Theme 4: Universities as interactive partners

Academic inventors and patenting activities: a case study on University-owned and University-invented patents in two Italian universities

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Abstract

The contribution of the academics to the process of invention is not restricted to the direct patent activity of a university. As already known, very often, in particular in Europe and in Italy, patents are assigned to subjects different from universities: private firms, research bodies, inventors. Looking at the role of university in knowledge exchange, it seems very important to take into account the two forms of patenting to which academics contribute: patents directly owned by universities (*university owned*) and patents owned by other organisations (*university invented*) in which academic inventors play a key role. In this study, we use Social Network Analysis to compare the co-invention network generated by the academic inventors, tenured by one of the two Italian universities located in Friuli Venezia-Giulia – when their patenting activity is made with their own university or with different organisations, such firms and public research organisations. Three sub-network structures are detected that seems to characterize in different measure the two Universities and more in general, the interaction of academics with the external world. From a methodological point of view, and as far as invented patents are concerned, the paper points to the importance of the cross-link between firms and prominent academic inventors (brokers) in the process of knowledge transfer and to a strong complementarity between academic patenting and the various possible forms of cooperation with external actors that academics (and Universities) deal with.

Keywords: Academic patenting, Science-industry linkages, Social network analysis, brokerage roles.

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1. Introduction

In recent years the number of patents owned by Universities has been growing at high speed in Italy and in Europe following science and innovation policy strategies that placed at central stage the role of patenting in innovation and hence in fostering competitiveness and growth. However, a substantial body of literature has shown that this form of patenting was, at least in the past, in Europe and only a part (a minor part) of the overall patenting activity of academics which very often cooperate in inventions owned by external organisations (Meyer, 2002; Balconi *et al*.2004; Balconi and Laboranti 2006; Crespi *et al.* 2006; *Lissoni et al*.,2008; Thursby *et al*. 2009; Geuna and Rossi, 2011; Lissoni 2012).

The mentioned literature showed, in particular, that to analyse the complete mechanism of knowledge exchange between science and the market we should take into consideration the whole process of the patenting activity of the academics. This can be done by taking into account the different kinds of ownership that patents can take: the case in which patents are assigned to the universities (*University owned patents*) and the case in which patents are assigned to other organisations (*University invented patents*). These two subsets can also some time partially overlap because of the presence of co-assigned patents in which there is at least one University and one different organisation[1].

This distinction is also reflected in the general literature on patenting, where we can single out two main approaches: the one that considers patenting from the point of view of the organisations – looking at understanding strategies and performance of different subjects (firms, universities, public research organisations) – and the other that considers patenting from the point of view of the individual inventors, possibly connected to different organisations. The choice of the unit of analysis is closely connected to different research questions: in the first case, the focus is on the strategies of the organisations, while in the second approach the attention is more oriented toward understanding the patterns of knowledge diffusion.

However data on patents make it possible to consider jointly both information on individual inventors and on the organisation's ownership allowing us to better understand the role of patents, and in particular of the invented patents, in shaping the patterns of collaboration between science and industry, that represents an important part of the triple-helix mechanism (Leydersdorff and Meyer 2003, 2007)

From a methodological point of view, in recent years Social Network Analysis (Wasserman and Faust, 1994) has received increasing attention as a tool for understanding the pattern of knowledge diffusion (and

[1] For the sake of completeness, it should be considered that there can be patents assigned only to inventors, but in our framework this case is subsumed in the case of university invented patents

ultimately of innovation) and the importance of network ties inside it. In particular, the role of academic patenting in the knowledge diffusion process is extensively analysed in a flourishing stream of literature (e.g., Balconi et al. 2004, 2006; Breschi and Lissoni 2009; Breschi and Catalini,2010; Lissoni et al. 2011) that shows (*inter alia*) how knowledge diffusion is related not only to the characteristics of the academic inventors (and to their productivity as scientists) but also to their position in the social network of inventors.

In the present paper we explore the co-invention networks generated by academic inventors employed in two Italian universities, namely the University of Trieste and the University of Udine, both located in Friuli Venezia Giulia region involved in the two forms of academic patenting (University owned and University invented patents) in order to understand possible structural differences in the network generated by the two forms of patenting, keeping both information at the ownership level (assignees) as well as at the individual level (inventors). In our opinion, the position of individual inventors – especially the academic ones – in the social network of inventors has importance to the extent they can have access to various organisations different form the ones in which they are employed. This is especially important if we look at the process of knowledge diffusion form academic to the market. For this reason, we keep both level of analysis – individual and organisational – in our networks in order to understand how the two different forms of patenting (University owned and University invented) produce differences in both whole network structure and individual inventor network positions.

The analysis is carried out in different steps. Firstly, the structural characteristics of both networks are detected and inventors' centrality according to their brokerage roles is measured (Gould and Fernandez, 1989; Lissoni, 2010). Secondly, the attention is shifted to a micro-level approach to detect different sub-network structures in which academic inventors play brokerage roles in connecting different subjects and in particular academia to the external world.

The results of the network analysis are then used to identify the subjects for in-depth interviews, aiming firstly, at understanding the quality of information arising from the identified network ties, and secondly to explore some important aspects of academic patenting activity: the reason why academics patent with their own universities or with different subjects; the complementarily of the two forms of patenting as well as between patents and other possible channels of cooperation

The paper is structured as follows. In sect.2 we describe theoretical and methodological aspects related to network construction from patent documents. Next, in sect. 3 we describe the data used to construct the co-invention network of the two Universities. In sect.4, we present the main characteristics of the co-invention networks and some peculiar structures that arise from the collaboration of academic inventors and external actors. In sect.5, the results of a qualitative analysis on key academic inventors are discussed. Finally, some concluding remarks and open questions for further research are summarized (Sect. 6).

2. Patent data and network construction: theoretical aspects.

The application of network analysis to the invention process is extensively discussed in the economic literature (see among others, Balconi and Laboranti 2006; Fleming *et al*. 2007; Uzzi *et al*. 2007; Lissoni *et al*. 2011). Usually, the analysis is carried out on the co-invention network constructed on the basis of inventors' collaboration (e.g., Breschi and Lissoni 2009) or by means of the cited documents inside each patent (Verspagen, 2005) because of the main assumption which states that knowledge diffusion is related to individual inventor position in the social network of inventors.

Consequently, when Social Network Analysis (SNA) is applied to the study of co-invention networks, assignees are excluded, because of two main reasons: *i*) the heterogeneity of the two kinds of nodes; *ii*) the presence of a hierarchical structure arising from the fact that inventors can be nested into assignees (and into other organisations). In fact, typically (but not always) assignees and inventors belong to different levels of analysis as they are usually represented by organisations (ownership level and organisation level) and individuals (individual level), respectively.

However, considering together ownership level, individual level, and organisation level (assignees excluded)[2] seems particularly important in studying academic patenting because in this way we introduce in the analysis the information on relationships between inventors and between inventors and organisations (as assignees but also as organisations to which inventors belong).

When assignees are not excluded, the observed networks – directly derived from patent data – are made up of various types of actors (or nodes) and relationships.

Concerning the actors we can distinguish at least three categories:

- *inventors* (as individuals);
- *assignees* (organisations or individuals);
- *organisations to which inventors belong* (that can be assignees or not)

Only the first two actors are directly observable whereas the third one depends on the availability of individual inventor information, collected from sources external to patent data. Notwithstanding, this third actor category is of not minor importance in the process of knowledge transfer.

[2] It is worth to note that higher level of analysis (i.e., the organization level) is not only composed of assignees (ownership level) but also of all that organizations to which inventors may belong (membership level).

As far as relationships are concerned, in such a network we can *a priori* identify five different kinds of links which can convey different level of intensity of knowledge:

- *co-invention*: inventor-inventor link (I);
- *co-assignment*: assignee-assignee link[3] (A);
- *membership:* inventor-assignee or inventor- organisation link (M);
- *observed cross-level link:* inventor-assignee link (OIL);
- *unobserved cross-level link*: inventor- organisation link (UIL).

The above described relationships are observed, partially observed and completely unobserved (i.e., latent) in the network (see figure 1). This is due to the fact that organisations different form the assignees are not observed (at least not from patent data). More specifically, relations I, A, and OIL are directly observed; *membership* is only partially observed (when inventors are employed in the assignee organisation); *UIL* is latent (unobserved unless of external information availability).

Co-invention relations are the typical collaboration ties among inventors and it is the most important knowledge exchange mechanism between intra-level actors (at the individual level). Co-assignee relations can typically be considered an intra-level relationship (at the ownership level) and it may convey scarce knowledge transfer being mainly an inter-organisational agreement.

Membership is a form of cross-level linkage that is important for other types of relations, which are fundamental in knowledge transfer process. In particular, we are referring to the relationships among academic and industrial inventors that carries a “latent” or “implicit” relation between each of them and between the organisation to which they are affiliated. Such a latent relationship can convey knowledge spillovers and, possibly, gives rise to a variety of different forms of cooperation, which is one of the focuses of our analysis. We distinguish two types of such relations on the basis of their observability in the data, namely OIL and UIL. In particular OIL is observed by means of the link between individual inventors and assignees, whereas UIL is not observed because organisations (not assignees) are not included in the patent data.

In our opinion, these cross-level relations are important in understanding knowledge exchange and spillover effects, mediated by patent. The motivation to this importance is due to the different functioning of the two main organisations involved in academic patenting activity – universities and private firms – the first, belonging to the open-science environment are not hierarchical organized and academic scientists are able

[3] This link can also represent an inventor-inventor link (or inventor-assignee link) whenever the individual inventor is registered as assignee of the patent. In the following we disregard this possible complication because we assume that the inventor co-assignment relationship between inventors is “absorbed” by the co-invention link.

to get in direct contact with external actors (i.e., private firms) allowing to directly convey their (research-based) knowledge outside of the academia. Therefore cross-level relationships are standard, tangible and their effect in knowledge diffusion processes should not be neglected. Our main assumption is that cross-level relationships are one of the core channels of the patent-based knowledge transfer.

In this paper, the network is constructed directly from patent data and nodes are represented by all the inventors as well as the assignees that contribute to the realization and the publication of the patent, whereas relationships are: A, I, M (only inventor-assignee part), and OIL. In general this is true for all networks constructed following our strategy. UIL relations are not observed as links, so they are not analyzed here even if their effect involves spillover.

3. Data description

We collect data on academic patents of two Italian Universities, namely University of Trieste and University of Udine. These two universities present an interesting case study because even if they are both located in Friuli Venezia Giulia – an Italian region of medium size (1.4 million inhabitants) – the areas in which they operate are pretty different. Trieste University is surrounded by numerous (mainly international) PROs while Udine University by several manufacturing large firms and SMEs.

In order to collect patent authored by academic inventors employed in one of the two universities, we extend the methodology already adopted in the literature (Meyer et al., 2005; Lissoni et al., 2006). Specifically, we retrieve all patents registered in EPO, USPTO, and WIPO databases, in which at least one of the reported inventors associated to Udine or Trieste geographic areas. We compare then the list of inventors to a data base of all the academics employed either at the University of Trieste or University of Udine in the period 2000-2010.

The resulting data set is composed by 118 academic patents (56 for the University of Udine and 62 for that of Trieste); 50 of them are owned by one of the two regional universities and 68 are derived from the collaboration of at least one academic inventor to patents owned by external organisations.

Academic inventors, are classified by their scientific field, whereas non-academics, according to their affiliation to one of the three above mentioned organisation categories.

Assignees other than the two universities have been classified in three different categories according to their principal characteristics: private firms, public research organisations (PROs), and public sector organisations (including hospitals and governmental institutions). For every assignee we identified the relevant industry (according to the official Italian Ateco classification) and localization (regional, national and international).

Data are briefly summarized in Table 1, considering only researchers holding permanent positions[4].

Table 1 Distribution of patents (by ownership), inventors and assignees.

	University	
	Trieste	**Udine**
Academic Patents (Total)	62	56
owned by		
*Only Universities**	25	25
Only Firms and/or Research bodies	29	21
Only group of inventors	8	10
*Co-patented bet. Universities** and Firms/Research bodies*	7	3
Academic inventors**	43	44
Assignee (*Firms, Research bodies, Public*)	26	17

* Local Universities (Trieste and Udine)
** Ph.D., post-doc and students are not included

Taking into account a broader category (non-fixed term researchers, doctoral students and student), the total number of researchers working around the academia rises to 59 and 71 for Trieste and Udine University, respectively.

The distribution of academics by scientific fields provides evidence of a clear pattern of specialisation, characterised by the presence of an Udine specific scientific field (Agricultural and Food) and a higher quote of researchers in Biology and Chemistry for Trieste. It is worth noting the importance of engineering in both universities.

From the network of collaboration in patenting activity, we observe that the total number of inventors (in both universities and excluding possible overlapping) is 278. In the large majority, they participate to only one patent. Very few of them are multiple inventors. Two inventors participate to more than five patents. The

[4] Weighting these numbers on the average of researchers employed in the period 2000-2010 in each of the two universities, the percentage of academic inventors varies from 5% (Trieste) and 7% (Udine). If we consider only researchers of scientific areas the percentage almost doubles: a data quite higher than that reported by Lissoni (2012) on the basis of a more general data.

average dimension of groups of inventors is around 2.5, without substantial differences between the two universities. The large majority of groups have from three to five members.

Looking at the distribution per patent class both universities have a relatively high number (about 20% of the total patents) of patents in medical and veterinary science (A61 IPC code); besides this common feature some peculiarity emerges: for Trieste University organic chemistry (IPC code C06, 20.6%) and biochemistry (IPC code C12, 8.8%) are the most important patent classes, while in the case of Udine a prominent position is taken by textile laundering (IPC code D06, 19.4%).

The number of assignees other than the two universities is limited (Table 1), because some of them own more than one patent. They are in large majority private firms (mainly in pharmaceutics sector and in medical apparatus and therapy) and are, with some exception mainly multinational firms. It is worth noting the presence of some international universities and PROs cooperating with each of the two universities as co-assignees.

4. The results of the network analysis

4.1 Global network structure

The analysis of the pattern of collaboration in patenting activity gives rise to co-invention networks of the two universities which are slightly different in size: 145 inventors and 26 assignees for the University of Trieste, and 148 inventors and 18 assignees for Udine. Looking at the global network indexes, both networks exhibit a similar structure: low density, high centralization, similar average degree (Table 2). In particular, networks are strongly centralized around the two universities, due to their role of assignees (or co-assignees) of more than the two thirds of total patents considered.

However, looking at the sub-network level some non-marginal differences emerge.

The most noticeable of them is the extension of the giant component, which mainly includes owned patents and to a lesser extent (especially for Udine) invented patents. The giant component is larger for the University of Trieste, including 73% of total nodes, whereas in the case of Udine, this percentage is about 56%. This fact seems to be an indicator of a weaker attitude to interact in patent activities with external subjects, via co-assignee formulas as well as via inventors participating in patents owned by different agents.

In fact, in the case of Trieste, the network generated by University owned patents presents a large amount of multiple ties (i.e., inventors cooperating for the realization of University owned as well as University invented patents). Moreover, the cliques are quite heterogeneous, linking different types of actors (non-academic inventors, companies, PROs). In the case of Udine University owned co-invention network is almost completely disconnected from the University invented co-invention network. The external components are very large and the percentage of academic inventors involved in both activities is quite low. These differences at microeconomic level that seems to carry different characteristics of the knowledge transfer process motivate the attention devoted in the following to the sub-network structure characterizing the two universities.

Table 2. Network of inventors and assignee. University of Trieste and Udine.

	University	
	Trieste	**Udine**
Number of nodes	171	166
% of assignees	15.0	11.0
Patents	62	56
Density	0.036	0.038
Number of links	1024	1204
% of multiple links	7.3	3.2
Number of components	12	12
Number of nodes in the giant component (% nodes)	124 (73.4%)	103 (56.6%)
Number of cliques of Min. size 3	41	36
Average degree	12.1	13.9
Network Centralization	40.7%	47,0%

Before shifting the attention to these substructures it is useful however to we explore the co-invention activity at the individual level aiming at identifying the subjects that have a central role in the network.

4.2 Brokerage roles

Following Lissoni (2010), who adapts the frame of Gould and Fernandez (1989), we look for the the role that the academic investors can play inside the described network, excluding in this analysis the assignees. The four brokerage roles depicted in *Figure 1* can be described following Nooy et al. (2005).

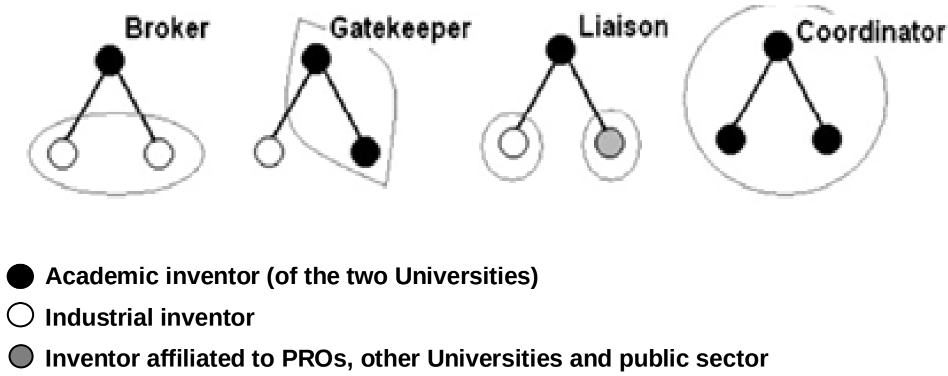


Figure 1. Brokerage roles (adapted from Lissoni, 2010)

Two roles involve mediation between members of a given group: the coordinator and the itinerant broker. Coordination involves mediation between members of the same group, itinerant brokerage, instead, implies coordination of inventors belonging to groups different from the one of the broker. The other two roles describe mediation between members of different groups. In one role, the mediator is a gatekeeper, who regulates the knowledge flow to his group from the outside. In the second, the liaison, she/he is an inventor who mediates between members of different groups but who does not belong to these groups himself. Given the objective of our analysis, we focus on the roles that imply mediation between different groups.

We identify some prominent actors in the network of the two universities. We find that itinerant brokerage roles are more present in the Udine network, whereas gatekeeping and liaison are overrepresented in the case of Trieste. In general, the distribution of brokerage scores are much more concentrated around few inventors (manly academic) in the case of Udine. Looking at the scientific sectors, we can say that chemists have a high connecting role in both sub-networks, whereas engineers act more often as itinerant brokers. The different sub-network structures described hereafter imply different brokerage roles played by academic inventors of the two universities.

4.3 Representative sub- network and prominent brokerage roles

From a previous analysis and from blockmodeling[5] results (Capellari and De Stefano, 2013) we identified (at least) three different kinds of sub-network structures emerging from the patenting activity of academics interacting with external (to their own university) actors. Inside these sub-network structures and

[5] For an introduction to blockmodeling see Doreioan et al. (2004) and De Nooy et al. (2011).

looking at the role and the interactions between academic inventors, non-academic inventors and assignees we are able to identify some of the previous described relationships (see sect. 2) taking into account especially the cross-level links in which scientists are involved.

The *first structure* is typical of academics of the two universities collaborating with scientist belonging to other open science organisations. As we can easily imagine, these structures are pretty common and similar across the two universities (although more frequent in the case of Trieste) in owned patenting activities. Co-patenting can be or cannot be present. This sub-network is depicted in the following in Figure 2 considering a particular case observed in the Trieste network. The central actor is a star scientist in chemical sciences and act as a gatekeeper connecting two different international open science organisation. The network ties detect real collaboration; the circles are scientists and triangles represent assignees.

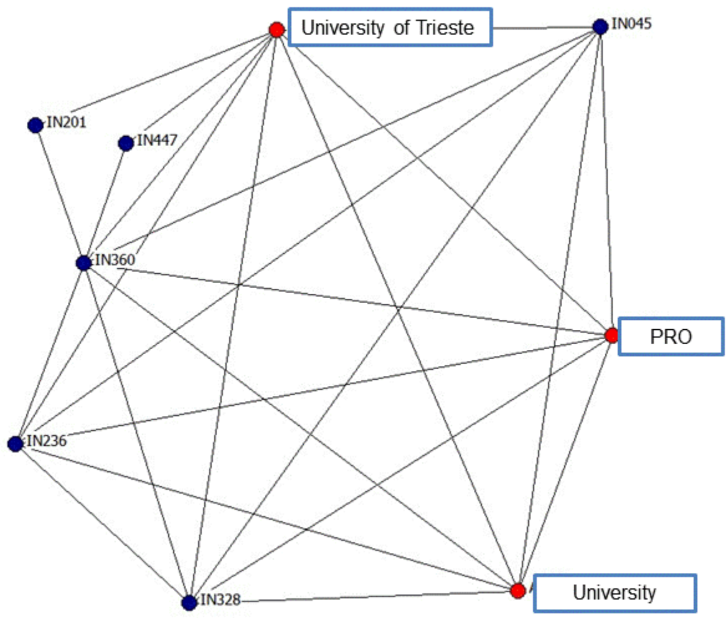


Figure 2. Type A. Cooperation with external open science actors. Blue circles represent inventors, red circles assignees.

The *second substructure* arises from cooperation between more than one academic scientist and one or more private firms along with role of the University as assignee. Therefore, these structures imply co-patenting among assignees. This kind of sub-network is often composed of strongly connected nodes where ties are activated by inventors or assignees involved in both owned and invented patents. Therefore, this substructure represents the leading bridging structure between Universities and private sectors (as well as other organisations as PROs). The sub-network is depicted in *Figure 2* is observed in the case of co-patenting in the Trieste network. The organisation involved here are a private firm and a prominent Italian

PRO. This connection has been observed through the membership linkage of IN044 to this specific organisation. This inventor plays a very important bridging role from the inside to the outside. Central scientists are three leading academic chemists. In particular INV183 and INV212, both having a gatekeeping role, connect actors belonging to different organisations.

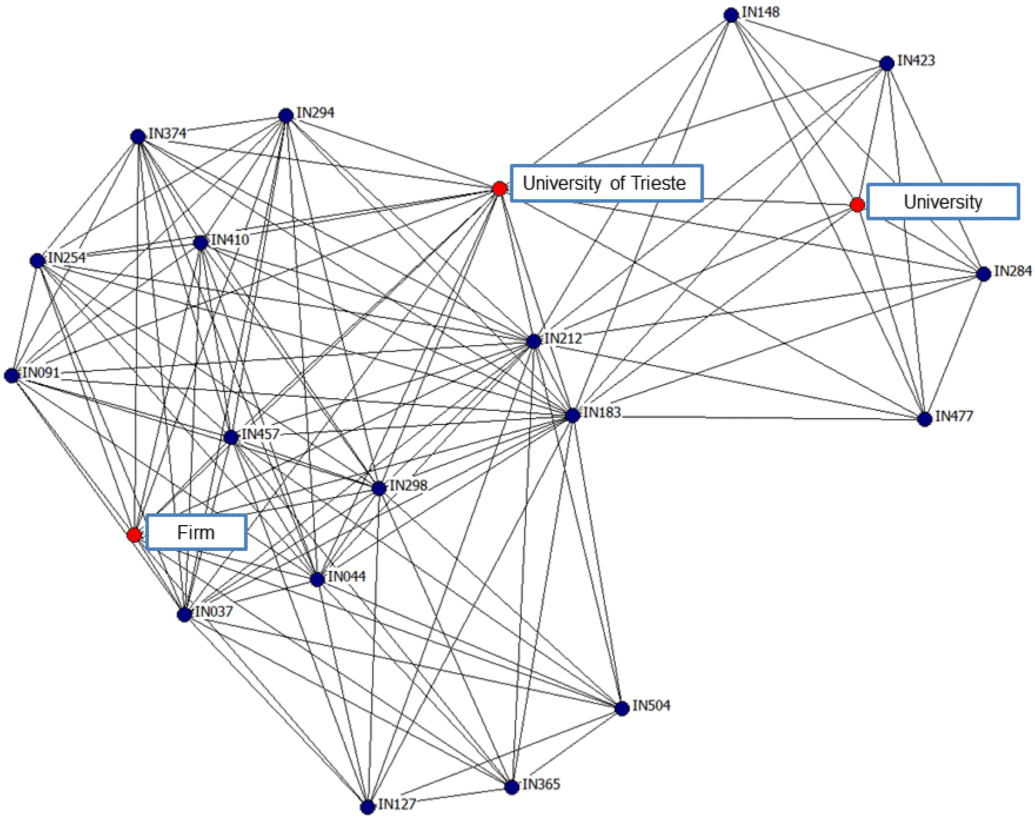


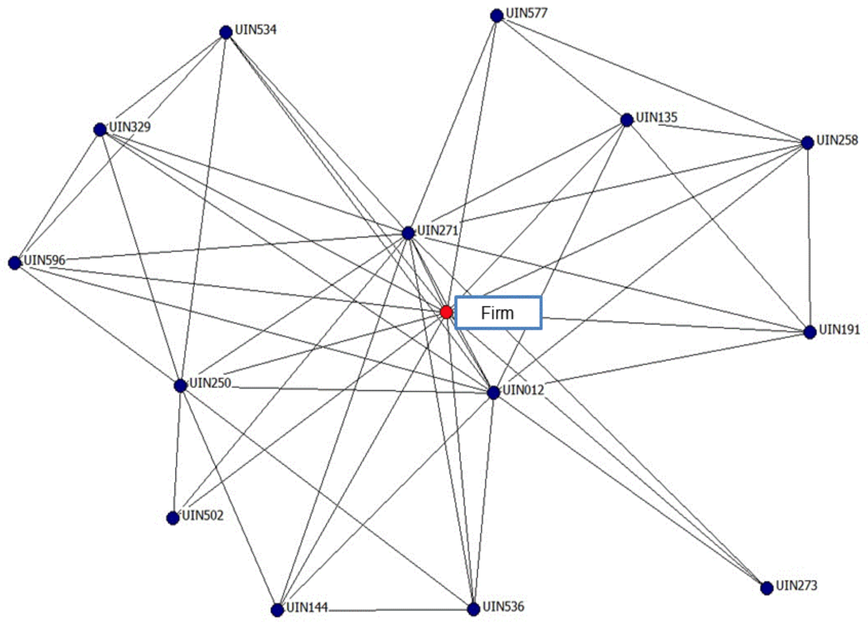
Figure 3. Type B. Multiple interactions and Co-patenting. Blue circles represent inventors, red circles assignees.

The *third structure* (Figure 4, disconnected sub-networks) emerges only from invented patents to which individual academics employed in the universities participate.

The first described case (Figure 4, *panel a*) consists of 14 nodes, in which there are only one academic inventor, acting as broker, connected by an external assignee (locally based multinational firm) and several external co-inventors.

Figure 4, *panel b* represent the case in which the academic plays a liaison role interacting with private firms and in the same time with external open science organisation (PROs and other universities).

Panel a)



Panel b)

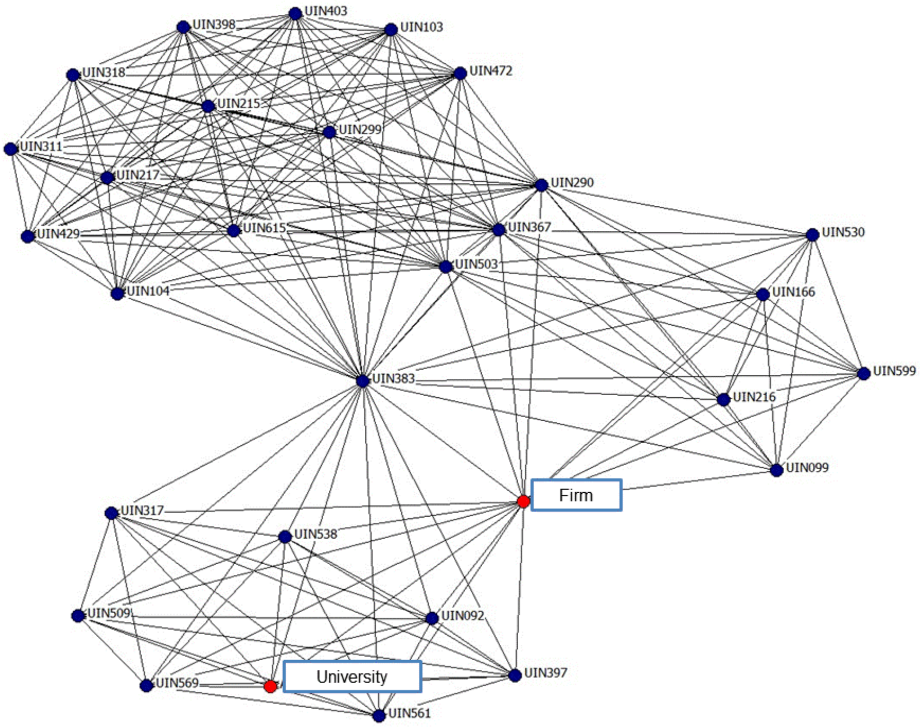


Figure 4. Type C. Disconnected sub-networks. Blue circles represent inventors, red circles assignees.

This sub-networks seems to represent a typical structure for invented patents, especially in the Udine network, where only an academic inventor – never involved in owned patenting – cooperates to the realization of the many patent of the same external assignee or of different and heterogeneous assignees (Figure 4, *panel a* and *b*).

The identified three sub-network types show different mechanisms of interactions between owned and invented patenting activities.

In type A the owned patenting activity is made up by internal university researchers involving collaboration with few external organisations. In type B, a strong interaction between owned and invented patenting activities is observed through the instruments of co-patenting and University research groups interacting external partners. In type C, invented patenting seems to not include owned activity and the network is made up by individual academic inventor contacts.

From an analysis focused on the specificity of the two universities, it emerges that Trieste mainly is characterized by the presence of type A and B sub-networks meanwhile Udine is characterized by the a few presence of type A sub-networks and by a net predominance of the sub-networks of type C.

Since the identified three sub-network types seem to represent a wide typology of interactions between universities and the outside world (opens science organisations, on the one hand, private firms on the other hand) that can be used in more general cases apart from the particular case study.

5. Qualitative analysis

The identification of the key actors – the academics playing brokerage roles – in the sub-network structures described in the previous pages is taken as a point of departure of the qualitative analysis. In the first place, the analysis is aimed at shading some light on the quality of the network links derived from patent data, an important topic not fully developed in the literature (Lissoni, 2010), and at verifying the existence and the importance of the cross-link between academics with external assignees, described in sect. 3. Then the general questions on patenting mentioned in the introduction are taken into consideration.

More specifically, the objective is to analyze the following interrelated questions:

1. The quality of the network ties based on patent data, in particular with regard to: real collaboration, direction of links; preferential link with assignee; hierarchical structure of collaboration with industrial inventors (when present);
2. The role of industrial partners if any;
3. Conditions that make it more reasonable to patent with their own university or with external organisations;
4. Complementarity or substitutability between patents and other different channels of cooperation and research with firms and markets (e.g., different possible kinds of research contracts).

We interviewed six key actors: One of them is a gatekeeper in the university owned sub-network type A (Figure 2); two are gatekeepers in the sub-network of type B (Figure 3); three are brokers or liaisons in the university invented network (in particular into the sub-networks of type C depicted in Figure 4)

The analysis seems to make us able to reach a reasonable set of conclusion related to the three kinds of network structures above identified.

In the following we discuss the analysis of the interviewed actors organizing the answer to the questions 1-4 listed before for the three types of sub-network.

Type A sub-network. Open science environment. Patents derive almost directly from the scientific work (Figure 2)

1) This is the typical sub-network of university owned patents with brokerage role arising from academic inventors that cooperate with external inventors affiliated to different open science organisations. The cooperation link arises from individual scientists and the role of the organisation to which they belong can be considered of secondary importance. The link is often mediated by previous professor-student relationships. We can define this structure as non-hierarchical (or horizontal).
2) Even if this structure refers to opens science organisations, a role of industrial partners is also recognized because of the necessity to develop or test the inventions through large scale and complex experiments.
3) Patenting with their own university is a way to recognize the economic effort made by the open science organisations and to give a reward for it. The patent can be thereafter licensed.
4) There are no conflicts in establish other types of cooperation with external actors, that seems to be highly complementary activities.

Type B sub-network. Multiple interaction and Co-patenting (Figure 3).

1) This typical sub-network of university invented patent is described in figure 3. The key actors are brokers and/or gatekeepers bridging not only scientists and industrial inventors but also scientist and private firms as organisations. This network exemplifies the importance of the cross-level links (sect.2). The academic inventors mainly involved in this sub-network have a brokerage role. The cooperation link they activate with external inventors is mediated by the organisations (firms) to

which they belong. The interviewed inventors underline that their linkages are governed by the firm headquarters (CEOs). Indeed, the industrial inventors named in the patents are not always the industrial researchers that worked to the research project that give rise to the patent but often also middle managers or even CEOs.

2) There is a decisive role of industrial partners because of the necessity of laboratories that can be rarely available inside universities. Cooperation with firms is essential also for the general academic research from which patentable results can emerge. Very often patentable results arise inside a previous research contract.
3) Essentially differences in efficiency and possibly in resources to be devote to take out and defend a patent.
4) There are no conflicts in establish other types of cooperation with external actors, that seems to be highly complementary activities.

Type C sub-network. Disconnected sub-networks (Figure 4)

1) This typical sub-network of university invented patent is described in Figure 4, *panel a* and *b*). The key actors are brokers and/ or gatekeepers, bridging scientists and industrial inventors but also scientists and private firms (or other organisations). This network, as the previous one, exemplifies the importance of the cross-level link mentioned when analyzing methodological aspects. The difference from the sub-network of type B, is that the two sub-networks are completely disconnected from university owned patents and the link with the University is only mediated by the one academic inventor. The cooperation with industrial inventors can be more or less intense. Sometimes the industrial inventors named in the patents are the real researchers (or, as type B sub-network, they can be middle managers or even CEO's).
2) There is a decisive role of industrial partners: patents arise from different degree of involvement of scientists in industry (form contract research to the direct responsibility and management of a sector of the firm's research).
3) There are no reasons why you should patent with your own university, being the results achieved in a context where the resources pertain in large part to the industrial partner.
4) There are no conflicts in establish other types of cooperation with external actors, that seems to be highly complementary activities.

Summarizing, we can single out some interesting points.

The first one is related to the goodness of the “horizontal” cooperation link among scientists and between scientists and industrial researchers. As far as scientists are concerned, ties represent a real cooperation linkages inside the research project that gave rise to the patent.

In a general sense, this is also true in the case of industrial researchers, paying attention to the fact that often it is the managers and not only the researchers involved in the project who are named. In fact inside the firms different formal or informal rules of attribution of patent rights can exist.

The second remark is that, when firms are involved, cross-links play a very important role because the scientist gets into contact and operates first and foremost with the management.

Thirdly, very often patents arise in a context of other forms of cooperation between scientists and firms and consequently we can observe a strong complementarily between different forms of cooperation (as, for instance, research contracts).

Lastly, as far as complementary or substitutability between the two forms of patenting is concerned, only in case of type B sub-network does there seem to be a real possible alternative between the two forms of patenting. A fact that seems to be in line with a net complementarily between owned and invented patents. Moreover it is interesting to note that, from a theoretical point of view, the model of Aghion and Tirole (1994) and Verspagen et al. (2006) applies well only to the sub-network type A and only partially to the type B.

6. Conclusions

The importance of taking into account the patenting activity of academics with subjects different from their own University, in particular with firms, is now widely accepted.

In the present paper we used Social Network Analysis (SNA) to analyse the co-invention network generated by the academic inventors, tenured by two Italian universities, namely the University of Trieste and the University of Udine both located in the Friuli Venezia Giulia Region, in their patenting activity with their own Universities and with different organizations, in particular firms and PROs. To this end we construct a new database extending the methodology proposed in the literature, collecting raw data on patents and academics employed in the two Universities and matching the two data sets.

The fundamental aim is to understand if the network that originates from owned and invented patents differ, to what extent they might differ and, possibly, to derive some implications of the detected differences for the process of knowledge transfer.

The results show that, from a global and structural point of view the complete network of the two universities are very similar but, looking at the way in which the relationships with external actors take place, some non-marginal differences emerge. In fact, looking at the sub-network structures that arise around academic brokers, we are able to detected three sub-network typologies – open science, multiple interactions and co-patenting, disconnected sub-networks – that seem to characterize the two universities in different measures. This result seems to be easily extended to the general case of academic cooperation with external actors since the identified sub-network types represent a wide typology of interactions between universities and the outside world (opens science organisations, on the one hand, private firms on the other hand).

To make a statement regarding the process of knowledge transfer and innovation is however not so easy. In fact even if we can affirm that the sub-network type B is the most conducive for the diffusion of knowledge and for spillovers, getting in contact with numerous actors belonging to different kinds of organizations, the sub-network type C, being more close to production, seems to impact more directly the production process. More research both on empirical and theoretical grounds is needed to confirm these results and understand in depth all the possible implications.

From a methodological point of view, the results of the qualitative analysis based on in-depth interviews with the central actors in the identified sub-networks leads to some interesting results.

As far as scientist and open science organizations are concerned, the network ties identified through patent data still represent a real link of collaboration.

Instead, in the case of firms, it is not always the real researchers but the research managers (and even the CEOs) who are the named inventors, depending on the specific internal rules. The direct link of the prominent academic (broker) with the firm (assignee or not) – the cross link identified in the methodological section – seems to be of great importance. This fact highlights some kind of asymmetry between the network generated by open science ties and the one generated from the cooperation with actors working in the market.

The qualitative analysis makes us able to draw some conclusions on the complementarity or the substitutability issues involving the assignments of patents and the other possible channels of cooperation with firms. Starting from the second and more general alternative, as can be easily imagined, complementarity with research in cooperation, contract research and more, is a general rule. As far as competing forms of ownership of the patents are concerned, we find a possible case on the sub-network type A (that seems to represents well the theoretical setting of the model of Aghion and Tirole ,1994) and, in part, on multiple collaboration and co-patenting (sub-network of type B). In both cases there does not seem to be a distinct alternative with important negative feedbacks.

The general message from the qualitative survey points to the importance of the different forms of collaboration and to the necessity of taking into account the many possible channels of interaction between academic and industrial partners. In a sense, we can say that the patenting activity of academics with external actors can be damaged not only by an aggressive attitude of universities toward rights of patent assignments but also mainly through the limits imposed on the various forms of cooperation ranging from research projects to exchange of researchers.

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