration of three different sources: the KEINS database on academic inventors; the information gathered from a sample of Italian academic inventors through a questionnaire; and some extra information on these inventors' publication record, obtained through the ISI–Web of Science database. In Section 3.1 we say more on these sources, while in Section 3.2 we present the brokerage measures employed in the rest of the chapter.

3.1 Data

The KEINS database is the result of a collective effort of many researchers (Lissoni *et al.* 2006). It contains information on academic patents and inventors in France, Italy and Sweden. It originates from the EP–INV database produced by CESPRI–Università Bocconi, which contains all EPO applications published since 1978, reclassified by applicant and inventor; and from three lists of university professors of all ranks (from assistant to full professors), one for each of the above-mentioned countries (PROFLISTs). Academic inventors have been identified by matching names and surnames of inventors in the EP–INV database with those in the PROFLISTs, and by checking by email and phone the identity of the matches, in order to exclude homonyms.

Each country section contains information on individual characteristics of the scientists (such as age, affiliation, academic rank, discipline), although the extent and quality of such information may vary across countries. Information on Italian academic inventors originates from the complete list (provided by the Italian Ministry of Education) of professors and researchers who, in 2000 and 2004, held a position in a scientific or technical discipline in an Italian university (including medical and engineering schools).

In the KEINS database, professors' disciplines are defined according both to national classification and to a harmonized one. All of them are quite detailed and allow for some compression into broader categories, which we will refer to as 'fields'.[3] In this chapter we focus on Italy and on the four fields with the highest share of academic inventors over the total number of professors in that country, namely chemical engineering (it includes technology of materials, such as macromolecular compounds), biology, pharmacology, and electronics and telecommunications. We also limit our analysis to professors who were already on duty in 2000, for a total of 301 academic inventors, who count for around 10 per cent of Italian professors active in the selected disciplines in 2000 (Table 7.1).

As shown in Table 7.2, most patents signed by the selected academic inventors are owned by business companies, rather than 'open science' institutions (such as universities and public research organizations); a minority of patents are assigned to individuals, most often the professors themselves, or a relative. The ownership patterns vary across the professors' disciplines, with biology standing out as the one that records the highest percentage of patents assigned to open science institutions and individuals.

Publication data were collected from the 1975–2003 online version of ISI's *Science Citation Index* for all the 308 academic inventors in the selected fields. A more detailed description of these data can be found in Breschi *et al.* (2007).

Finally, we contacted the academic inventors in order to ask them questions related to the various aspects of the research behind the observed patents. The questions most relevant for this chapter were those related to the identity of and the relationship with the co-inventors:

1 Whether they actually knew the co-inventors listed along with them on the patent document (all answers were positive).
2 Whether those co-inventors were academic colleagues, industrial researchers or students, at the time when the patent was signed.
3 Whether they had gone on collaborating with co-inventors at a later time.
4 Whether they planned to do so in the future.
5 And, in case of negative answers to both questions three and four, whether they were at least still in touch and exchanged information, albeit occasionally.

We successfully interviewed 156 academic inventors (51 per cent of the total), who provided information on 741 of their 771 co-inventors (interviewees who had worked with many co-inventors sometimes refused to provide information on all of them, since this would have prolonged the interview too much). However, due to the fact that several co-inventors signed patents both with

Table 7.1 Italian university professors in 2000, selected fields

Field	*Professors, active in 2000*	*Of which: academic inventors, no. and (%)*
Chemical engineering and materials technology	355	66 (18.5)
Pharmacology and pharmaceutical sciences	613	84 (13.7)
Biology	1,359	78 (5.7)
Electronics and telecommunications	630	73 (11.6)
Total	2,957	301 (10.2)

Source: Breschi *et al.* (2007).

Table 7.2 Ownership of academic inventors' patents[§] by type of applicant and field; number and (%) of patents

Field	*Business companies*	*'Open science' institutions*[a]	*Individuals*[b]	*Others (n.e.c.)*	*All applicant types*
Chemical engineering and materials technology	125 (78.1)	18 (11.3)	15 (9.4)	2 (1.3)	160 (100)
Pharmacology	192 (85.0)	24 (10.6)	10 (4.4)	–	226 (100)
Biology	91 (54.5)	43 (25.7)	30 (18.0)	3 (1.8)	167 (100)
Electronics and telecommunications	199 (81.9)	28 (11.5)	13 (5.3)	3 (1.2)	243 (100)
All fields	607 (76.3)	109 (14.2)	68 (8.5)	8 (1.0)	796 (100)

Source: EP-INV-DOC database.

Notes
a Universities, public labs and government agencies; both Italian and foreign.
b Same applicant's and the inventors' names.
§ Patents owned by more than one applicant were counted more than once.

academic inventors that agreed to be interviewed and with academic inventors who did not, we have information also on the co-inventors of 29 of the latter, for a total of 185 academic inventors.

3.2 Methodology: brokerage positions from patent data

Once the group affiliation of co-inventors is established, one can move to calculate the number and type of brokerage positions of academic inventors. However, several difficulties stand in the way of a straightforward application of Gould and Fernandez's methodology. Both derive from the fact that networks of inventors derive from archival data, rather than questionnaires.[4]

First, a questionnaire aimed at gathering network information can phrase questions in such a way that the resulting ties between actors are directed (for example: 'who do you rely upon for information among your friends?'; information requests may go from *j* to *z*, and not be reciprocated). This is not the case with patents: when *j* and *z* are found to be co-inventors of the same patent, there is no way we can tell who was asking for information from who, and whether he was reciprocated. No directed graph can be built.

Second, when *n* inventors have worked on the same patent, they immediately form a clique of size *n*. If $n=3$ this is a triangle whose vertices (nodes) are all connected to each other: no node is in between the other two. This means that counting how many times an academic inventor stands in-between two co-inventors (as required by Gould and Fernandez's method) makes sense only for academic inventors with at least two patents.

Last, standardized brokerage measures, based upon the ratio between the observed instances of in-betweenness and the hypothetical instances for a random ego-network, do not make sense. In fact, academic inventors' ego-networks can never be random, because they are the sum of several complete subgraphs, one for each patent signed by the academic inventor.

The first problem can be confronted simply by adapting Gould and Fernandez's methodology to our data, which implies giving up some of the nuances of the original definitions of brokerage positions. Figure 7.1 reports the definitions we will use in this chapter.

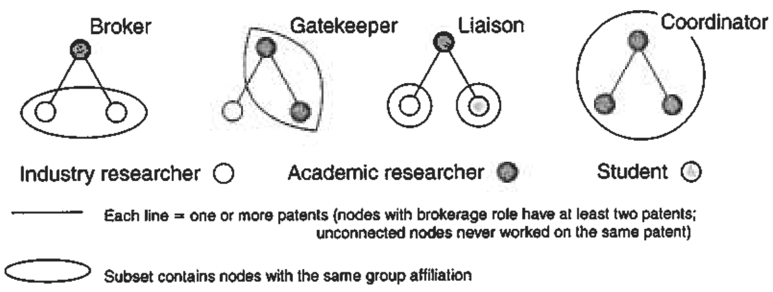

Figure 7.1 Brokerage positions: definitions.

Academic inventors find themselves in the position of brokers whenever they stand in-between two industrial researchers (or, more rarely, students). They act as gatekeepers whenever they stand in-between an industrial researcher (or a student) and an academic researcher;[5] and as liaisons when they stand in-between an industrial researcher and a student. Finally, they act as coordinators whenever they stand in-between two members of their own affiliation group, that is two academic researchers.

The second methodological problem mentioned above forces us to restrict our analysis only to academic inventors with at least two patents. They are a minority in our sample, only 74 out of 185 (see Table 7.3).

As for the last problem, we have found no other solution, so far, than considering the absolute number of brokerage positions taken by each academic inventor, but controlling for the number of patents signed by the inventor any time we use his brokerage score as an independent variable in a regression.

Figure 7.2 provides some summary statistics on the distribution of brokerage scores over the 74 academic inventors considered. Most academic inventors do not play any brokerage role at all, that is they are never in-between any two co-inventors; this is particularly true for 'liaison' scores, since students are a rare presence in the set of co-inventors.

Academic inventors' age and seniority also contribute greatly to explain academic inventors' brokerage scores. From Table 7.4 we see that it is only full professors who achieve the highest scores. However, age and seniority are also correlated to the number of patents held by each academic inventor, and possibly with other variables highly correlated to the observed brokerage scores. Therefore, in the next section, we move on towards a more systematic exploration of the characteristics of academic inventors with high brokerage scores.

Table 7.3 Number of academic inventors, by number of patents signed

Number of patents per inventor	*Number of inventors*
1	111
2	22
3	15
4	9
5	11
6–10	9
11–20	6
21–30	2
All inventors	185

Source: KEINS database.

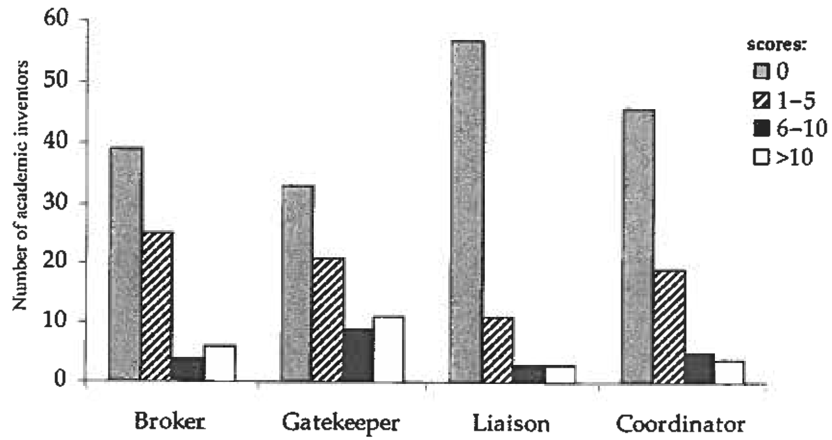

Figure 7.2 Distribution of brokerage scores.

4 Results

4.1 Who are the brokers?

In this section we examine how many of the 74 academic inventors in our database with more than one patent hold brokerage positions. On the basis of their biographical information, and of their publication record, we also produce a profile of those with the highest brokerage scores.

In order to do so, we first run a regression of various measures of brokerage over a number of characteristics of the academic inventors, such as their observed scientific productivity, their age, their academic rank (full, associate or assistant professor) and disciplinary affiliation. Productivity is measured as the number of articles published on academic journals listed on the ISI–Web of Science database between the academic inventor's twenty-fourth birthday (a conventional date for the start of his career) and 2003 (when the publication data were collected). Alternatively, a 'late-productivity' measure is similarly produced, which spans only over the last ten years of the academic inventor's career.

When running the regression, we control for the number of patents signed by the academic inventors which, by construction, are positively correlated to the brokerage scores. However, we distinguish between patents owned by business companies, open science institutions and individuals, as we expected only the former to be signed by co-inventors from the 'industrial researcher' affiliation group.

By no means the proposed regression can be interpreted as an explanatory one, that is no causation link can be assumed to run from the independent variables to the dependent ones. In order to 'explain' the brokerage position reached by any academic inventor, one would need to observe the accumulation of social

Table 7.4 Brokerage scores and academic seniority

Score	Broker		Gatekeeper		Liaison		Coordinator	
	Full	*Assoc. and assistant*	*Full*	*Assoc. and assistant*	*Full*	*Assoc. and assistant*	*Full*	*Assoc. and assistant*
0	45.5	63.3	40.9	50.0	77.3	76.7	54.5	73.3
1–5	31.8	36.7	20.5	40.0	11.4	20.0	25.0	26.7
6–10	9.1	–	15.9	6.7	4.5	3.3	11.4	–
>10	13.6	–	22.7	3.3	6.8	–	9.1	–

ties (with co-inventors) over time, and find a way to solve two problems of endogeneity in the regression. The main problem is that a fixed effect may explain a lot: highly productive professors have a higher probability of producing not only papers, but also patentable inventions; and those who have many patents have a high probability to record a high brokerage score.

However, one can interpret our regression coefficients as a set of partial correlation indexes, which help producing a portrait of who acts as a broker among academic inventors.

We can first look at Table 7.5, which provides descriptive statistics for the variables used in the regressions. It confirms that the distribution of the dependent variables is highly skewed, with the median always at zero (one for the gatekeeper score) and the mean well above one; the 'max' column indicates also the presence of a few outliers for the broker and gatekeeper score.

The distributions of independent variables concerning productivity and the number of patents signed are also highly skewed, with some academic inventors having produced no publications over the observed time span.

The 74 academic inventors considered are predominantly senior ones, with a mean age of 55; over half of them are full professors, less than one-fifth are assistant professors.

With respect to the original distribution of academic inventors across disciplines (see Table 7.2), biology is slightly under-represented, in favour of chemistry and pharmaceuticals.

Table 7.6 reports the results of the regressions. Since the proposed brokerage measures can be considered as count data (number of instances of in-betweenness), and have a highly skewed distribution, we made use of negative binomial regressions (we also tested whether zero-inflated negative binomial

Table 7.5 Descriptive statistics

Variables	*Obs*	*Mean*	*Median*	*Variance*	*Min*	*Max*
Broker	74	4.81	0	210.2	0	109
Gatekeeper	74	7.30	1	386.5	0	131
Liaison	74	1.61	0	23.5	0	31
Coordinator	74	2.08	0	26.6	0	25
Age	74	55.5	56	78.4	38	74
Productivity	74	2.72	1.98	6.26	0	14.68
Late productivity	74	3.81	2.88	13.8	0	20.38
Business-owned patents (no.)	74	4.64	3	30.0	0	28
University-owned patents (no.)	74	0.78	0	1.10	0	4
Individual-owned patents (no.)	74	0.35	0	1.57	0	7
Chemistry	74	0.28	–	–	0	1
Electronics and telecommunications	74	0.24	–	–	0	1
Pharma	74	0.31	–	–	0	1
Biology	74	0.16	–	–	0	1
Full professor	74	0.59	–	–	0	1
Associate professor	74	0.26	–	–	0	1
Assistant professor	74	0.15	–	–	0	1

Table 7.6 Brokerage scores; negative binomial regressions over academic inventors' characteristics

	Broker (1)	Broker (2)	Gatekeeper (3)	Coordinator (4)	Liaison (5)
Productivity	0.40*** (0.13)		0.36*** (0.13)	0.30** (0.13)	0.23 (0.26)
Late productivity		0.21** (0.09)			
Age	0.08** (0.03)	0.07** (0.04)	−0.01 (0.03)	−0.04 (0.04)	0.14* (0.08)
Business-owned patents (no.)	0.66*** (0.11)	0.68*** (0.11)	0.54*** (0.11)	0.44*** (0.12)	0.84*** (0.26)
Business-own pat.2	−0.02*** (0.004)	−0.02*** (0.00)	−0.01*** (0.00)	−0.01*** (0.00)	−0.02*** (0.01)
University-owned patents (no.)	0.002 (0.72)	0.10 (0.73)	1.66*** (0.63)	1.73** (0.68)	2.58* (1.40)
University-owned pat.2	−0.02 (0.25)	−0.05 (0.25)	−0.35* (0.22)	−0.29 (0.22)	−0.63 (0.42)
Individual-owned patents (no.)	−0.59** (0.29)	−0.44* (0.27)	−0.41* (0.24)	−0.34 (0.24)	−0.32 (0.50)
Chemistry	0.31 (0.68)	0.13 (0.66)	0.10 (0.62)	0.31 (0.70)	0.68 (1.27)
Electronics and telecommunications	0.95 (0.77)	0.63 (0.75)	−1.25* (0.71)	−1.42* (0.79)	1.59 (1.44)
Pharma	−0.32 (0.65)	−0.52 (0.63)	−0.90 (0.61)	−0.64 (0.69)	−2.74* (1.67)
Associate professor	0.20 (0.73)	0.11 (0.77)	−0.32 (0.62)	−0.53 (0.72)	1.58 (1.43)
Assistant professor	0.62 (0.84)	0.40 (0.89)	0.03 (0.78)	−1.77* (1.08)	1.38 (1.46)
constant	−7.43*** (2.49)	−6.65** (2.57)	−1.12 (2.14)	0.59 (2.49)	−13.74** (5.92)
	*LR test of alpha = 0: chi²(01) = 352.78****	*LR test of alpha = 0: hi²(01) = 363.14****	*LR test of alpha = 0: chi²(01) = 412.3****	*LR test of alpha = 0: chi²(01) = 103.3****	*LR test of alpha = 0: hi²(01) = 139.0****
	No. of obs = 74	*No. of obs = 74*	*No. of obs = 74*	*No. of obs = 74*	*No. of obs = 74*
	LogL = −126.6	*LogL = −128.8*	*LogL = −158.2*	*LogL = −97.5*	*LogL = −76.0*
	LR chi²(12) = 61.2	*LR chi²(12) = 56.8*	*LR chi²(12) = 54.0*	*LR chi²(12) = 40.3*	*LR chi²(12) = 25.5*
	Prob > chi² = 0.00	*Prob > chi² = 0.00*	*Prob > chi² = 0.00*	*Prob > chi² = 0.00*	*Prob > chi² = 0.01*
	Pseudo R² = 0.19	*Pseudo R² = 0.18*	*Pseudo R² = 0.15*	*Pseudo R² = 0.17*	*Pseudo R² = 0.14*

Note
Standard errors in brackets.

regressions were more appropriate, but the Vuong test returned negative results; see Vuong 1989). Notice that the estimated coefficients cannot be directly interpreted as the marginal influence of the independent variable on the dependent one, as in OLS regression; instead, estimated coefficients indicate the difference between the log of the expected counts for a unit change of the independent variable; this is the same as the log of the ratio of the expected counts, which implies that by taking the exponential of the estimated coefficient one can measure the expected percentage increase of the dependent variable for a unit change of the independent one.

The regressions have been run for all of the 74 academic inventors susceptible to brokerage measurement; excluding outliers did not change much the estimated coefficients, nor their significance.

We will comment first on the estimated coefficient of control variables, and then explain how the number of patents, by type of ownership, affects the brokerage score, leaving the discussion of the effect of scientific productivity until last.

Age matters, but not much. It is not significant in regressions (3) and (4), and barely significant in regression (5). Regressions (1) and (2) indicate that being one year older increases an academic inventor's expected broker score by no more than 8 per cent. Seniority dummies are not significant. Dummies for disciplines are either insignificant or significant at no more than 90 per cent.

Estimated coefficients for the number of patents, classified by ownership type, depend directly on the technical constraints of the proposed brokerage measures, but they are also quite informative of the nature of contacts established by academic inventors through their patenting activity.

We first observe that individual patents are not associated with high brokerage scores. On the contrary, having signed one's own patent diminishes the brokerage score by up to 55 per cent (regression (1)). This is because individual patents are very often signed by one or very few academic inventors, most of them colleagues at the same university, which explains why the negative effect is particularly severe for the broker measure (which requires the academic inventor to stand in-between two industrial researchers).

University-owned patents do not seem to be associated with high broker scores, which again is a largely predictable result. University-owned patents are most often signed by colleagues in the same university, and occasionally by some students; at most, they can originate some brokerage position in-between students. On the contrary, one extra university-owned patent increases the expected coordinator score of 464 per cent. The effect on the gatekeeper score is lower, because it is non-linear, that is it depends on the total number of university-owned patents signed by the academic inventors, with a negative second derivative; moving from one patent to two, the score increases by 84 per cent; moving from two patents to three, we have a 8 per cent decrease (academic professors with three university patents only, that is with no additional business-owned patents, are very rare, however).

Business-owned patents affect all of our brokerage measures, in a non-linear way. Adding one more of these patents to the portfolio of an academic inventor with one patent only, increases the broker score by either 82 per cent or 90 per cent (depending on the regression: (1) or (2)), the gatekeeper score by 68 per cent, the coordinator score by 52 per cent, and the liaison score by 123 per cent. Even the academic inventor with the highest number of patents in our sample would see his brokerage score going up with one more patent: 6 per cent to 8 per cent for the broker score, 27 per cent for the gatekeeper score, 15 per cent for the coordinator score, and 27 per cent for the liaison score.

While the relationship between business-owned patents and broker and liaison scores is pretty obvious (both these scores derive from the academic inventor standing in between two co-inventors, one of which has to be an industrial researcher), it less so for the gatekeeper score, and even less for the coordinator score.

Academic inventors may be gatekeepers when standing in-between an academic colleague and either an industrial researcher or a student. While university-owned patents grant some chances for the academic inventors to stand in-between a colleague and a student, business-owned patents provide also the chance to stand in-between a colleague and an industrial researcher; in addition, mixed teams (of academic scientists and industrial researchers and/or students) are much more common with business-owned patents than with university-owned ones.

The existence of a positive effect of business-owned patents on the coordinator score is explained again by the high frequency of business-owned patents counting at least two academic co-inventors. If academic inventor *j* has worked on two business-owned patents, one with the academic colleague *i* and another with colleague *z*, he will end up acting as a coordinator between the two even in the absence of any university-owned patent in his portfolio.

Figure 7.3 may help clarifying some of these technicalities, and also provide nice examples of top brokers, gatekeepers and coordinators. It represents the ego-networks of selected academic inventors, who are represented by large black circles and labelled with a number, which is the code they have been given in the KEINS database; small circles are co-inventors and they are coloured according to their affiliation group; grey lines around subgraphs, each labelled with a different letter, indicate that the inventors/nodes inside the line are team members, that is they worked on the same patent(s).

Inventor *1622030* (centre-top of the figure) has not an especially high score, but is representative of what we may call a 'pure' coordinator, that is an academic inventor who stands in-between several of his colleagues, and has never worked with inventors from outside his affiliation group. He and the co-inventors circled by the 'A' line have worked on the same patent, as one can understand by noticing that every node is connected to all others. This means that the coordinator score of inventor *1622030* does not derive by his collaboration with the other inventors of patent 'A', since they are connected to each other independently of him. In fact, inventor *1622030*'s coordinator score derives from his work on a different patent, which he has produced by working with the two inventors represented by the nodes on the right hand side of his ego-network,

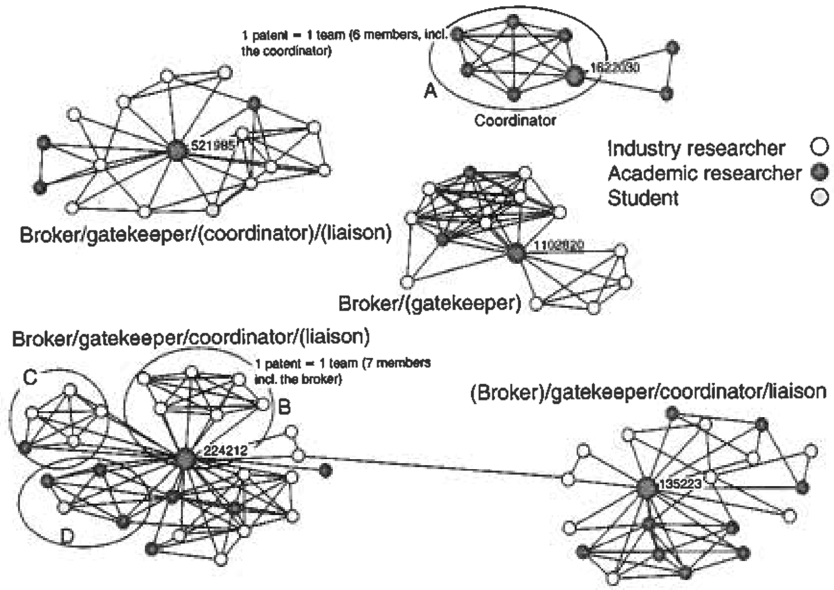

Figure 7.3 Top brokers, gatekeepers and coordinators.

outside the 'A' line. Inventor *1622030* acts as a coordinator between these two inventors, and those circled by 'A'.

Similarly, all of the brokerage scores of inventor *224212* (bottom-left corner of the figure) derive from his work on several different patents, such as those invented with co-inventors/nodes circled by the 'B', 'C' and 'D' lines (for the sake of tidiness, 'C' and 'D' have not been extended to include inventor *224212*, but the reader should be aware that he belongs to all teams). Notice that patent 'B' lists inventor *224212* as the only academic co-inventor, while 'C' and 'D' are more mixed (as much as the other patents, not represented by any circle line, which must have seen the participation of the co-inventors/nodes on the bottom-right hand side of *224212*'s ego-network). This heterogeneity explains why inventor *224212* records very high scores on all measures. A similar explanation applies to inventor *135223* (bottom-right corner of the figure), albeit this inventor's broker score is not particularly high, due to the limited number of industrial researchers in his ego-network.[6]

Finally, we notice that inventor *1102820* (centre of the figure) has zero liaison score, because his ego-network does not include any student, and also zero coordinator score, because the only two academic co-inventors in the ego-network are linked by a direct tie. A similar explanation applies to the relatively low liaison and coordinator scores of inventor *521985* (top-left corner of the figure), whose ego-network includes only two students and only three academic co-inventors, two of which are linked by a direct tie.

Going back to the regressions in Table 7.6, we notice that from all of them, with the exception of number (5), academic inventors with strong brokerage positions emerge as highly productive scientists, both when their overall publication record is considered and when the attention is restricted only to their recent years of activity.[7] Regression (1), for example, tells us that one more paper per year by the academic inventor increases his expected broker score by 49 per cent (from regression (2) we see that a similar increase in late productivity produces a 23 per cent increase).

These results cannot be explained by the positive association between scientific productivity and number of patents (found by the studies we reviewed in Section 2), since in all the regressions we control by the latter. Rather, it is suggestive of the possibility that highly productive scientists have, *ceteris paribus*, a more diverse set of collaborations, which includes actors from different affiliation groups, several of whom are connected only through the co-inventing activity performed along with the productive scientists themselves. This is confirmed by looking at the biographies of the top brokers and gatekeepers from our sample.

4.2 A close look at the top brokers and gatekeepers

In this section we briefly report some significant biographical information on the top brokers and gatekeepers in our sample, which we retrieved using standard search engines on the World Wide Web and from a close look at the identity of the patent assignees.[8]

Only six academic inventors have a brokerage score higher than ten. All of them are senior full professors, born between 1935 and 1956. For two of them, M.B. and F.P., who scored respectively 109 (top score) and 33, we could not find much biographical information of sorts, besides a short CV listing the affiliation (University of Rome, 'La Sapienza', the largest university in Italy, and the University of Modena and Reggio, respectively) and the discipline (pharmaceutical chemistry and materials technology, respectively). M.B.'s 15 patents belong to six different assignees, one of which is a large public research organization, while the others are medium-sized Italian pharmaceutical companies. Three out of F.P.'s 13 patents are assigned to General Electrics, all the others (but one) to companies within the ENI group.

The most junior of the remaining four academic inventors with high brokerage scores is G.P., a professor of Electronics at the University of Catania (Sicily), which he represents within *Plast_Ics*, an academic consortium supported both by the Ministry for University and Research and by STMicroelectronics, the Italian company with the highest number of academic patents. The consortium lies at the core of the most important high-tech district of southern Italy, the so-called 'Etna Valley', whose origin dates back to the decision of STMicroelectronics to locate some of its R&D facilities in Catania (Santangelo 2004). G.P.'s patents in our database are eight, three of which are for STMicroelectronics, the remaining ones for Italtel, once the manufacturing arm of Telecom Italia (when the latter held the monopoly over Italian telephone services), now a service company jointly shared by Telecom Italia and Cisco Systems.

STMicroelectronics also plays an important role in explaining the high brokerage score of R.Ca., a professor of Electronics at the University of Pavia. All 28 KEINS patents signed by R.Ca. belong to STMicroelectronics. In particular, R.Ca. is the founder of Microlab, a joint initiative of his university and STMicroelectronics that signed contracts also with Conexant Systems, Lucent Technologies and National Semiconductor, among others. More recently, R.Ca. played a key role in the decision of Marvell Semiconductor, a US multinational, to open an R&D centre in Pavia, and to locate its Italian headquarters there.

Also P.C., who heads the pharmacy department of the University of Parma, has been the promoter of a university consortium, Tefarco_Innova, for the production innovative pharmaceutical technologies. Before then, P.C. signed a number of patents for several pharmaceutical companies (ten different assignees for 24 patents).

Finally, R.Co. is the academic 'broker' with the longest experience in foreign universities, first in Cambridge, then in Heildeberg. A molecular biologist, he came back as full professor at his alma mater, the University of Naples, in 1980. In 1990 he also became head of IRBM–Angeletti, a laboratory staffed with over 150 researchers under the control of the pharmaceutical multinational Merck and located in Rome. Most recently (December 2007), he was shortlisted for the presidency of CNR (Centro Nazionale delle Ricerche), the largest public research organization in Italy. All of his six patents in our database are assigned to IRBM–Angeletti. He's the founder of an academic spin-off presently hosted within the premises of a consortium of private and public institutions in Naples.

With the exception of R.Co., all the academic inventors with a brokerage score over ten also have a comparable gatekeeper score. Among those who have a very high gatekeeper score but a broker score of less than ten, five have a gatekeeper score over ten.

The top gatekeeper scorer among them is L.N., a chemical engineer from the University of Naples with a long record as promoter of public and joint public–private research consortia, which ultimately launched into quite a remarkable political career, which culminated in his appointment as Minister for Reform and Innovation in the Public Administration, from 2006 to 2008. Almost all of his ten patents have different assignees, one which is L.N. himself (three are assigned to as many individual inventors: one to the Ministry of University and Research, one to the University of Brighton in the UK, and the remaining to Italian and foreign multinationals).

Another academic 'gatekeeper' of some relevance is M.M., who is presently deputy rector of the University of Urbino and was until recently the president of CIB, the Inter-University Consortium for Biotechnologies, to which 25 Italian universities are affiliated. He also is the assignee of one of his three patents in the KEINS database, alongside with his co-inventors; the other two belong to the European Union and to a local company, respectively.

Finally, G.G. also deserves some mention. He is full professor of telecommunications at the Tor Vergata University of Rome and a leading expert in radar technology, having represented Italy at a number of international organizations involved in air traffic control, such as ICAO (the International Civil Aviation Organization) and Eurocontrol (European Organisation for the Safety of Air Navigation). Four out of his 11 patents are assigned to his university, all the others, but one, to Selenia, now Selex–S.I., a manufacturer of professional electronic systems belonging to the Finmeccanica group.

These short biographical notes suggest that high brokerage and gatekeeping scores are not necessarily associated with in-between positions across companies, but only to in-between positions across co-inventors: several of our 'brokers' have patented just for one or two assignees, although they have worked with many different of the assignees' employees. All brokers and gatekeepers, however, appear also to have consulted for or cooperated with a variety of assignees, both from the business sector and from the public one (public research organizations, universities and consortia).

4.3 How good are brokers at keeping in touch with co-inventors?

Brokerage scores calculated so far amount to structural properties of the network of inventors, and of nodes therein. They do not tell us anything about the quantity and quality of information or knowledge which academic inventors may pass on or receive from co-inventors.

In this section we report the results of three questions asked to academic inventors about their relationships after the patent was applied for. In the first question it was asked whether the inventor and the co-inventor had worked together on any research project after the patent (the question was asked separately for each co-inventor). In case of a negative answer, a second question was asked, about whether the inventor foresaw any chance of future research cooperation with the co-inventor. In case of a further negative answer it was asked whether at least the inventor and the co-inventor were still in touch, for occasional exchanges of information.

Here we summarize answers to the first two questions in a 'cooperation' variable, which takes value one in case of a positive answer to at least one of the two questions, and zero otherwise. Another variable, 'contacts', takes a value of one in case of a positive answer to at least one of all the three questions, and zero otherwise.

Table 7.7 shows that instances of after-patent cooperation are much more frequent when the co-inventor is an academic, rather than an industrial researcher or a student: academic inventors have engaged or foresee to engage in more joint research effort with almost one out of two academic co-inventors, but only with one out of four industrial ones (and a bit less than one out of three students).[9]

As one may expect, academic inventors are still in touch with the vast majority (84 per cent) of their academic co-inventors. They are also in touch with the majority of their (former, at the time of the questionnaire submission)

Table 7.7 After-patent research cooperation and contacts, by affiliation group of the co-inventor (% of co-inventors)

Co-inventor's affiliation	*Research cooperation*§	*Contacts and info. exchanges*§
Academic	47 (135)	84 (128)
Industrial	25 (148)	45 (145)
Student	29 (24)	63 (24)

Note
§ Number of valid answers in brackets.

students (63 per cent), and a much lower percentage of industrial researchers (45 per cent).

A research question of immediate interest is the following: are academic inventors with high brokerage scores any better, or just more interested, at keeping in touch with their co-inventors? A positive answer would suggest that they may be pursuing the brokerage position in order to manage actively and take advantage of it, or at least that they take advantage of it once they reach it.

Logit regressions in Table 7.8 try to answer the question. Units of observations are inventor–co-inventor pairs, and the two dependent variables considered are the 'cooperation' and 'contacts' variables described above. The independent variables are pretty much the same as those summarized in Table 7.5. Once again, parameters do not lend themselves to an immediate interpretation as marginal effects of the regressors, which we report in the comments to the tables.[10]

Specification (1) includes as regressors the academic inventor's scientific productivity, number of patents and age (and related quadratic terms, if significant), as well as dummies for the academic inventor's rank and disciplinary affiliation, and for the co-inventor type (industrial researcher or student, with academics as the reference case). It also includes the academic inventor's brokerage, gatekeeping and coordination scores (liaison scores cannot be included, due to multicollinearity problems).

We notice that the number of patents signed by the academic inventor negatively and significantly affects the probability of the latter collaborating further on research with the co-inventor: obviously, academic inventors with many patents face increasing opportunity costs for maintaining strong ties with all co-inventors than with their colleagues with fewer patents.

We also notice that academic inventors are less likely to maintain research links with industrial researchers, as opposed to academics and students (the coefficient for students is negative but not significant). This result holds regardless of the academic inventor's rank and number of patents.

Finally, we notice that high brokerage and coordination scores negatively affect the probability of further research cooperation with both academic and industrial co-inventors; on the contrary, higher gatekeeping scores increase such a probability. This is tantamount to saying that academic inventors who are central in one of the two groups of co-inventors, but do not stand in between the groups (as gatekeepers do), entertain weaker relationships with their co-inventors. One

Table 7.8 After-patent research cooperation and contacts; logit regressions over brokerage scores and co-inventors' characteristics

	Cooperation – All co-inventors (1)	*Contacts – All co-inventors* (2)	*Contacts – Academic co-inventors only* (3)	*Contacts – Industrial co-inventors only* (4)
Productivity	0.02	0.23**	0.47*	0.16
	(0.07)	(0.09)	(0.26)	(0.12)
No. of patents	–0.44***	0.00	–0.17**	0.48**
	(0.13)	(0.04)	(0.09)	(0.20)
(No. of patents)²	0.01**	–	–	–0.01**
	(0.00)			(0.01)
Age	–0.01	0.02	0.09	0.04
	(0.03)	(0.03)	(0.07)	(0.04)
Associate prof.	–1.39**	0.38	–0.72	2.13**
	(0.61)	(0.58)	(0.99)	(0.97)
Assistant prof.	–1.38*	–0.57	–1.06	0.24
	(0.71)	(0.66)	(1.13)	(1.00)
Chemistry	–2.41***	–3.18***	–1.25	–6.14***
	(0.54)	(0.73)	(0.81)	(1.71)
Electronics & telecom	0.73	–1.01	1.30	–3.81***
	(0.70)	(0.87)	(1.15)	(1.69)
Pharma	–3.09***	–2.38***	1.88	–6.15***
	(0.64)	(0.77)	(1.25)	(1.68)
Broker	–0.03	–0.07***	–0.04	–0.13***
	(0.02)	(0.02)	(0.04)	(0.04)
Gatekeeper	0.06**	0.08***	0.05	0.15***
	(0.03)	(0.03)	(0.05)	(0.05)
Coordinator	–0.13**	–0.22***	–0.15	–0.47***
	(0.06)	(0.06)	(0.11)	(0.15)
Industrial	–1.31***	–1.91***	–	–
	(0.35)	(0.33)		
Student	–0.90	–1.35**	–	–
	(0.58)	(0.56)		
Constant	4.46**	2.34	–2.95	0.65
	(2.08)	(2.11)	(4.60)	(3.09)
Obs	337	325	141	160
LogL	–147.6	–157.6	–44.6	–74.6
LR chi²	134.68***	117.97***	54.01***	71.31***
Psuedo R²	0.31	0.2724	0.3769	0.3233

possible explanation is that academic inventors with a high brokerage score and a low gatekeeping score may in fact be consultants, whose patents stem from several short-lived collaborations with industry. On the contrary, gatekeepers whose ties with industry arise alongside those with the rest of academia via public–private ventures and consortia maintain more stable relationships with all co-inventors. As for coordination scores, we know that they are much lower than brokerage and gatekeeping scores, which possibly indicates that academic inventors with high coordination and low gatekeeping scores (that is, pure coordinators) have fewer patents, which in turn arise from more occasional projects.

Finally, we note that discipline dummies are very important: a median academic inventor from chemistry or pharmaceutics has 50–64 per cent less probability of maintaining research ties with co-inventors than a similar academic inventor from biology or electronics and telecommunications. Marginal effects for assistant and associate professors, compared to full professors, are around –22 per cent, which is also the marginal effect for co-inventors being industrial ones.

Columns (2) to (4) regression exercises parallel those in column (1), but with reference to looser contacts, such as those for mere information exchanges. Here we note a different impact for scientific productivity and number of patents. The former has a significant coefficient in all specifications except (4), the latter on the contrary appears significant only in this specification. This suggests that highly productive academic inventors tend to maintain contacts with more co-inventors than less productive ones, but this holds for academic co-inventors and not for industrial ones. At the same time, having many patents is associated with keeping in touch with many more co-inventors from industry, but not from university (in specification (3) the sign of the coefficient for the number of patents is indeed negative and significant); however, such contacts are not for research, but for more generic exchanges of information.

The effect of academic rank on the probability of maintaining contacts with co-inventors is less marked than in regressions on research cooperation: full professors do not appear to behave differently from assistant professors, while associate professors seem more likely to maintain contacts than colleagues from both the other ranks, but the effect is significant only in specifications (2) and (4). Effects of disciplines are significant in all models except (3), which suggests they mainly refer to relationships with industrial co-inventors (that is, the probability of maintaining contacts with academic co-inventors does not vary across disciplines).

Coefficients in model (2) suggest that contacts and information exchanges, like research cooperation ties, are maintained with different probabilities according to the type of co-inventor. In this case, contacts with both industrial and student co-inventors are less likely to be maintained than those with academics.

The impact of brokerage, gatekeeping and coordination scores differ across types of co-inventors. In specifications (2), which refers to all co-inventors, and (4), which refers only to co-inventors from industry, all coefficients are significant. However, contacts with university co-inventors are maintained regardless of the network position of the academic inventor. Overall, this suggests that gatekeepers, as opposed to pure brokers or coordinators, do a better job of keeping in touch with industry, while relationships within the academy do not depend on the scientist's position within the network of inventors.

5 Conclusions

In this chapter we have adapted a set of brokerage and gatekeeping measures proposed by Gould and Fernandez (1989) that may be of help in clarifying the relationship between academic inventors and their co-inventors, whether from industry or from the academic or student body.

We find out that brokerage and gatekeeping positions are very few, and they are held by scientists with both a large number of patents and a strong publication record. Brokers and coordinators are not especially better than colleagues at further cooperating on research with co-inventors after the patent experience. Gatekeepers, do better, especially when it comes to keeping in contact with industrial researchers. More generally, network ties between academic and industrial researchers may be short-lived as far as knowledge exchanges are concerned, but may serve well other purposes.

The joint reading of our quantitative evidence and the top brokers' biographical notes suggests that the latter manage actively their relationships outside university. Some of them, especially those who have signed patents only for one or two different assignees, are likely to keep in touch mainly for research or research-funding purposes. Others, such as those academic inventors with many different assignees and/or many assignees such as public consortia and the likes, may nurture their personal links outside universities for more strategic purposes. The existing literature on university patenting has focused almost exclusively on academic inventors' monetary incentives (Lach and Shanckerman 2003; see also Stern 2004, for a more general treatment). Here we find that the social contacts gained through collaboration with industry may be part of the reward, as they help boosting the academic inventors' reputation and career both inside and outside the university.

Future research will have to test further this hypothesis through the collection of longitudinal data on academic scientists' careers, and more detailed questionnaire data on the exact contents of the information exchanges between academic inventors and their co-inventors, both during and after their collaboration on the patent. Longitudinal data will help testing whether social contacts with industrial co-inventors do help academic inventors throughout their career, while refined questionnaire data will also help building a directed graph, thus allowing more precise applications of the brokerage concepts and scores.

A related research line will possibly investigate benefits enjoyed by students of academic inventors with high brokerage scores. Data from the KEINS database for Italy have already been exploited to find out whether master's students supervised by academic inventors have easier access to the labour market, with positive results (Zinovyeva and Sylos Labini 2007). Inclusion of brokerage scores and extensions to other countries will help confirming the general validity of this result.

Notes

1 Università di Brescia and KITeS–Cespri–Università Bocconi.
2 US universities have been entitled with the IPRs over federally funded research since 1980, with the introduction of the Bayh–Dole Act, which has been imitated only recently by a few European countries. Some of the latter, in addition, held for long (or still hold now) the so-called 'professor's privilege', by which all inventions produced by university professors do not belong to their employers (as it is the norm with business companies and their R&D staff), but to the professors themselves, who dispose of them freely. And even in countries where the 'privilege' never existed, university professors are civil servants under direct control of the state, whose disclosure duties towards their universities are rather unclear. More on this in Lissoni *et al.* (2008).
3 The major limitation of the KEINS database for Italy is that it includes only those professors and researchers who had passed a competitive examination for a tenured position (from now on, we will refer to them simply as 'professors'). Thus our data miss the large number of fixed-term appointees who, at the time, had been working in one or more universities for one or more years, as well as all the PhD students, post-doc fellows and technicians. In the current Italian system, assistant professor (called 'researcher') and associate professor positions, despite being only the first two steps of the academic career ladder, are not offered as fixed-term appointments, but as tenured ones. The main differences with the position of full professor lie in wage and administrative power and responsibilities.
4 For a more general treatment of the advantages and disadvantages of using archival data, as opposed to questionnaire results, as inputs for social network analysis, see Burt (1983).
5 In the absence of direction, it is impossible to distinguish between gatekeepers and representatives.
6 The ego-networks of inventors *224212* and *135223* share a common co-inventor/node, which explains the line linking them.
7 We report the results of the regression including 'late productivity' instead of 'productivity' only for the case with the broker score as the dependent variable. Results with different dependent variables are pretty much the same.
8 The academic inventors mentioned in this section checked and amended their biographical information, after a brief email exchange.
9 The number of co-inventors for which valid answers have been obtained is very low compared to the number of co-inventors whose affiliation could be retrieved. This is due to the fact that, even in the absence of valid answers to the questionnaire by one academic inventor, some information on his co-inventors' affiliation could be obtained by other academic inventors who also knew those co-inventors. It is also due to the fact that the questionnaire was rather long, and questions on after-patent cooperation were asked at the end of the interview, when many interviewees (especially those with many co-inventors) said they had run out of time and declined to answer any more questions.
10 They are available on request.

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8 New innovators and knowledge-intensive entrepreneurship in European sectoral systems

A field analysis

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1 Introduction

This chapter is about the characteristics and factors of survival and success of knowledge-intensive entrepreneurship in some sectoral systems in Europe. Literature and evidence on the US case are rather rich and detailed but the European case is relatively less explored and documented. Also, in both cases, existing studies are concentrated on a limited number of sectors. They rarely take on a cross-sector cut. Differently, this chapter proposes a cross-sector and cross-country comparison at the European level with a specific focus on some key elements in the process leading to the birth, start-up and early evolution of a new firm.

In particular, this chapter reports and comments on the results of a survey conducted on a sample of companies defined as new innovators, i.e. recently founded firms able to innovate soon after entry into the market, and active in selected technologies characterized by strong innovative and competitive dynamics in the last 15 years: biotechnology, electronics and medical devices.

In the rest of the chapter, we first present the research streams that inspired this work and from which we draw the main dimensions to be analysed (Section 2). We next present the methodology used in this study (Section 3) and describe and comment the results of the questionnaire (Section 4). Finally, we present some concluding remarks (Section 5).

2 The main variables and dimensions considered

The literature on entrepreneurship and new ventures creation has largely investigated the determinants and factors of success of (innovative) start-ups and has tried to assess their relative importance, especially in technologically highly dynamic contexts in which innovative capabilities are crucial.

These factors include, among others, the human and intellectual capital of the founders and the personnel available to the new venture, the access to external sources of financing, the intellectual property rights (IPRs) portfolio, the

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