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# Evaluating policies for innovation and university-firm relations. An investigation on the attitude of Italian academic entrepreneurs towards collaborations with firms

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### Abstract

The paper is the first step of an analysis of the university-firm technology transfer mechanisms in a perspective of evaluation of innovation supporting policies. In particular, this work presents the results of the construction of an original database and of the preliminary study of individual behaviours with regards to the transfer of knowledge between universities and firms. The research questions underlying this work and the future research agenda are the following: “what would have happened had the spin-off not been created? Which other technology transfer channels would have been activated by the same academics?”. These questions arise from the consideration that the existing literature seems to widely neglect the issue of possible trade-off effects among the different forms of technology transfer. Consequently, the final net impacts that can derive from the promotion of spin off supporting policies instead of policies favouring other forms of technology transfer are not considered. The empirical analysis presented in this work is based on the population of Italian spin-offs set-up between 2002 and 2007, for each of which societal data have been collected. Once selected the academic co-founders, we have then retraced their academic position at the date of the spin-off establishment, as well as four years before and four years after and we have studied the number and features of their publications and patents. First results show that it is possible to identify very different behaviours among scholars engaging in an entrepreneurial activity. Some of them show an increased propensity to collaborate with other firms after the establishment of the spin-off, while others, on the contrary, do not seem to change their co-publishing and co-patenting attitude, or they even decrease it,

with a sort of “substitution effect”. The study of the determinants of such heterogeneity becomes therefore essential in order to design effective policies supporting innovation and technology transfer.

**JEL Classification:** *L52; O38*

**Keywords:** *Technology transfer; Policy evaluation; Patents; Publications; Italy.*

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# 1 Introduction

According to the so-called European Paradox, Europe is particularly effective in producing innovation, but not as much as effective in commercializing it, especially when compared to other industrialized countries, such as the U.S (Clarysse *et al.*, 2005; Dosi *et al.*, 2006; Conti and Gaule, 2011). The 2000 Lisbon Agenda had among its main objectives that of reducing this gap, by encouraging policy makers to define clear rules for the exploitation of the results of academic research. Up to now most of the debate in the literature on technology transfer (TT) has concentrated on the scientists' ability to become entrepreneurs and on the desirability of commercializing academic results. In this context, the university-firm relations have gained particular attention in the last decade (see among others Abramo *et al.*, 2012; Di Gregorio and Shane, 2003; Harrison and Leitch, 2010; Lockett *et al.*, 2005). Academic entrepreneurship is becoming a widespread phenomenon all around the world. This is stimulated both by a perceived changing role of Universities, more and more oriented towards technology transfer and commercialization of research activities (the so-called "third mission" of Universities, beyond the traditional ones of education and research) and by increasing support provided by national and local institutions (Henrekson and Rosenberg, 2001; Gulbrandsen and Slipersæter, 2007; Acs *et al.*, 1992).

While the United States have been traditionally considered the pioneers of university-firm technology transfer, several European countries have been implementing and discussing reforms that might resemble, for instance, that of the American Bayh-Dole Act, at least in the intention to promote the commercialization of academic research results. Most of the specialised international literature seems to have concentrated on such issues as: patenting by academics and universities (among others Baldini *et al.*, 2007; Coupe, 2003; Powell and Owen-Smith, 1998); growth and survival rates of academic spin-offs (Harrison and Leitch, 2010; Iacobucci *et al.*, 2011; Bigliardi *et al.*, 2013; van Geenhuizen and Soetanto, 2009; Lawton Smith and Ho, 2006), and technology transfer policies (Macho-Stadler and Pérez-Castrillo, 2010; Friedman and Silberman, 2003; Bozeman, 2000).

Less attention seems to have been paid, on the other and, to other aspects. Among these our analysis highlights a shortage of studies on the impact of the different forms of TT on the territories and their overall effectiveness (Fontes, 2005; Shane, 2004; Vincett, 2010). In particular, there is a lack of researches on the potential trade-offs existing between different forms of technology transfer and therefore on the desirability of any particular tool of TT with respect to the others. For instance, in the case of spin-offs, which represent one of the most studied forms of TT, most of the available empirical analyses tends to evaluate their effectiveness by concentrating on their absolute performance (turnover, growth, survival rates and etc.) or by comparing them with other new technology born firms (Colombo and Piva, 2008, 2012; Goethner and Cantner, 2010; Zhang, 2009, to name some). Very little seems to have been written on which tool among the many available is more effective, efficient and less risky, in transferring knowledge and technology to firms.

In this paper, we intend to suggest a different perspective. One that goes in the direction of policy evaluation and that takes explicitly into account the possible trade-offs that exist among different forms of TT. Questions such as, what would have happened had the spin-off not been created? Or what would have happened to the other channels of TT? are examples of the perspective that this study wishes to promote. In this work we take a first step towards the attempt to compare different forms of TT. Building on an original dataset of 248 academics involved in spin-offs in the years 2002-2007, we analyse the evolution in the activity they carry

out with firms (i.e. co-publications and co-patenting) four years before and four years after the spin-off creation. Preliminary findings show that, overall, the productivity of the considered academics (both in terms of publications and patents) increased after the spin-off creation in general and also with firms. However, a deeper analysis shows the existence of categories of academics with very different behaviours according to their academic position or their academic fields, suggesting room for further, deeper studies.

Section 2 briefly illustrates the recent increased orientation of universities towards the commercialization of science. Section 3 describes the main typologies of technology transfer mechanisms and the literature discussion on which one is the most appropriate. Section 4 introduces the linkage between technology transfer and policy evaluation, highlighting the need to find ways to compare the different forms of technology transfer so as to evaluate the most efficient ones. In section 5 the main results of the empirical investigation are presented while section 6 summarises the main conclusions.

## 2 Issues on the “third mission” of Universities

Universities were born as institutes of higher education. Then a second mission came along. Particularly starting from XIX century universities started to engage in research activities and especially in basic research, that was often overlooked by firms given its public good nature (Etzkowitz, 1998; Nelson, 1959).

In the last decades, a so-called “third mission” has come to play an important role in universities’ activities. This third mission is related to the increasing involvement of universities with the commercial and entrepreneurial sphere, with more and more direct relations with firms (Gulbrandsen and Slipersæter, 2007). In practice, it includes all the activities of technology transfer that are carried out within the academia. On the definition of technology transfer much has been written (see the most quoted Bozeman, 2000; Reisman, 2005; Teece, 1977; Siegel *et al.*, 2004). Here we will refer to a broad definition suggested by Siegel *et al.* (2004), where technology transfer includes any form of knowledge originated within university that is transmitted to firms.

Different forces have contributed to a “capitalisation of knowledge” (Etzkowitz, 2004). One is the constantly diminishing amount of public funding devoted to research, which has urged universities to look for private support to their research activities. To this some authors add the increasing autonomy of universities in management and administration, the pressure for a greater direct involvement in local development dynamics, the scientification of innovation processes, which requires different competences (Cesaroni and Gambardella, 2001; Piccaluga, 2001; Bell, 1993).

According to many this change is both positive and inevitable: it represents the chance to increase the diffusion of knowledge and the innovation capacity of the whole economic systems. Universities can give a great contribute to societies by helping firms reducing their R&D costs, generating financial resources and building their reputation over strong universities ties (Bell, 1993; Grigg, 1994). Moreover, the financial resources generated can be further invested to improve research and education services and structures within universities. This type of arguments has pushed many governments to support, through public financing, the different forms of technology transfer and academic entrepreneurship (Lowe and Gonzalez-Brambila, 2007).

However, on the other hand, several authors have highlighted the potential risks coming

from this “third mission”. “Commercializing” universities’ activities can alter the way research is carried out, shifting away resources from basic research towards applied research (more easily commercialised), up to the point of threatening completely the traditional second mission of universities (Partha and David, 1994; Lee, 1996; Bell, 1993). Several empirical studies investigate the effect of becoming an entrepreneur on the productivity of academics (normally measured by publications) and exclude, in most, cases a substitution effect, while revealing in some cases a multiplicative effect (Stephan *et al.*, 2007; Lowe and Gonzalez-Brambila, 2007; Van Looy *et al.*, 2004; Abramo *et al.*, 2012). In most of these works no investigation is done on changes in the nature of publications due to the engagement of scientists in an entrepreneurial activity. One of the few exceptions is the work by Van Looy *et al.* (2004), according to which the spin-off engagement does not affect the type of publications, in particular it does not lead towards more applied research.

### 3 The variety of technology transfer mechanisms

There are several forms of university-firm relations and actually most of university activities could enter the category of technology transfer (Lee, 1996; Etzkowitz, 1998, 2004; Rogers *et al.*, 2001; Piccaluga, 2001; Bell, 1993; Bianchi and Piccaluga, 2012; Capellari, 2011; Baglieri, 2008; Landry *et al.*, 2006; Klofsten and Jones-Evans, 2000):

1. Research contracts financed by firms. These are activities that involve academics in finding solutions to relevant social, economic and technological problems, thus increasing their integration with the surrounding environment and increasing their financing opportunities (Lee, 2000). These agreements might have a negative impact on the overall technology transfer if they are carried out, with exclusive clauses, with one single firm, thus limiting the possibility to interact and collaborate with other firms.
2. Consultancy contracts by single scholars, students or researchers, carried out with or without visiting periods inside the firm.
3. Establishment of spin-offs, that is new firms founded by academics to exploit the results of their researches.
4. University incubators, that can provide a particularly favourable environment for technology transfer since they normally envisage co-location, in a specific area close to the university, of both academic spin-offs and external firms.
5. Exploitation companies, meaning organisations built by public research institutes to manage activities that are related to the local economic and social development.
6. Licensing and patenting activities, including cross-licensing among different firms or institutions to encourage the development of specific innovations.
7. Publications, which represent the main output of academic research. Among these for sure those that are realised together with firms’ representatives are to be considered tools of technology transfer. However, academic publications in general can be considered a source of knowledge transfer upon which firms can build and widen their knowledge base.
8. Workshop and conferences, which allow a direct exchange of information and knowledge through personal interaction.
9. Finally, even though it might seem less related to the enterprises’ activities, also the institutional activities of specialised training carried out by universities can be considered as a form of technology transfer, since they allow to transfer knowledge from the academia to firms through the hiring of qualified personnel, trained in an academic context.

University patenting, firms creation from universities, consulting and joint research contracts are often studied as separate, alternative technology transfer mechanisms. However, in practice, they are often utilized in a variable mix and one form of technology transfer does not necessarily exclude the use of other forms by the same actors.

The question of what instrument is the most appropriate to transfer different pieces of knowledge has been widely discussed. From a theoretical point of view there are pros and cons that can be highlighted for each of the above-mentioned technology transfer forms. In practice, one could argue that no single tool should be preferred in absolute terms and that the only way to choose which mechanism of TT is to be promoted is to engage in empirical, highly contextualized analyses. Much of the literature has so far concentrated on the motivation that pushes individual researchers and institutions to choose between engaging in a new company that produces and sells the results of their research or patenting and licencing the same results to existing firms.

First of all, this choice is driven by a personal motivation of the involved actors. For example, [Stephan and Levin \(1996\)](#) suggest that patenting might be both a way to achieve personal enrichment and a way to gain further financing to support on-going researches and career opportunities within the academy. Such personal motivations might change according to the academic position of the scientist-inventor: older scientists might feel more free to exploit their knowledge in the market than their younger pupils, who need to invest more time in gaining scientific reputation within the academy ([Audretsch and Stephan, 1996](#)). This can be especially true when the academic context discourages for-profit activities. However, other studies suggest exactly the opposite, i.e. that founding a new company might be a strategy for younger scientists, not yet solidly employed within the academia (new PhDs, research assistants and etc.) and with uncertain career opportunities, but who wish to carry on their researches in close contact with their university ([Foray and Lissoni, 2010](#); [Iacobucci et al., 2011](#)). University administrators, on the contrary, might find an incentive in exploiting the results of academic researches through licensing, which gives the opportunity to improve the budget of their institutions. Furthermore, increasing the number of patents and licenses might be a way for technology transfer office to legitimize their existence, through a visible and easy-to-communicate measure of their activity ([Iacobucci and Micozzi, 2014](#)).

Second, as it has been suggested by several authors, the choice of the technology transfer mechanism depends upon the degree of appropriability of the innovation. When innovations are characterised by low-appropriability, licensing may be hard and the commercialization of new inventions might be discouraged. However, if the new knowledge produced is also characterised by natural excludability, then the creation of a company that translates the scientist's specific knowledge into a market opportunity becomes an effective and viable solution ([Franzoni and Lissoni, 2009](#); [Shane, 2004](#)). A few empirical studies seem to provide further confirmation that the probability of patenting increases when the degree of appropriability increases, whereas the probability of establishing a spin-off is rather related to the novelty and technological sophistication of inventions ([Shane, 2002](#); [Franzoni and Lissoni, 2009](#)).

A third aspect that must be mentioned, that is strongly linked with the one above-mentioned, is the degree of tacitness of the knowledge involved in a new research result. In other words, when the technology involved in the development of a new invention is strongly dependent on the inventor herself in order to be correctly employed, then the spin-off might be the only effective solution. If sold to other existing firms, the same invention would not be as easily commercialized ([Lowe and Gonzalez-Brambila, 2007](#); [Lowe, 2001](#)). Furthermore, when an academic invention is disclosed at an early stage of development, it can be hard to find existing



firms willing to take the risk and bear the costs of bringing it to a stage that is suitable for the market. There must be some form of involvement of the scientist-inventor, and thus spin-off companies become an ideal and effective solution (Audretsch and Stephan, 1996; Shane, 2004).

Fourth, the choice of the specific technology transfer mechanism also depends on the university's institutional setting, including its organisational form, its resources configuration and its level of experience (Di Gregorio and Shane, 2003; Bercovitz and Feldman, 2007; Chapple *et al.*, 2005; Debackere and Veugelers, 2005).

Patenting requires larger structures, financial and technical resources and therefore it seems to be strongly related with, for instance, the establishment of dedicated structures, such as technology transfer offices, or the employment of specialised personnel that can support the researchers in the patenting process (Baldini *et al.*, 2007). In this sense, smaller universities might prefer technology transfer through consultancy contracts, even though learning-by-doing is possible and therefore one could argue that any university can improve its ability of generating licencing revenues (Thursby *et al.*, 2009).

Finally, the nature of technology transfer activities also depends on the economic incentives to academic entrepreneurship. These can in turn be affected by national ad hoc legislations and reforms, as well as by the structural institutional features of the national research system. In this sense, the reforms that Italy has experienced in the last decade have stimulated the engagement of Italian university in technology transfer activities, also through academic entrepreneurship (Baldini *et al.*, 2007; Barbieri and Santarelli, 2010; Breschi *et al.*, 2008). And even the more recent procedures of university performance evaluation place value on research products as patents and spin-offs, thus offering *de facto* an incentive to universities to engage in such activities.

The various mechanisms of technology transfer generate different benefits. From the university point of view, spin-offs may not be the most profitable way of transferring knowledge. Moreover, even though, as we explained, they might be the only viable way under specific circumstances and they might bring benefits in terms of local development and increased competitiveness of the production system, they might also carry "conflict of interest" within the academia and also vis-à-vis existing firms (Lee, 1996; Lerner, 2004; Mustar *et al.*, 2006a; Etzkowitz *et al.*, 2000). Iacobucci and Micozzi (2014), for instance, show that research contracts are the most important way of commercializing academic research, in terms of financial benefits gained by universities. Most of these benefits are appropriated directly by the scholars involved in the research and consulting activity. However, a significant share is retained also by the university to cover general expenses and to contribute to the research infrastructure. In the case of patents, in Italy the Code on Industrial Property of 2005 states that when they are issued as a result of publicly funded research, financial benefits go both to the university and to the inventors. However, several studies demonstrate that even in universities that manage a large portfolio of patents the revenues from fees hardly cover the expenses (Balconi *et al.*, 2003). Moreover, the commercial value of knowledge generated by university research is hardly known in advance so that the university may not be able to fully capture the value of its technology through a licensing agreement (Lockett *et al.*, 2003).

This said, there are reasons to support all different forms of technology transfer. What seems to be really missing in the available literature, and in particular in that on the Italian case, is a clear understanding of the substitution effect across the different forms. In other words it might be worth engaging in further investigations of how the behaviour of single scholars, or research groups, changes when engaging in a particular form of technology transfer with the respect to the other TT channels available.

## 4 Policy evaluation and technology transfer

As anticipated in the introduction, the so-called “European paradox” has placed the issue of technology transfer at the core of the European Union growth strategies. In the last decade the reform process of several European countries has gone in the direction of encouraging the third mission of universities by different means. More and more autonomy has been granted to universities and they have been endowed with the necessary resources and competencies to stimulate the entrepreneurial side of their activities. The United States have been often taken as the comparison term to judge a country’s progress in technology transfer. Following the experience of the American Bayh-Dole reform, several European countries, including Italy, have started promoting an increased autonomy of their universities encouraging their entrepreneurial mission and the commercialisation of their academic results.

As highlighted elsewhere (Mowery *et al.*, 2001; Barbieri and Santarelli, 2010; Shane, 2004) there are still doubts on the actual role of the Bayh-Dole Act in the U.S.A. in promoting technology transfer. Empirical evidence has not produced a shared view on this matter. Yet, the choices taken in other countries do not seem to be based upon a thorough analysis of such evidence, but rather they seem to take for granted some degree of effectiveness of certain tools. It is the case for instance of the reforms seeking to abolish the so-called “professor’s privilege” and the support to academic entrepreneurship by different means.

Policy evaluation in this scenario seems to be crucial. It is an issue where Italy comes in as a *late comer* (for a review see European Commission, 1999; Barbieri and Santarelli, 2010). Significant progresses have been made, also thanks to demand activated by the European Commission (Barca, 2010; Oliva and Pesce, 2001). However, the evaluation culture in Italy seems to have been based so far upon the single researchers’ curiosity or law requirements, rather than on policy makers’ desire to understand and openly discuss the results of their interventions.

Policy evaluation is not trivial and it carries some complexities. At the core of policy evaluation lies the counterfactual question “what would have happened without that reform or policy programme?” The answer may be difficult at least for two reasons: 1) technical difficulties related to the possibility to provide rigorous and reliable evaluation results; 2) the fear that results will reveal that no effects (or negative effects) have been produced, thus mining the legitimisation of government intervention. The first aspect has been extensively studied by many scholars (see for a review Martini and Sisti, 2009). Here it is worth recalling that social experiments are normally considered as the benchmark methodology in terms of rigorousness of results. These resemble the clinical trials typically used to evaluate medical treatments. Several studies have emphasised the ethical, practical and economic limits that characterize social experiments (Shadish *et al.*, 1991; Stame, 1998), while others suggest that in some cases they might be feasible even with limited economic resources (Martini and Trivellato, 2012).

Beyond feasibility, one may argue that social experiments might have a value per se. They represent, in fact, a specific idea of government, where the assessment of the effects of policy intervention is an integral part of the policy process, starting from the very beginning of policy design. Furthermore, they can offer an opportunity to test a policy on a smaller scale and enlarge the intervention (and the economic investment) only when the policies show some effect. Experimenting, in other words, can be viewed as a *modus operandi* of policy making and it has been used in fact by both industrialized and industrializing nations (see for instance, the case of China in Di Tommaso *et al.*, 2013).

When social experiments are not feasible, several other tools have been developed in the fields,



for instance, of statistics and econometrics, that try to simulate the traditional comparison between beneficiaries and controls, typical of experiments. These tools have been applied to different contexts: from labour policy, to incentives to firms, education and training policies (Barbieri *et al.*, 2012; Rettore *et al.*, 2003; Battistin and Rettore, 2002; De Blasio and Lotti, 2008). The extent to which they can be applied to innovation policies is still debated (see among others Perrin, 2002). The so-called quasi-experimental methods suffer from a number of limits, that can become particularly relevant in the context of innovation and technology transfer policies. Data availability is but one of the major issues, upon which evaluation results largely depend. Among the most widely recognised limitations is the inability of such methods to explain why policy do or do not work and therefore guide specific policy changes. This comes in part from the fact that most of the available studies retrieve, in the end, an average effect of the policies on the beneficiaries, without deeply investigating the cases of success – for instance single groundbreaking discoveries – which might be more relevant than the mean results. As a consequence, most evaluation studies produce policy implications that either accept policies as they are or wish to cancel them *tout court*, allowing little space for improvement. Some other themes are not even taken into account by most articles on policy evaluation, particularly by those dealing with technological innovation. Anticipation effects is one of these. Quite often firms that declare that “they would have invested anyway, even in the absence of specific public incentives, but later in the future” are treated as ‘non-additional’ cases. However, when talking of innovation policies the timing of an investment might be everything that counts, especially in a scenario of global competition, where international competitive (rather than comparative) advantages matter. Policies might see anticipation and acceleration of changes as objectives per se.

Given such limitations, one might ask if it is worthwhile approaching technology transfer policies with the typical counterfactual perspective and tools. We think that, in the experience of a *late comer*, as it is Italy, the answer is “yes”. Notwithstanding the limitations above mentioned, thinking in counterfactual terms, at least as a first (not definitive) step of evaluation, forces to clarify the specific objectives of a policy programme. It furthermore urges administrations to think about ways to measure these objectives and it then forces the debate, both within and outside public administrations, to concentrate also on the results of policy action.

Take the case of academic entrepreneurship for instance: is it desirable per se? As a tool for generating new innovative firms? Or it is desirable because it is a more effective way to commercialise academic research results? What empirical evidence do we have to support this view? Can both objectives be pursued?

Most of the empirical research on spin-offs for instance compares their growth and survival rates with respect to other firms, particularly NBTF (*new born technology firms*). However this comparison seems to have an hidden counterfactual hypothesis: in absence of a spin-off opportunity, the researcher would have created another firm anyway. But this seems to contrast a great deal of the available literature on spin-offs, which highlights how academic entrepreneurship does largely depend upon university resources, competencies, and technical support.

If one wants to think in terms of technology transfer, the relevant question would rather be: what other forms of technology transfer would the researcher have activated had she not created a spin-off? Are there reasons to believe that there might be substitution effects among the different forms of technology transfer?

## 4.1 Policy evaluation, technology transfer and possible substitution effects

In order to fully understand if a form of technology transfer is desirable, we need to state clearly the objectives that it might pursue. Academic entrepreneurship, in the form of spin-offs for instance, is to be evaluated as a means to generate new firms, or to increase employment? As a way to transfer technology to an industry? Are we interested in the impact they have on the innovative capacity of the local context? Or are we interested in the way they can contribute to co-financing of universities?

There might be trade-offs between these different objectives. For instances, firms that are born as an attempt to commercialize a new idea, can have a limited impact on the surrounding environment or a limited capacity to contribute significantly to university financing. [Harrison and Leitch \(2010\)](#) among others in their study on Northern Ireland, conclude that firms born within universities do not display higher growth potentials than other high-technology firms. As for universities, spin-offs do not seem to offer a substantial source of financing if compared with licensing or other forms of technology transfer. Furthermore, as highlighted by [Valentin and Jensen \(2007\)](#), in their empirical investigation on Denmark, a formal involvement of universities in commercializing the results of academic research – in terms of capital investment or property rights – can be counterproductive in terms of technology transfer, inducing firms to look for collaborations elsewhere, even outside the country, where universities are less “entrepreneurial”.

From a public policy perspective [Harrison and Leitch \(2010\)](#) suggest that academic entrepreneurship can offer only a marginal contribution to the local economic development, especially since firms born within universities tend to remain isolated from the entrepreneurial system. Therefore when treating academic entrepreneurship as a form of technology transfer some cautions should apply. In particular, when comparing academic firms with other enterprises one should consider what follows:

1. The former are born in a non-commercial context and therefore they start off with an handicap with respect to other start-ups ([Mustar et al., 2006b](#)). According to [Shane \(2002\)](#) many of these are firms that were created because the researcher could not sell her invention to existing firms;
2. They often maintain a strong linkage with the university, which has its own culture, rules and incentives ([Moray and Clarysse, 2005](#)). Quite often academics become “part-time entrepreneurs” and do not abandon their academic position ([Doutriaux, 1987](#); [Iacobucci et al., 2011](#); [Piccaluga et al., 2011](#));
3. There can be conflicts between the objectives of commercial exploitation of research results and the diffusion of such results that is typical of the second mission of universities ([Mustar et al., 2006b](#); [Clarysse et al., 2005](#)).

This said, spin-offs are often judged as an inadequate tool for technology transfer, but they are seldom compared to the other tools of university-firm knowledge transfer. In other words, they might be less performing as firms, but more effective and efficient in transferring technology. In our view, the issue is inherently empirical and the comparison has to be made between spin-offs and other forms of technology transfer (such as contract research, university-firm co-publications, co-patenting and etc.). In what follows we offer the results of the first step of this research and the research agenda for the future.

## 5 An investigation on the Italian case

### 5.1 Building the database

Data have been collected for all the Italian academics that have founded a firm in the period 2002-2007 and whose spin-off was still active in 2010. The initial set included 838 founders of the 115 Italian spin-offs established in the period. We have first of all deleted all the spin offs that ceased their activity within 4 years after the establishment. Secondly, we have excluded those associates that entered the spin-off after its foundation; this is to say that our investigation is particularly focused on those academics that chose to establish a new firm and not just to participate in an existing one. Subsequently, by cross-checking every founder with the list of academics employed in Italian universities in the considered years (available in the database of the Italian Ministry of University and Research – MIUR), we have selected only those with tenured academic positions at the year of foundation (researchers, associated professors and full professors). Then, since our aim is to compare the productivity of academic spin-off associates before and after the spin-off establishment, we have included in our database only those spin off associates who had an academic position at the time of the foundation as well as 4 years before and 4 years after.<sup>1</sup> This led to a new dataset of 248 spin-off academic associates that represents therefore the universe of researchers and professors involved in an academic spin-off for the whole selected period (while, it does not take into account post-doc and temporary research assistants not included in the MIUR database).

For each of the 248 selected academics we have collected the following information:

- academic position at the foundation of the spin-off,
- academic position 4 years before and 4 years after,
- scientific field (Settore Scientifico Disciplinare, SSD)
- university of affiliation.
- number and characteristics of publications 4 years before and 4 years after the spin-off establishment using the SCOPUS database. In particular, we have identified:
  - total number of publications for the two periods;
  - number of publications with co-authors whose affiliation was a firm;
  - number of firms involved in each publication (divided into Italian and foreign);
  - number of publications where the only firm mentioned in the authors' affiliations was the spin-off;
  - number of publications where the spin-off appeared in the authors' affiliations along with other firms (Italian or foreign).
- number and characteristics of patents on which the selected academics appeared as inventors during the 4 years before and 4 years after the spin-off establishment using the European Patent Office database. In particular, we have identified:
  - total number of patents;
  - number of patents with firms among the applicants;

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<sup>1</sup> The 4 year time span has been chosen as a reasonable time to ensure that research results complete the publication procedures. Furthermore, in many university regulations, professors have to quit the board of directors of the spin off after the end of the incubation period, therefore by the fourth year he can maintain his shares but he cannot have formal institutional positions in the firm. SCOPUS database has been chosen because at the moment it seems to be the most complete database of accredited scientific journals. EPO database has been chosen to select patents going beyond a mere local or national impact, given the Italian nationality of all selected scholars.

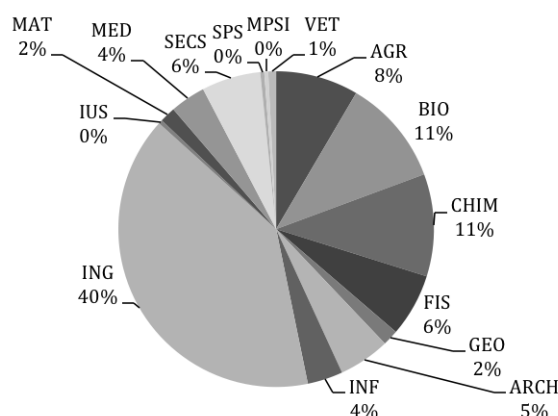
- number of patents with the spin-off among the applicants.

In order to avoid mistakes due to cases of homonymy, every single publication and patent has been checked to make sure that both the affiliation and the content of the research product meet those of the selected academic.

## 5.2 Observed trends

The 248 academics included in our final dataset are mainly full professors (41%), followed by researchers (30%) and associate professors (29%). Among the scientific sectors in which they operate, engineering dominates with 39%, followed by mathematics and other disciplines of the so-called “hard sciences” such as biology (11%) and chemistry (11%) (see Figure ??).

**Figure 1:** *Distribution of academics according to the field*

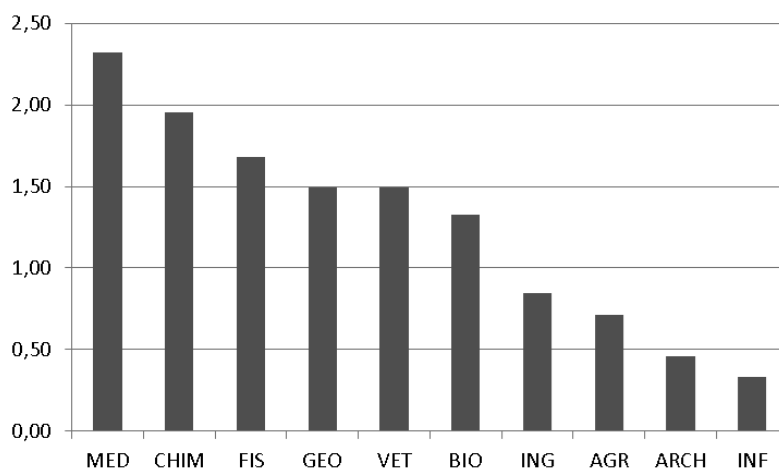


Source: authors' elaboration.

Analysing the productivity of the included academics, in absolute terms both the number of publications and the number of patents increased during the 4 years after the establishment of the spin-off. In particular, the total number of publications passes from 3409 to 4223 (with an increase of 23.9%), while patents grow from 84 to 136 (+61.9%). While during the 4 years before the spin-off establishment each of the analyzed academics published on average 13.75 articles and was the inventor of 0.34 patents, in the subsequent years the average number of publications reached 17.03 and the number of patents 0.54.

Regarding the relations with firms, the number of publications with firms passed from 309 the 4 years before the spin-off establishment to 455 4 years after (+47.25%). The increase is much higher if we include the publications with the spin-off (meaning publications where the spin-off appears as affiliation of one or more of the authors), which take the total number of publications with firms 4 years after to 649 (+110.03%). Also the total number of firms other than the spin-off involved in the publications increased, passing from 330 in the first period to 530 in the second. The average number of other firms per publication passed from 1.07 before the establishment to 1.16 after. In particular, Italian firms passed from 193 to 323 (+67.36%), and foreign firms from 137 to 207 (+51.09%).

As regards patents, the total number of academics that patented during the whole considered period (8 years) is 83, equal to 33.5% of the total. In particular, 20 patented only before the establishment of the spin-off, 39 started patenting only after the spin-off foundation and 24 patented both before and after the beginning of their entrepreneurial activity.

**Figure 2:** *Patenting intensity index by academic field*

Source: authors' elaboration.

In order to visualize the academic fields and the academic positions with a higher propensity to patent, we have created a patenting intensity index by academic field and by academic position. These are calculated as follows:

$$\frac{\# \text{ patenting academics in } SSD_j / \text{total } \# \text{ patenting academics}}{\# \text{ academics in } SSD_j / \# \text{ of academics}} \quad j = 1, \dots, 15 \quad (1)$$

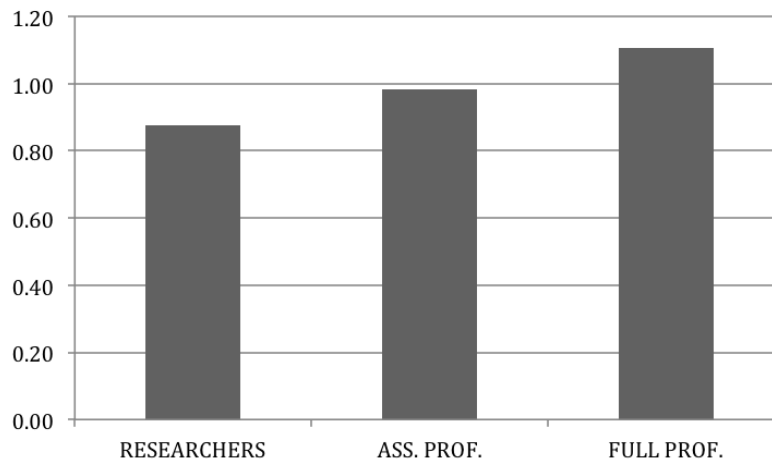
$$\frac{\# \text{ patenting academics in academicposition}_j / \text{total } \# \text{ patenting academics}}{\# \text{ academics in academicposition}_j / \# \text{ of academics}} \quad j = 1, \dots, 3 \quad (2)$$

If the two indicators are equal to 1 it means that the weight of the scientific field (or academic position) among the patenting academics is equal to the weight of the field (or academic position) on the total number of academics included in our database. In other words, the higher the value of the indexes the higher the propensity to patent of the specific scientific field or academic position. Figures 2 and 3 illustrate the values of the two indexes for our universe.

Figure 2 shows that the propensity to patent of the different fields varies considerably. In proportion to the dimension of their scientific field, the leading position goes to academics in medicine-related disciplines: their weight among the patenting academics is almost 2.5 times higher than their weight on the total number of academics, while, for example, engineers are proportionally more present in the total number of entrepreneurial scholars than among the patenting academics. Mathematics, psychology and social sciences on the other hand do not display any propensity to patent. As regards the academic position, full professors turn out to be relatively most active in patenting (Figure 3) even though the distribution in this case is more balanced, with all the categories displaying values close to 1.

These general numbers could hide very different behaviors among scholars. We have already signaled that the total number of publications increased in the second considered period, but not for everyone. In particular, in 152 cases the total number of publications increased, in 62 it



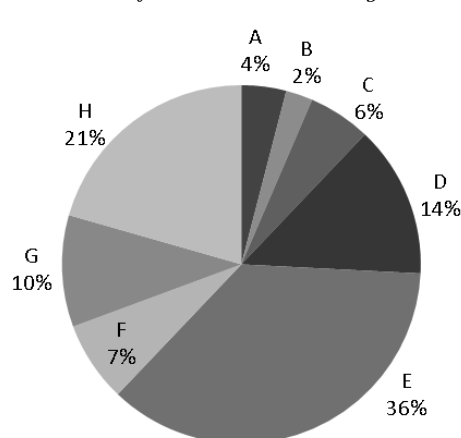
**Figure 3:** *Patenting intensity index by academic position*

Source: authors' elaboration.

decreased and in 34 cases it did not change. As regards the number of publications with firms (excluding the spin-off), in 32.7% of cases it increased, in 18.9% it decreased and in 48.4% it remained unchanged, including 97 academics that never published with other firms, both before and after the spin-off establishment.

This has suggested us that it could be useful for the interpretation of the results to further divide the 248 academics in sub-groups. A more careful look to the data has suggested us to classify our observations according to the technology transfer attitude of scholars, measured with the fact of having or not published with firms before and after the establishment of the spin-off. In particular we have identified the following categories:

- A *Spin-off centered technology transfer*: in these category are included the 10 academics who never published with firms before the establishment of the spin-off, and with no firms other than the spin-off after its establishment.
- B *Substitution approach*: this category encompasses 6 academics who used to publish with other firms, but that only published with the spin-off in the 4 years after its establishment.
- C *Multiplying approach*: here are 14 academics that did not use to publish with other firms but that after the spin-off creation started publishing both with the spin-off and with other firms.
- D *Additive technology transfer*: this category includes 34 academics who had publications with other firms before the spin-off foundation and continued to do so (along with the spin-off) afterwards.
- E *No technology transfer*: this is the most numerous category, with 90 academics who never published with firms, both before and after the spin-off establishment, not even with the spin-off itself.
- F *Ceased technology transfer*: these are 18 academics who used to publish with firms, but ceased to do so after the spin-off establishment (not even published with the spin-off itself).
- G *Starting technology transfer*: here are included 25 academics that started to publish with other firms only after the spin-off establishment, but never published with the spin-off.
- H *Stable technology transfer*: 51 academics that published with other firms both before and

**Figure 4:** *Distribution of academics among the identified categories*

Source: authors' elaboration.

after the spin-off establishment, but never with the spin-off.

The following tables summarize the main features of each of these groups in terms of publications (Table 1) and relations with firms and patenting (Table 2), while Figure 4 illustrates the weight of each category in terms of number of academics.

The most numerous category is the “no technology transfer” one, with 90 academics, equal to 36.3% of the total. They appear to be also the less productive group in terms of other forms of TT: they never published with firms before the establishment of the spin-off and continue to do so also during the subsequent 4 years (group E). They publish on average much less than the others, both before (3.43 publications) and after (4.63) the beginning of their entrepreneurial activity. This is the only group where the number of academics whose publications increased in the second period (45.5%) is lower than those whose publications decreased (23.3) or did not change (31.1) (Table 1). This group also shows a particularly low propensity to patent, with 0.06 patents per academic before the spin off establishment and 0.15 after the starting of their entrepreneurial activity (Table 2).

A totally different category is group H (“stable technology transfer”). These academics have a very high average number of publications in both the considered periods (21.3 and 24.7) and at the same time they are the most active category in terms of average number of patents, with 0.56 patents before and 1 patent after the establishment of the spin-off.

The academics that used to publish with firms before the beginning of their entrepreneurial activity and that continued in the 4 subsequent years, also including the spin-off (group D, “additive technology transfer”), register the highest average number of publications (31.5 and 37.5, respectively before and after). The only academics publishing less after the spin-off establishment are those that used to publish with firms only before starting their entrepreneurial activity (group F, “ceased technology transfer”). Overall, their publications decreased by 7.78%, with 41.7% of the 18 academics in the category reducing the number of published articles in the second period.

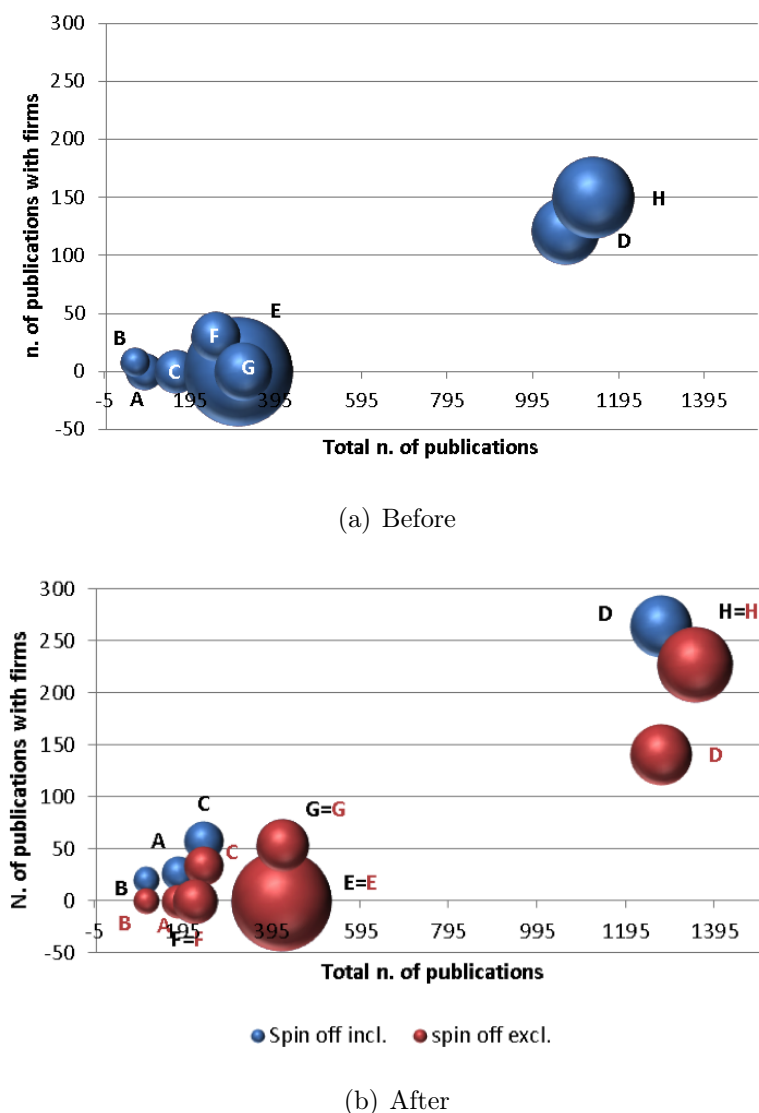
**Table 1: General features of the identified categories**

	Researchers using the spin-off as affiliation in their publications					Researchers never using the spin-off as affiliation in their publications					TOT
	A	B	C	D	E	F	G	H			
Number of academics	10	6	14	34	90	18	25	51	248		
Researchers	n. 4	2	4	8	32	5	9	11	75		
	% 40.0	33.3	28.6	23.5	35.6	27.8	36.0	21.6	30.2		
Associate professors	n. 2	3	4	9	26	4	5	20	73		
	% 20.0	50.0	28.6	26.5	28.9	22.2	20.0	39.2	29.4		
Full professors	n. 4	1	6	17	32	9	11	20	100		
	% 40.0	16.7	42.9	50.0	35.6	50.0	44.0	39.2	40.3		
Tot. n. of publications	Bef. 88	68	162	1070	309	256	320	1136	3409		
	Aft. 185	112	241	1275	417	223	420	1350	4223		
Average n. of pub. per academic	Bef. 8.80	11.33	11.57	31.47	3.43	14.22	12.80	22.27			
	Aft. 18.50	18.67	17.21	37.50	4.63	12.39	16.80	26.47			
Variation in n. of pub.	% 110.23	64.71	48.77	19.16	34.95	-12.89	31.25	18.84			
Academics whose publications increased	n. 7	5	10	25	41	7	19	38	152		
	% 70.0	83.3	71.4	73.5	45.5	38.9	76.0	74.5			
Academics whose publications decreased	n. 2	1	4	9	21	10	4	11	62		
	% 20.0	16.6	28.6	26.5	23.3	55.6	16.0	21.6			
Academics whose publications did not change	n. 1	0	0	0	28	1	2	2	34		
	% 10.0				31.1	0.05	8.0	3.9			

**Table 2: Technology transfer: publications with firms and patenting behavior of the identified categories**

	Researchers using the spin-off as affiliation in their publications						Researchers never using the spin-off as affiliation in their publications				TOT
	A	B	C	D	E	F	G	H			
Number of academics	10	6	14	34	90	18	25	51	248		
Tot. n. of publications with firms											
Before	0	8	0	121	0	30	0	150	309		
After	27 (only spin-off)	20 (only spin-off)	34	141	0	0	53	227	455		
Total involved firms											
Before	0	8	0	129	0	32	0	161	330		
After	0	0	45	164	0	0	69	252	530		
Total Italian firms											
Before	0	6	0	72	0	15	0	100	193		
After	Only spin-off	Only spin-off	35	89	0	0	49	150	323		
Total foreign firms											
Before	0	2	0	57	0	17	0	61	137		
After	0	0	10	75	0	0	20	102	207		
Number of patenting academics											
Only before	0	0	1	4	2	3	2	8	20		
Only after	2	2	2	13	7	1	4	8	39		
Both bef. and after	0	1	1	6	2	1	1	12	24		
Tot. n. of patents											
Before	0	3	2	27	5	9	3	35	84		
After	3	3	9	39	10	3	14	55	136		
Tot. n. of patents with firms											
Before	0	3	0	17	2	7	1	19	49		
After	1	2	2	9	4	2	1	30	51		
After with appl. (also) SO	0	0	1	24	2	0	5	13	45		
Av. # patents per academic	0.00	0.50	0.14	0.79	0.06	0.50	0.12	0.69			
Variation in n. of patents											
After %	0.30	0.50	0.64	1.15	0.15	0.17	0.56	1.08			
Av. # patents with firms on total n. of patents											
Before		1.00	0.00	0.63	0.40	0.78	0.33	0.54			
After	0.33	0.67	0.22	0.23	0.40	0.67	0.07	0.55			
Aft., including SO		0.67	0.67		3.00	0.29	6.00	2.26			

**Figure 5:** Distribution of groups according to their publishing behavior in the 4 years before and after the spin-off establishment (the dimension of spheres is proportional to the number of academics in each category)



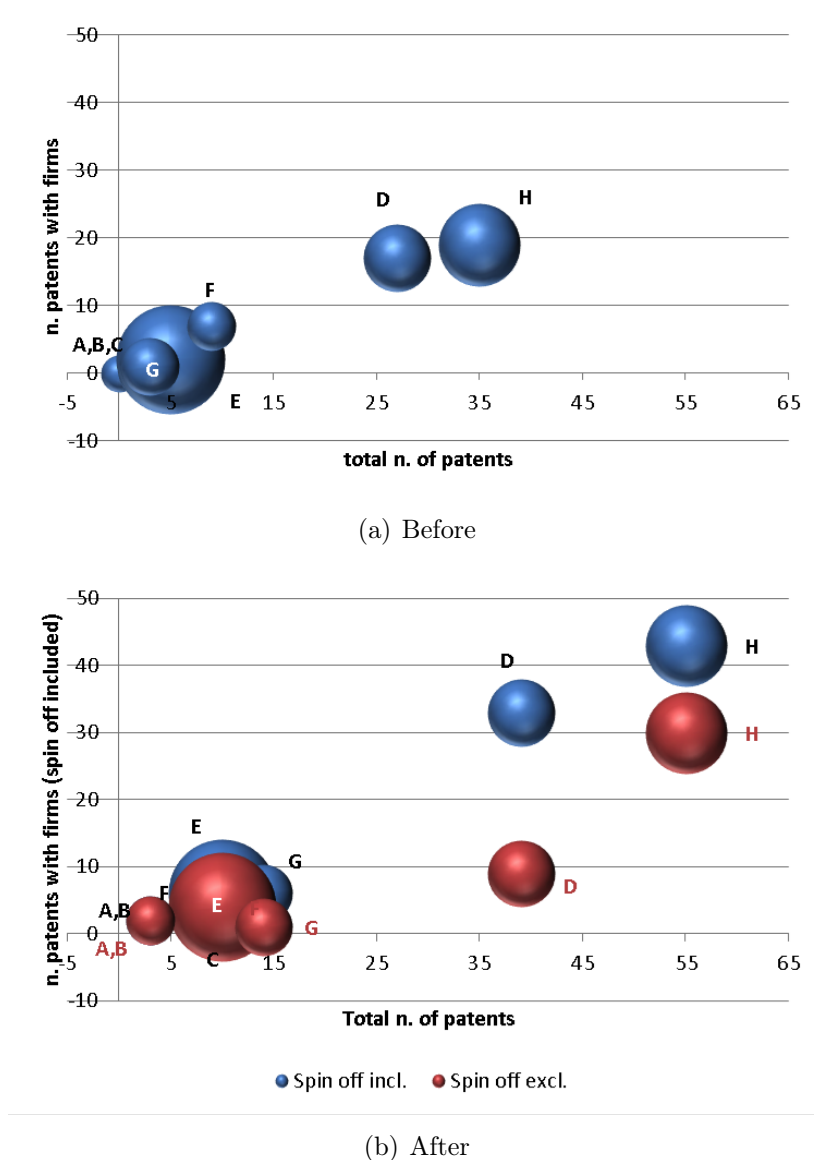
Source: authors' elaboration.

Already at this stage, two of the identified groups seem to display a potential reduction (F) or substitution (B) effect of the spin-off on the technology transfer activities towards other existing firms. The graphs in Figure 5 summarize the publishing behavior of the different categories. Each category is placed on the graph according to the total number of publications and to the number of publications with firms. The dimension of the sphere is proportional to the number of academics in each group. So, for example, in the first graph of Figure 5 we can see that the group E, which is the most populated (it has the biggest sphere), has a medium-low productivity in terms of total number of publications, but a very low propensity to publish with firms.

Figure 5 show that categories F and B display a reduction in the publications with other firms, while group D, which we defined as “additive technology transfer”, in numerical terms seems



**Figure 6:** *Distribution of groups according to their patenting behavior in the 4 years before and after the spin-off establishment (the dimension of spheres is proportional to the number of academics in each category)*



Source: authors' elaboration.

to be the one with the highest effect on the number of publications with firms. Particularly evident, in group D, is the effect on publications of the spin off establishment, which is very frequently included in the affiliations of co-authors. The figure also underlines the already mentioned particularly poor performances of group E and the high productivity of group H.

A similar analysis can be done on the number of patents (Figure 6).

In general, all categories experience a growth in the total number of patents (a part from group F for which passed from 9 to 3). However, it is worth recalling here that the general increase trend in productivity (in terms of publications, patents, and publications and patents with firms) could be the result of a trend common to all academics that needs to be further clarified. At the same time, all the categories seem to increase the number of patents with firms,

including those completed with the spin-off (again with the exception of group F that passed from 7 to 2). Group D displays a peculiar behavior: a sort of “substitution effect” between the spin off and other firms. Academics of this group (34 in total), in fact, after the beginning of their entrepreneurial activity decreased the number of patents with other firms, while heavily increasing the number of patents where the spin off appears among the applicants.

Also in the case of co-patenting, the categories F and B, seem to experience an overall decrease in the degree of TT towards existing firms, which is not compensated by the patenting activity of the spin-off. Since this behavior is detectable both for co-publications and for co-patenting, one could conjecture that for these two categories the establishment of a spin-off reduces the overall TT activity, measured by co-patenting and co-publishing. Again this is a first evidence that needs to be further validated.

We recall here also that the most numerous group in terms of number of academics is group E which is the one that, in the end, does not seem to change its attitude towards the collaboration (both through publications and patents) with existing firms, which remains *de facto* inexistent both before and after their participation in a spin-off.

The differences in publishing and patenting habits of the identified groups have led us to think that this could also reflect differences in the distribution of academics across professional position or field.

First of all, the categories differ in terms of academic position of the components. For example group H (stable TT) has the lowest percentage of researchers (21.6% of the total number of academics included in the category), while group A (spin-off centered TT) the highest (40%). The incidence of associate professors is the lowest in categories A and G (starting technology transfer) (20%) and the highest in group B (substitution approach) (50%). Finally, the incidence of full professors in the different groups range from 16.7% of group B, to 50% in groups A and F (ceased technology transfer).

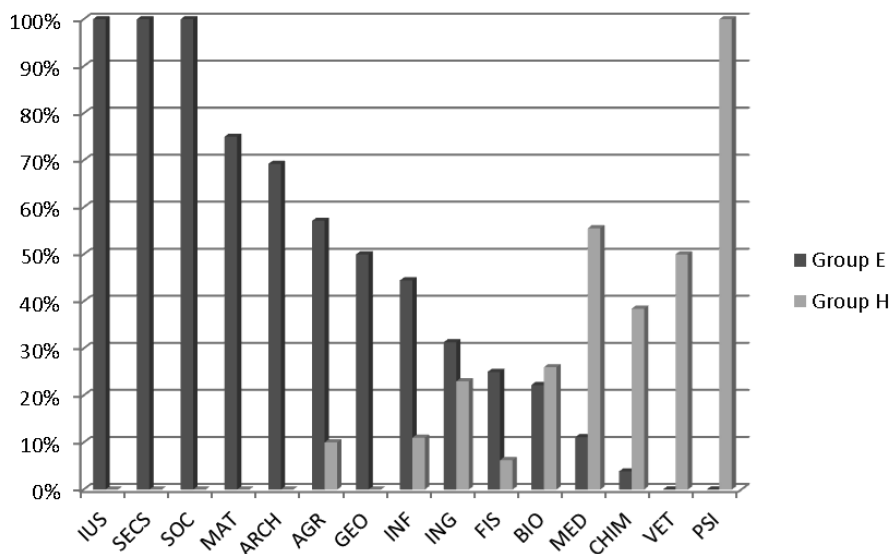
Secondly, they differ according to their scientific field. Figure 7 shows that there is a quite contrasting situation between group E and group H. Among those never publishing with firms (not even with the spin-off), there are 100% of economists (SECS), jurists (IUS) and sociologists (SOC), about 80% of the mathematicians (MAT) and almost 70% of the architects (ARCH). On the contrary, among those publishing with firms both before and after the spin-off establishment (even if never with the spin-off), we find the only psychologist, the majority of physicians (MED), and a high part of veterinarians (VET) and chemists (CHIM).

Here we do not enter the determinants of such differences, but it is clear for further researches that both academic position and scientific sector seem to be important aspects of the technology transfer behavior of academic entrepreneurs.

## 6 Conclusion

The paper is a first step towards an investigation on technology transfer from a slightly different perspective than that offered so far by most of the available literature. Even though it has been highlighted that technology transfer often implies a mixture of different tools (such as contract research, university-firm co-publications, co-patenting and etc.), in practice most of the available researches tend to treat these mechanisms as separate entities. In the case of spin-offs, for instance, they are often judged as an inadequate tool for technology transfer because they show poor performances in terms of survival and growth rates, turnover or returns on investment. However their performances are mainly compared to those of new-born

**Figure 7:** *Distribution of academics in group E (“no technology transfer”) and group H (“stable technology transfer”) according to their scientific field (% on total n. of academics in the considered fields)*



Source: authors' elaboration.

high-tech companies. Hardly any attempt has been made to understand whether engaging in a new academic entrepreneurial activity might change the attitude of researchers towards other forms of technology transfer, therefore producing “substitution” effects. This paper offers some preliminary thoughts on this matter, based on the description of an original database that we have built for the purpose. The dataset itself is a result, since it collects information on the universe of academics that have been involved in the establishment of an enterprise. Its peculiarity lies in the fact that it was built with the purpose of taking a closer look at the productivity (both in terms of publications and patents) of academics involved in the establishment of spin-offs, with particular attention to their attitude towards co-publishing and co-patenting with existing firms. This allows to observe, for each academic, his/her attitude with respect to different forms of technology transfer.

As a first step it was possible to identify sub-groups of academics that differ in their co-publishing and co-patenting behaviour, both before and after the spin-off creation. This is a second significant result. It would suggest that academic entrepreneurship does not have a unique impact on the overall technology transfer of universities. It is neither good nor bad in absolute terms, but it depends on the behaviour of the different academics, which in turn can depend upon some specific characteristics, such as academic position and scientific field. Our main findings on the sub-groups of academic entrepreneurs reveal that:

1. the largest group of academic spin-off founders include scientists that show a very low productivity in general and an even a lower propensity to work with firms, both before and after the spin-off establishment;
2. some groups are instead made of academics that also before the spin off establishment used to work with firms and that continue to do so, even more intensively, after the spin-off foundation;

3. in some cases there seems to be a sort of “substitution effect”, according to which academics who used to work with firms before starting their entrepreneurial venture decreased their collaboration in terms of co-publishing or co-patenting with other firms while starting to publish and patent with their own spin-off;
4. there are also cases of ceased technology transfer, where academics that used to collaborate with firms before their entrepreneurial activity stop doing so, and after the spin-off creation they publish or patent neither with other firms nor with their own spin-off.
5. variables such as the scientific field or the academic position seem to matter in the analysis of the technology transfer attitude of academics.

These first preliminary findings set the further steps and the research agenda for the immediate future. As said, we suggest that it is possible to identify different behaviours among scholars engaging in an entrepreneurial activity. Some of them show an increased propensity to collaborate with other firms after the establishment of the spin-off, while other, on the contrary, do not seem to change (or even seem to decrease) their co-publishing and co-patenting attitude not only with other firms, but also with the spin-off itself. In this paper we have defined such categories and described their patents and publications at an aggregate level. In our future research agenda we would like to understand what determines the differences in behaviour. For sure there are signals that scientific sectors and academic position are important, but we expect that, for instance, the specific university or the experience of the TT offices also matter.

Of course this is but a first step towards answering the question of what would have happened had the spin-off not been created and another form of technology transfer had been chosen. A comparison with researchers that had similar probabilities of generating a spin-off (but chose not to) is a necessary step forward to better understand any causal relationships. Notwithstanding the limits (of methodology, data availability and etc.) of these exercises, we believe they are necessary and urgent. They are important in order to design reforms, such as those encouraging academic entrepreneurship, on the basis of a clearer and unprejudiced understanding of the effects they produce, rather than on a generic perception of the effectiveness they had in other, different, countries.

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# Valutazione delle politiche per l'innovazione e relazioni università-impresa. Un'analisi dell'attitudine degli imprenditori accademici italiani verso la collaborazione con imprese

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## Sommario

Il paper rappresenta una prima analisi dei meccanismi di trasferimento tecnologico università-impresa in un'ottica di valutazione delle politiche a sostegno dell'innovazione. Il lavoro propone in particolare i risultati della costruzione di un database originale e dell'analisi preliminare di comportamenti individuali rispetto al trasferimento di conoscenza università-impresa. Le domande di ricerca che sottendono il presente lavoro e l'agenda di ricerca futura sono del tipo: "Cosa sarebbe accaduto se uno spin-off, ad esempio, non fosse stato avviato? Quali altri canali di trasferimento tecnologico si sarebbero attivati da parte degli stessi accademici?". Queste riflessioni si rendono necessarie alla luce della letteratura esistente, che sembra trascurare largamente il tema del trade-off fra diverse forme di trasferimento tecnologico, tralasciando così di indagare l'impatto netto finale che può derivare dalla promozione di politiche di sostegno agli spin-off piuttosto che ad altre forme di trasferimento università-impresa, fra cui co-brevetti, co-pubblicazioni, convenzioni di ricerca ecc. L'analisi qui proposta è strutturata a partire dall'universo di spin-off nati dal 2002 al 2007, di cui sono stati raccolti dati sulla compagine societaria. Individuati i soci accademici, si è ricostruita la posizione accademica ricoperta in un periodo precedente e successivo rispetto alla data di fondazione dello spin-off e sono stati osservati il numero e le caratteristiche delle pubblicazioni e dei brevetti. I primi risultati dell'analisi mostrano che i comportamenti individuali sono marcatamente eterogenei: alcuni aumentano la propensione a collaborare con altre imprese dopo la fondazione dello spin-off, per altri la partecipazione allo spin-off non impatta sull'attività di pubblicazione e brevettazione con altre imprese e infine per alcuni sembra esserci un potenziale effetto di sostituzione. Lo studio delle determinanti di tale eterogeneità diviene quindi fondamentale al fine di strutturare efficaci politiche per l'innovazione e il trasferimento tecnologico.

**Classificazione JEL:** L52; O38

**Parole Chiave:** *Trasferimento tecnologico; Valutazione delle politiche; Spin-off; Brevetti; Pubblicazioni; Italia.*