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THE ROLE OF INSTITUTIONAL CHARACTERISTICS IN KNOWLEDGE TRANSFER: A COMPARATIVE ANALYSIS OF TWO ITALIAN UNIVERSITIES

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The Role of Institutional Characteristics in Knowledge Transfer: A Comparative Analysis of Two Italian Universities

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1. Introduction

Although academics in Italian universities have a long tradition of interactions with industry, especially in applied fields such as engineering and chemistry, in the case of most university institutions, it is only since the late 1990s that they have begun to formally acknowledge the importance of knowledge transfer activity, and to establish dedicated infrastructures to support it. Italian policymakers' interest in promoting interventions to support university-industry knowledge transfer is also relatively recent. Empirical studies provide a mixed picture, with a small group of institutions heavily engaged in institutional knowledge transfer, but the large majority barely involved. These studies also provide evidence of sustained interactions with businesses outside of the institutional university set up, which are not included in institutional statistics on university-industry knowledge transfer. Following a general overview of the university-industry knowledge transfer system in Italy, this chapter focuses on a comparative case study of the two universities (University of Torino and Politecnico of Torino) based in Torino, the capital city of the Piedmont region in North-West Italy, to explore contrasting models of knowledge transfer engagement.

The chapter is structured as follows. Section 2 provides a brief overview of the Italian university system and the recent literature on knowledge transfer by Italian universities, and the impact of institutional factors in particular. Section 3 introduces the comparative case study, describing the two universities and comparing their involvement in knowledge transfer. Italy is characterized by a relatively late institutionalization of knowledge transfer activity, and a very important role of formal and informal channels that bypass the university institutions (Bodas Freitas et al. 2013). In Section 4 we analyze the business perspective on the transfer of knowledge from these two universities. Based on two original datasets, we highlight the factors that facilitate knowledge transfer from the perspectives of companies and industry inventors in the same region as the two universities. Section 5 concludes with a discussion of the differences between the approaches of the two universities to knowledge transfer.

2. Italian universities' knowledge transfer activities

In 2013, there were 96 university institutions in Italy. These included 76 traditional 'bricks and mortar' universities, 11 virtual universities providing distance learning

courses, 6 schools for advanced post-graduate studies, and 3 universities specialized in teaching the Italian language and culture to foreign students. Despite the system's formal homogeneity (universities are the only institutions authorized to award bachelor level and higher degrees but were granted some degree of autonomy from central government during the 1990s), there are remarkable differences among Italian universities. They have different histories,[1] traditions, and cultures, and different relationships with their local economies. The system includes both public and private institutions. The public university system expanded substantially between 1960 and 1990 but most of the universities established since the early 1990s are private institutions (Rossi 2009). Universities also differ greatly in terms of size (the system includes a small number of large universities and a larger number of small and medium-sized universities) and the mix of disciplines taught (on average, larger universities are more diversified and smaller ones are more specialized - Rossi 2009).
While several attempts have been made to introduce criteria for allocating funds to reward high quality research and knowledge transfer, the largest share of government funding continues to be distributed to universities on the basis of historical costs, with some small corrections to account for the number of enrolled students, exam completion, and past research performance. Historically public universities have had little incentive to diversify their income by commercializing their research and teaching activities. In 2009, only 1.1 percent of university research and development (R&D) was funded by business, compared with 6 percent in the US, 8 percent in Spain, and 14.3 percent in Germany (Geuna and Sylos Labini 2013).

2.1 The importance of private collaborations between academics and industry

The relatively small share of university R&D funded by business may not provide an accurate picture of the extent of university-industry knowledge transfer in Italy. The figure of 1.1 percent accounts only for business-funded R&D performed with the formal involvement of university institutions. Academics in Italy tend to interact with business without the involvement of the university, and recent evidence suggests that a relevant share of knowledge transfer activities is informal, or formal but not organized through the university (Bodas Freitas et al. 2012).

[1] A fairly large share (23%) was founded before the French Revolution, especially in the Middle Ages, and another 17% were established in the 19th and early 20th centuries. The largest group (60%) includes universities founded after World War II. See also Antonelli et al. (2013) for a historical analysis of the evolution of Italian universities in the first half of the 20th century.

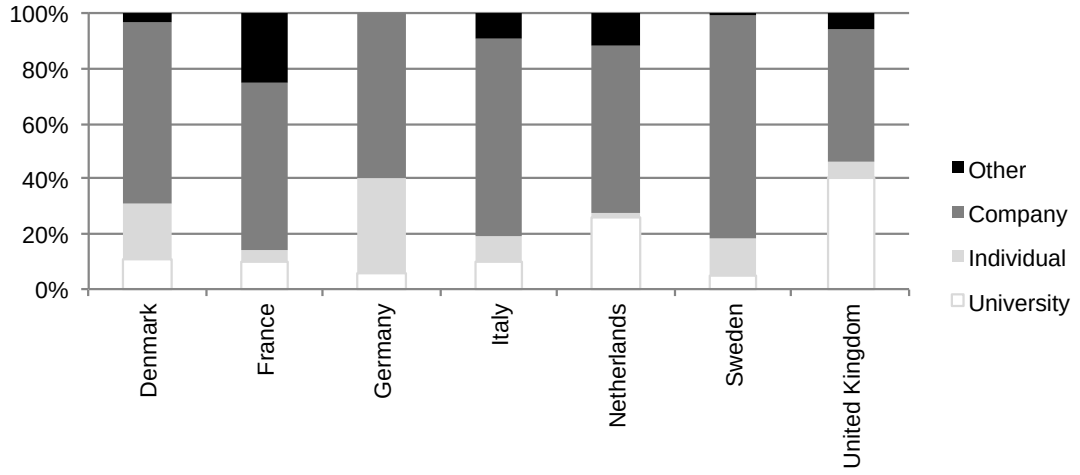
Muscio (2010) analyzes 197 Italian engineering and physics departments in 2007, and finds that most knowledge transfer activities involve collaborative and contract research, consulting, sale of patents and royalties, researcher mobility to and from departments, and 'soft' forms of transfer such as participation in events organized by companies, conferences, joint supervision of graduate students, and personnel exchanges. Almost half of these collaborations are initiated directly between companies and individual professors, with no involvement of intermediate actors. If third parties are involved these are usually other universities and/or research centers, and other companies; only 20 percent of cases involved a university knowledge transfer office (KTO).

Evidence from industry confirms that a large share of the collaborations between academics and industry bypass the university institution. Based on a survey of a representative sample of industrial firms in the Italian region of Piedmont, Bodas Freitas, Geuna and Rossi (2013) find that direct, contract-based interactions between academics and industry researchers are as frequent as research contracts mediated by the university institution. While institutional interactions mostly involve large firms which vertically integrate R&D activities, small firms prefer direct personal interactions involving an open innovation strategy. This suggests that direct collaborations with university researchers allow firms that lack the material and social/cognitive resources, to interact with a university in order to benefit from knowledge transfer.

The importance of interactions not mediated by the university institution is highlighted also by studies of academic patenting. The share of business-owned academic patents (i.e. patents with at least one academic in the list of inventors) is a rough indicator of the importance of collaborative activities that do not involve the university institution since businesses tend to claim ownership of patents generated in collaborative research and particularly if these activities are funded by industry with no direct institutional involvement of the university. Data for the period 1994-2001 collected by Geuna and Rossi (2011), suggest that in Europe, most academic patents (50%-80%) are business-owned (Figure 1). Della Malva et al. (2007) confirm that most (72%) Italian academic patent applications filed at the European Patent Office

(EPO) between 1994 and 2001 were assigned to companies, while Lissoni and Montobbio (2012) show that the share of business-owned academic patents in Italy in the period 1995-2001 is comparatively higher than in France, the Netherlands, or Denmark. The situation has not changed substantially in recent years. As a result of legislation introduced in 2005, Italy is one of only two countries in Europe (the other being Sweden) where academics enjoy the so-called 'professor's privilege', that is, they own the intellectual property for any inventions emerging from their publicly-funded research activities. However, because of the high costs of patent filing, most academics transfer these rights to the university institution,[2] or in the case of research carried out with industry, to the collaborating companies. If the research is industry-funded, the contracting company generally stipulates ownership of the rights to any resulting intellectual property. Therefore, although the share of university-owned patents has increased in all countries over time, in Italy this increase has been due mainly to a decrease in the share of patents owned by government research institutes, with business-owned academic patents remaining very important.

Figure 1 Shares of patents with at least one academic inventor, according to ownership (university ownership, individual ownership, company ownership, other ownership), 1994-2001



Source: Elaboration of data presented in Geuna and Rossi (2011).

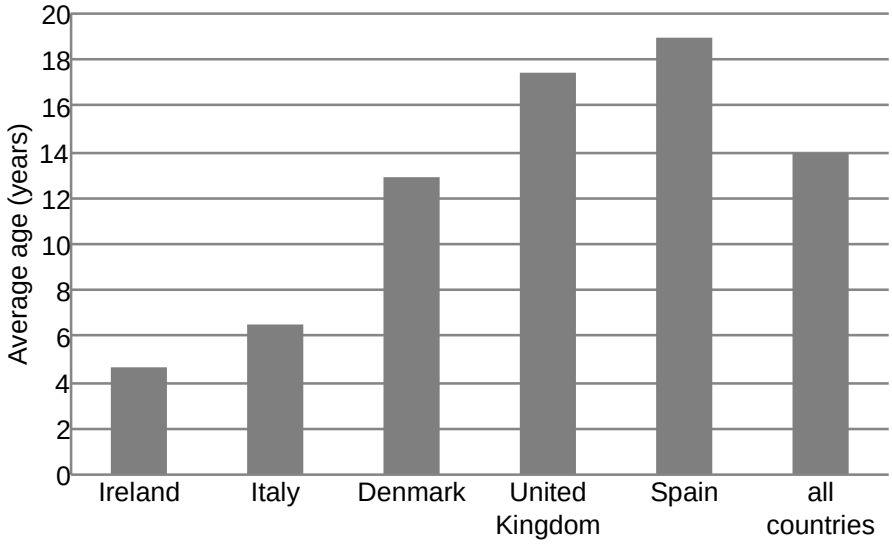
2.2. Public policies supporting university-industry knowledge transfer

Italy lacks coordinated and effective public policies to support universities' knowledge transfer. The responsibility for science, innovation, and technology policy

[2] The university acquires the right to commercially exploit any invention that has not been commercialized in the 5 years since the patent was granted.

is split between central and regional government. Central government supports and coordinates pre-competitive research, and provides generic incentives such as R&D tax credits (OECD 2011); regional government implements policies designed to support local businesses through the provision of services and/or grants, and other funding. Interventions aimed at developing a knowledge transfer infrastructure have been fragmented. The first publicly-funded science and technology parks date back to the early 1980s but it was mainly in the 1990s that a variety of other structures were created: EU-funded Business Innovation Centers, development agencies, special agencies of the chambers of commerce, technology centers, and others (Muscio and Orsenigo 2010). There are numerous centers that support technology transfer and innovation in different ways; however, most are small, not specialized, poorly integrated, and vary greatly in the services offered, their business models, and their involvement in technology transfer activity (IPI 2005). This contrasts with the situation in countries such as Germany and Sweden, where effective, publicly-funded KTOs have been set up at regional level (Sellenthin 2006).

Figure 2 Average age of KTOs, 2011



Source: ProTon Europe (2012)

2.3 The development of an infrastructure for university-industry knowledge transfer in Italy

As Italian universities cannot rely on a solid external infrastructure to support their knowledge transfer activities, they have developed internal structures to manage their interactions with businesses, and to support research commercialization and the

creation of spinoff companies. However, these efforts are recent: in most cases, the organizational structures to facilitate knowledge transfer were not set up until the 2000s. Most KTOs were established between 2001 and 2008,[3] with activity concentrated especially in 2004 to 2006. According to the latest survey carried out by NetVal (Network per la Valorizzazione della Ricerca Universitaria, Italy's main association of university technology transfer offices), in 2011, 59 out of the 61 Italian universities surveyed had a formal KTO (NetVal 2013). Figure 2 shows that Italian KTOs are much younger on average than those in the other European countries surveyed except Ireland (ProTon Europe 2012).

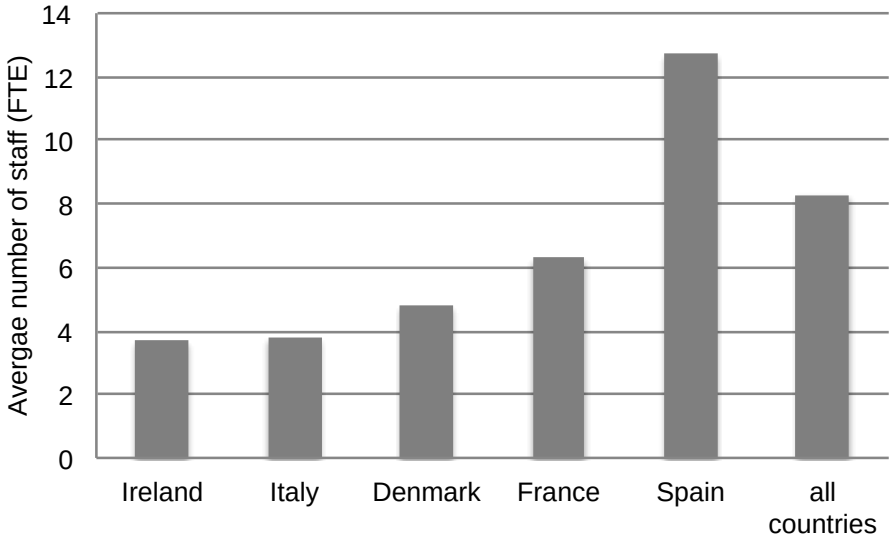
In the same period, most universities formulated internal policies to regulate interactions with business. Baldini, Fini, and Grimaldi (2014) study the 64 Italian universities with science, technology, engineering, and mathematics (STEM) departments. They report that in 2000 none had spinoff, patenting, or consultancy policies but by 2007, 60 percent had at least one of these initiatives in place. Most university knowledge transfer policies are fairly similar, with less prestigious universities emulating the policies of their more prestigious competitors (Baldini et al. 2010).

The KTO system in Italy is immature, and the variety of organizational forms is limited with most structures focusing on a narrow set of activities. The most common structures are patent filing and management offices, Industry Liaison Offices (which facilitate the process of technology transfer and support researcher's spin-off creation) and incubators to support university spin-offs (Muscio 2010). Most of these structures serve a single university, are publicly owned, and are managed by a university professor (Muscio 2010). KTOs in Italy tend to be smaller (see Figure 3) than those in most other European countries, with the exception again of Ireland (ProTon Europe 2012), and this small size, according to international evidence,[4] is associated with lower efficiency.

[3] In 2000, a Ministerial Decree allowed universities to set up Industry Liaison Offices and to organize and invest equity in spin-off companies (Muscio and Orsenigo 2010).

[4] See among others, Rogers et al. (2000), Thursby and Kemp (2002), Nosella and Grimaldi (2009), Caldera and Debande (2010), Curi et al. (2012), and Algieri et al. (2013).

Figure 3 Average number of staff of KTOs (FTE), 2011



Source: ProTon Europe (2012)

Almost half of the 61 Italian KTOs included in the NetVal (2013) survey are linked to, or hold equity in, a science park, and/or an incubator. Most KTOs see intellectual property management as their main function, followed by support for spin-off companies, and licensing. Management of collaborative research and contracts with industry are less important but still relevant, while provision of continuing professional development courses, management of research funds, management of seed capital funds, provision of technical services, and management of science parks or incubators are much less frequent (NetVal 2013).

Italian universities' abilities to engage in knowledge transfer appear very skewed, with the best knowledge transfer performers doing significantly better than the rest. The best five performers have almost twice the ratio of technology transfer staff to academic staff than the remaining universities, and their average patent stock, number of licensing contracts, and licensing revenues are much higher (NetVal 2013).

Several recent studies highlight some basic characteristics of Italian universities, KTOs, and university researchers which promote interactions with industry. The following are the most relevant.

(i) Scientific excellence. Research quality is a very important determinant of the likelihood of interactions with industry. Sciacca (2012), using panel data for 69 Italian

universities in 2006-2009, found that research-oriented universities, those that are ranked higher for scientific productivity, very large universities, and technical universities ("politecnici"), have a larger share of research funding from industry. Muscio and colleagues (2013) found that business funding to Italian departments is positively affected more by these departments' academic research performance, which provides a quality signal to industry, than by the presence of a KTO (Hewitt-Dundas (2012) presents similar findings for the UK). Abramo et al. (2009) and Abramo et al. (2011) found that the number of Italian universities' collaborations with industry is positively influenced by the size of the university, the scientific excellence of its academics, and the proximity of collaborators. However, there are differences across disciplines: a separate analysis on a specific field, pharmacology, suggests that scientific excellence does not play a significant role.

Matricano et al. (2013) found that the likelihood of creating a university spinoff in Italy increased with the quality and size of the university's academic staff (number of research projects, share of projects coordinated by the university, and number of tenured academics), and differed according to disciplines (biotechnology and engineering are particularly likely to generate spinoffs). Similar relationships are reported in several international studies such as O'Shea et al. (2005) for the US, and Caldera and Debande (2010) for Spain.

(ii) Institutional size. Bruno and Orsenigo (2003) suggest that a critical mass of researchers is needed to improve the ability of Italian institutions to interact with firms. Institutions with more research staff not only have more resources but also enjoy greater prestige and higher visibility, are more specialized, and have more efficient procedures for the establishment and management of collaborations (Muscio and Nardone 2012). Several international studies suggest that the size of the university is positively related to the level of technology transfer (Belenzon and Schankerman 2009), measured in terms of amount of private research funds (Von Tunzelmann and Kraemer Mbula 2003), number of interactions with companies (Bruno and Orsenigo 2003; Landry et al. 2007), and spin-off creation (O'Shea et al. 2005). However, Muscio (2010), investigating engineering and physics departments in Italy, found that the size of the university did not substantially affect the interaction of the department with business.

(iii) Policies and incentives. Muscio, Quaglione, and Vallanti (2013) provide evidence that limiting the amount of money that researchers can earn from consulting and contract research, and increasing the university's overhead fees have a negative effect on participation in these activities by Italian engineering and physical sciences departments. Baldini, Fini, and Grimaldi (2014) focus on a subset of 64 Italian universities with STEM departments and find that having policies in place to regulate consultancy, patenting, and spinoff creation increases academic entrepreneurship. This is in line with international evidence. For example, Caldera and Debande (2010) found that Spanish universities' adoption of clear rules for dealing with conflicts of interest increase the number of R&D contracts and the amount of R&D income, while university regulation of researchers' participation in contract research has the opposite effect. Technology commercialization activity is shown to benefit from well-defined licensing contracts (Jensen and Thursby 2001; Macho-Stadler et al. 2007), higher royalty shares for academic inventors (Lach and Schankerman 2004), and the inclusion of patents and licenses in the criteria for promotions and tenure negotiations (Geuna and Muscio 2009), while optional disclosure and unclear intellectual property rights policies have been shown to lead to conflicts over ownership and poor KTO performance (Fisher and Atkinson-Grosjean 2002).

(iv) Size and quality of KTO. Baldini, Fini, and Grimaldi (2014) find that having a KTO, and in particular running more professional technology transfer operations (affiliation to a professional technology transfer association and staff trained in technology transfer) increases academic entrepreneurship in Italian universities. Muscio (2010), using original data from interviews with 197 university departments in Italy, found that, while the establishment of a KTO per se does not increase the frequency of university-industry interactions, KTOs that are managed by knowledge transfer professionals rather than academics, are more involved in mediating university-business interactions (Siegel et al. (2003) report similar results for the US). Nosella and Grimaldi (2009) use data from a survey of 43 Italian universities in 2005 and find that the presence of a KTO, on its own, does not affect the rate of spinoff creation but that the number of technology transfer staff, the number of services provided by the KTO, and the KTO's relationships with external organizations makes a positive difference. Algieri, Aquino and Succurro (2013), using data on 58 Italian universities in 2009, found a positive effect of KTO's resources (financial and human)

on the rate of spinoff creation. Fini et al. (2011), studied Italian academic spin-off companies and found that the existence of both institutional and regional infrastructures to support technology transfer facilitated the creation of spinoffs, however the marginal effect of institutional infrastructures on productivity decreased in contexts where regional support mechanisms made a positive marginal contribution to productivity. That is, in highly supportive regional innovation systems, the contribution of institutional infrastructure is less important.

Several international studies emphasize the importance of KTO staff competences and experience (e.g., Friedman and Silberman 2003; Markman et al. 2008; Lockett and Wright 2005; Siegel et al. 2003). However, studies of UK and European contexts find that KTOs generally lack both scientific expertise and business skills and capabilities (Geuna and Nesta 2006; Chapple et al. 2005) and are of variable quality (Lambert 2003), which is in line with recent evidence from the NetVal (2013) survey.

3. A comparative case study: The University of Torino and the Politecnico of Torino

In order to illustrate different models of university engagement in knowledge transfer activities, we present a comparative analysis of the two universities based in Torino, the capital of the Piedmont region in North West Italy. These institutions share the same socioeconomic environment, and operate within the same legal and regulatory framework but differ in origin, history, size, specialization, and institutional mission. A comparison of these institutions allows us to explore the relationship between institutional characteristics and the nature of these universities' involvement in knowledge transfer.

3.1 A brief overview of the two universities

The University of Torino, which is medieval in origin (founded in 1404), has 27 departments covering a wide range of disciplines including humanities, social, natural, and medical sciences. Compared with the average Italian university, the University of Torino's undergraduate and postgraduate education provision is oriented more towards the social sciences and less towards science, humanities, and medicine (Geuna et al. 2009). Based on data from the Italian Ministry of Education (MIUR), at the end of 2012 the university had approximately 63,000 enrolled students and

employed almost 2,000 tenured academics (more than 3,000 if temporary contracts are included), and just over 1,900 permanent and temporary administrative and technical staff. The University of Torino is one of 10 Italian universities that enroll more than 50,000 students.[5] The Politecnico of Torino was founded in 1859 and includes 11 departments, focused on architecture and engineering. At the end of 2012, its student enrollment was almost 29,000 and it employed just over 800 tenured academics (more than 1,000 including temporary contracts), and almost 900 permanent and temporary administrative and technical staff. Despite being a specialized technical university, the Politecnico is larger than about 75 percent of Italian universities in terms of enrolled students. The large numbers of students per academic staff in these universities is in line with the Italian average, and is one of the highest in Europe (Geuna and Rossi 2014).

The incidence of PhD students in the student population at the Politecnico of Torino (2.8%) is higher than the national average (2.2%) and higher than the University of Torino (1.8%). A more obvious indicator of research intensity is the scientific productivity of the university's academics, measured for example, in terms of publications per researcher. However, data on academics' publications aggregated by university or by department are not collected systematically. Moreover, since there are significant differences in publication practices across fields, the two universities are not easily comparable. According to the ISI Science Citation Index (expanded) data for the period 1995-2001, the University of Torino was ranked 12th for scientific productivity among the 31 universities with a medical school, while the Politecnico of Torino had the second highest index of scientific productivity among the three Italian politecnici, after the Politecnico of Milano (Conferenza dei Rettori delle Università Italiane 2002. Data from the Aquameth database (Daraio et al. 2011) built on ISI data for the same period, suggest that the number of publications per tenured academic staff at the University of Torino compared to the average for other large universities, is higher for the technical and medical sciences, and lower for the natural sciences, the humanities and social sciences. In terms of research impact (citations per researcher or per publication), the University of Torino is ranked 3rd among universities with a medical school, while the Politecnico of Torino is ranked 2nd

[5] The other 9 are Bari, Bologna, Catania, Florence, Milan, Rome La Sapienza, Naples Federico II, Padua and Palermo.

among the politecnici (Conferenza dei Rettori delle Universita Italiane 2002). Aquameth data indicate also that the University of Torino has a particularly high number of citations per publication compared to other large universities. Both universities are relatively better positioned in technical and scientific disciplines than in social sciences and the humanities.

Scellato, De Rosa, and Riva (2007), using ISI Science Citation Index (expanded) data for 2005, provide more detailed information on the scientific production of these two universities. In 2005, the Index included 600 articles published by Politecnico researchers and 1,453 articles published by university researchers.[6] Almost 50 percent of the Politecnico's publications were in technology, engineering, and computer science, while almost 50 percent of the University's publications were in medicine, biology, biotechnology, and pharmacy. Both institutions had a sizeable share of publications in the physical sciences. Researchers from the Politecnico participated on average, in smaller collaborations (in most subject areas the University of Torino has a higher average number of co-authors, and average number of different institutions per publication) but collaborated more often with foreign institutions and were more frequently first authors. In most subjects, the Politecnico's publications were more interdisciplinary (greater average number of different subject categories per article).

The ability to secure competitive public research funds is another indicator of university research strength. Data for the period 2000/01–2004/05 (Daraio et al. 2011) show that the Politecnico attracted a high level of competitive research funding per tenured academic staff, higher than the national average and the other politecnici. The figure for the University of Torino was lower than the national average and other large universities. This is confirmed by data from Consiglio Nazionale per la Valutazione del Sistema Universitario (2008) which show that in 2006 the amount of

[6] Note that the ISI Science Citation Index (expanded) does not include humanities and arts journals, and includes a limited number of social sciences journals, thus, it excludes a significant part of universities' scientific publications, especially from those that are particularly specialized in these disciplines. In 2008, the University of Torino's catalogue of research products (a very broad aggregate including books, book chapters, articles, and other publications, as well as software, databases, materials, etc.) included over 5,000 items, of which 2,347 were articles. Similarly, in 2007, the Politecnico's catalogue of research products included approximately 1,100 articles. For both universities, the actual number of articles produced was much higher than the yearly numbers reported in the ISI Science Citation Index (expanded) two years earlier: 67% higher in the case of University of Torino, 37.5% higher in the case of the Politecnico.

competitive research funds per tenured academic staff was over €90,000 at the Politecnico, and over €58,000 at the University. This difference can be explained by the University's above-average share of staff in social sciences (research fund allocations in this field are usually lower than in the natural, technical, and medical sciences) and by the particularly low level of research funds obtained by the University in these subjects (Comitato di Indirizzo per la Valutazione della Ricerca 2006).

3.2 The two institutions' knowledge transfer infrastructures and policies

The University of Torino has a small, relatively new infrastructure to support knowledge transfer, focused almost entirely on patenting and spinoff activities. The University's KTO (Settore Brevetti e Trasferimento di Conoscenze) was set up in 2001. In addition to providing training for academic staff related to intellectual property issues, the office is involved mainly in managing patent applications and licensing. The University of Torino introduced a formal intellectual property policy in 2003 (updated in 2009). If the academic inventor agrees to transfer the economic rights to exploitation of their invention to the university, the university pays all the costs of the patenting process, from a special central patenting fund and a matching contribution from the inventor's department. The academic is entitled to 50 percent of any profits from the commercialization of his or her invention, the remaining 50 percent being shared between the patenting fund and the department or research center to which the academic is affiliated. In 2003, the University also issued a formal policy on spinoff companies which entitles the University to a minority stake (between 5% and 49%) in any spinoff companies created to exploit intellectual property held by university staff. In 2006, it set up an incubator (a joint venture with three local government bodies), to host university spinoffs in the chemical, pharmaceutical and biotech fields. The incubator provides office and laboratory space at reduced rentals, and financial support for the purchase of equipment.

Company-sponsored research and consultancy contracts are another important channel for knowledge transfer. The University of Torino's Research Office deals with these contracts. Any intellectual property emerging from contracts funded, fully or partially, by private companies, is usually assigned to the business partner. The Research Office also manages research projects funded by national and international

government bodies.

The knowledge transfer activities of the Politecnico are managed through several structures, the oldest of which is its "Ufficio contratti" which currently employs about 10 staff. While the office deals with patent applications,[7] licensing, and spinoffs, its main activity historically has been management of company-funded research and consultancy contracts (Cuttica 2012). The Politecnico published its first intellectual property policy in 2001; the most recent one (2007) contains similar provisions to the University's, with academics having the right to assign the intellectual property of their inventions to the Politecnico in exchange for the latter covering all patenting expenses. Half of the profits from commercialized inventions are assigned to the inventor, with the remaining 50 percent going to the Politecnico (10% to the academic's department or research center, 40% to the KTO to support patenting expenses). The Politecnico has had a spinoff policy since 2003; the most recent one was published in 2012 and stipulates that the university should have an equity stake of between 5 percent and 40 percent in spinoff companies set up by its staff (a broad category that includes current students and recent alumni). Career-related incentives have been included to encourage staff to invest their time in the creation of spin-off companies (possibility to switch to a part time academic post or to take a sabbatical in order to work in the spinoff without this affecting career progression). Most spinoffs are hosted in the Politecnico's incubator, I3P, which was set up in 1999 and is currently the largest university incubator in Italy. Like the University of Torino's incubator, I3P is a joint venture with local government bodies and local organizations.

The Politecnico's knowledge transfer infrastructure also includes other components, such as two project management offices (one for projects funded by national structural funds, and the other for European Union funded projects), a contact point for businesses (Innovation front end), a venture capital hub launched in 2007, with an office at the Politecnico representing 27 Italian and international venture capital and business angel funds, and a Business Research Centre project, launched in 2008 which promotes the localization of company research centers on the Politecnico campus. This last initiative has resulted in several multinational companies (including

[7] Both the University and the Politecnico outsource the filing of the patent applications to external organizations.

General Motors, ST Microelectronics, Indesit, Avio, Pirelli, Prima Industrie) establishing research units in the Politecnico.

A study by Rolfo and Finardi (2014) compares the University and the Politecnico of Torino in terms of research personnel attitudes to knowledge transfer. The authors collected detailed data on the individual research laboratories' research projects, and studied how scientists transferred them to the commercial sector by publicizing them on two technology transfer portals. They infer that in the University of Torino, knowledge transfer activities are driven by the involvement of departments rather than individual scientists, while the reverse applies to the Politecnico. Moreover, in the University, knowledge transfer initiatives appear to be concentrated in the hands of laboratory directors, while at the Politecnico these activities are more diffused and laboratory directors are more often collaborators in projects than project leaders. This suggests that the knowledge transfer culture is different in these two institutions, and that knowledge transfer initiatives are more concentrated and hierarchical in the University and more diffused and egalitarian in the Politecnico.

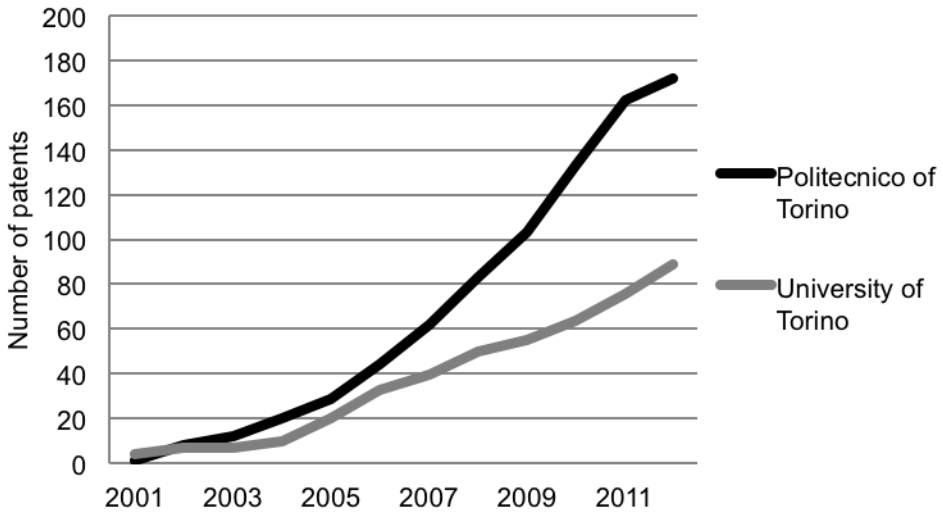
3.3 Engagement in knowledge transfer by the two universities

We consider patent filing and revenue from patenting and licensing activities, creation of spin-off companies, contract research and consulting, to compare the knowledge transfer activities of the University and the Politecnico of Torino. Data on the output from these knowledge transfer channels is collected by the university institutions. This does not cover all the knowledge transfer activities of these institutions, For example, it does not include all the interactions with the public sector, the media, and the general public and specific communities or groups which are especially important for the social sciences, arts, and humanities. It also does not include education-related knowledge transfer activities (joint supervision of graduates, industry support for PhD students, or university-industry personnel exchanges). In addition, many interactions between academics and external stakeholders take place outside institutional channels (Bodas Freitas et al. 2012).

3.3.1 Filing of patents and revenue from patenting and licensing activities

Patenting activity at Italian universities has intensified in recent years (Baldini, Grimaldi and Sobrero, 2006). Italian academics can retain the intellectual property rights to their scientific discoveries but the costs of patenting are prohibitive for an individual and most academics transfer these rights to their institutions. In addition, since the early 2000s, universities have more actively pursued the commercialization of research results. In 2012, the Politecnico of Torino had a portfolio of 172 patents, 44 dating from the six years between 2001 and 2006 and the remaining 128 filed in the six years to 2012. Since then, patenting activity has slowed and several patents (19) have been abandoned. The University of Torino's patent portfolio has also increased significantly, and in 2011 included 95 patents, 40 filed since 2010 (in 2001 the University only held 4 patents). In 2011, the University of Torino filed 12 patents and the Politecnico filed 27; the Italian average was 6.2 (Netval 2013).

Figure 4 Cumulative number of patents filed by the Politecnico and University of Torino since 2001



Source: Universities' websites

The revenues from licensing in Italy are very skewed, with the five best performing universities accounting for more than half of all licenses and 95 percent of all licensing income in 2011 (Netval 2013). While Italian universities registered an average of 1.3 licenses and earned €8,100 from licensing activity, the top five universities had 6.6 licenses and earned €61,400 from licensing. Of the 95 patents held by the University of Torino, 22 have been licensed representing an average of

8.1 patent applications and 2 licenses per year, in the period 2001-2012 (Università degli Studi di Torino 2012). The average number of patents filed by the Politecnico in the period 2001-2008 was 10 per year and the average number of licenses per year was 2.25 (Politecnico di Torino 2008).

Despite the recent increase in university patents, the share of academic patents granted to companies is likely to remain high. Torino hosts the research centers of several large companies which historically have engaged in collaborations with researchers at the Politecnico and several private and public research institutions. Some of this was direct participation by the universities to which the academics were affiliated: academics are not required to notify their university employers about inventions realized in the course of their research activity or to share the proceeds from their sale.

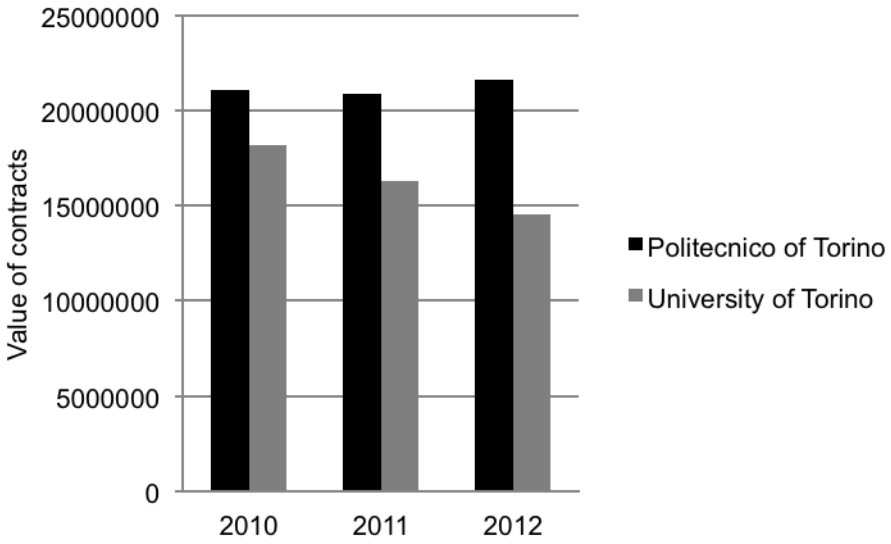
3.3.2 Spinoff activity

The most recent NetVal (2013) survey identified 1,082 companies active in 2012, spun-off from public research conducted in universities and public research organizations. Of these, 87 percent were established in the period 2002-2012 (96 were established in 2011). The five most active universities and public research organizations in terms of spin-off creation are responsible for almost 30 percent of these spinoffs, with the Politecnico accounting for 5.7 percent. The Politecnico is the most active creator of spinoffs among Italian universities. In January 2014, the number of companies hosted by the I3P incubator since its establishment in 1999 was 156, of which 85 the incubator, 30 had closed down, and 6 had been acquired. These companies, which specialize mainly in information and communication technology, engineering, and industrial technology, also include start-ups not spun off directly from research carried out at the Politecnico; the number of active Politecnico spinoffs is 62 (NetVal 2013). In 2011, the I3P incubator launched an incubation program for digital and new media companies which has attracted 59 such projects. The 2013 UBI Global Benchmark Report includes 150 spinoffs in 22 countries and ranks I3P as 4th in Europe and 11th in the world based on a set of performance indicators (I3P 2014).

The University of Torino has seen a substantial increase in the number of spin-offs: 25 of the 27 spin-offs established between 2001 and 2012 were established after 2007.

Seven of the 27 spinoffs active in 2012, had received an equity stake from the University, and 13 were hosted in the University's incubator. The incubator includes a total of 19 companies employing 133 staff and accounting for 12 patents.

Figure 5 Value of Politecnico and University of Torino third-party contracts, 2010-2012



Source: Politecnico di Torino (2013), Università degli Studi di Torino (2012)

3.3.3 Contract research and consulting

The importance of private financing for university research has increased for all Italian universities. Between 2001 and 2009, the share of financing received from the Italian Ministry of Education (MIUR) dropped from 73 percent to around 63 percent, while there was an increase in income from tuition fees (from 10.7% to 12.7%) and in funding from other sources (which includes contracts with public bodies, businesses and charities) (from around 12% to almost 18%) (Geuna and Sylos Labini 2013).

At the University of Torino, third party contracts[8] for research, consultancy, and services amounted to €14,577,472 in 2012 (down from €18,178,221 in 2010). Of this, approximately €12,055,000 was for research activities, and 24.6 percent of the University's overall research funding came from external (i.e. non-ministerial) sources (Università degli Studi di Torino 2012). In 2011, third party contracts for research, consultancy and services provision by the Politecnico amounted to

[8] The definition of "third party" adopted here includes private companies and also public administrations and charitable trusts (two of which play very important roles in funding research activities in Torino's universities).

€20,886,325, almost half of the total research funds from external sources. Third party contracts have increased in number, but increased only slightly in value since 2011 (Politecnico di Torino 2012). The amount of third-party funding per tenured academic is slightly more than €25,000 at the Politecnico, and slightly more than €7,000 at the University.

4. The perspective of companies and industry inventors on interactions with regional universities

To further explore differences in the knowledge transfer processes of the two universities, we investigate what drives companies' and industrial inventors' choices of collaborator. We rely on two original surveys conducted in 2008-2009, one addressed to companies and the other to inventors. All those surveyed were based in Piedmont, that is, in the same institutional, social and economic setting, which allows us to control for some of the determinants of different types of interactions.

The UIPIE questionnaire was administered in autumn 2008 to a sample of 1,058 representative firms in the Piedmont region; we obtained 1052 valid responses. The sample was developed and validated by the local chamber of commerce, which administered the questionnaire with its quarterly regional economic foresight survey (Bodas Freitas et al. 2013). Of the 1,052 companies that responded to the survey, 100 stated having collaborated with a university institution in the previous three years. Of these, 83 had collaborated with at least one of the two universities in Torino: 17 companies had collaborated with the University of Torino, 55 with the Politecnico of Torino, and 11 with both universities.

Compared with the 72 companies that collaborated with other universities, the 28 that collaborated with the University of Torino were significantly more likely to belong to the food industry, and significantly less likely to belong to textiles, transportation, or other manufacturing. They were also significantly less likely to have an R&D department. Compared with the 34 companies that collaborated with other universities, the 66 that collaborated with the Politecnico of Torino were significantly less likely to belong to the food or chemical industries, and significantly more likely to belong to the mechanical or other manufacturing sectors. They were also larger on average although this difference is only weakly significant.

Some differences emerge also with respect to the nature of the collaborations. Companies were asked whether their collaborations with university institutions were aimed at R&D, provision of services to support the firm's production activities (e.g. safety and quality testing and analysis), or support for the firm's business development via organizational, management, logistics, marketing, or legal consultancy. Compared with the companies that collaborated with other universities (72), those that collaborated with the University of Torino (28) were significantly more likely to pursue a greater number of different objectives. Compared with the companies that collaborated with other universities (34), those that collaborated with the Politecnico of Torino (66) were significantly less likely to engage in collaborations to provide organizational, management, logistics, marketing, or legal support.

Eighty-nine respondents stated that although they did not collaborate with a university institution, (they had not signed a contract with either a KTO, a department, or the university) they had contracts with individual academics (private contractual relationships), that is, almost as many companies as those that collaborated with the university institutions. However, due to space limitations, we could not collect more detailed information about these interactions through the UIPIE survey. Private contractual relationships were investigated in more detail in the PIEMINV survey.

The PIEMINV questionnaire was administered in autumn 2009 and spring 2010 to the population of inventors with a Piedmont address, that had applied for an EPO patent in the period 1998-2005, which included some 4,000 patents and 3,000 inventors (Bodas Freitas et al. 2014). We were able to identify 2,583 valid addresses for company inventors and obtained 938 valid responses from questionnaires (response rate 36%). After eliminating responses from inventors employed at public research institutions at the time of the invention (for which previous information was not available), we were left with 915 observations.

The questionnaire was designed to investigate various aspects of university-industry interactions and to enable quantitative measurement of the local universities' contribution to the invention process. Additional information (number of employees,

revenue, legal status, industry) on the firms employing the inventors was collected from the CERVED database of Italian company accounts. Further information on company size was collected for firms with non-Italian ownership and firms not present in the CERVED database. Finally, information was collected on inventors' patents.

Inventors were asked to indicate which universities they collaborated with, and how often. Of the 815 inventors who responded to this question, 570 stated that they had collaborated with at least one university (through any channel) in the previous two years; 36 inventors had collaborated with the University of Torino, 305 with Politecnico, and 146 with both.

Table 1 shows that the Politecnico of Torino is ranked first for interaction frequency, followed by other Italian universities. The other two Piedmontese universities (Torino and Piemonte Orientale) are less important, although there is a clear localization effect, with 58 percent of inventors declaring collaboration with one of the three. Forty-six percent of company inventors interacted at least every two years with a non-Piedmontese university, and 29 percent with a foreign university (13.4% with a US university), indicating a high level of internationalization in the university-industry interactions of innovative Piedmontese companies.

Table 1 Frequency of interactions with different universities

University	Frequency of interaction:							
	Very frequent		Frequent		Not frequent		Rare	
Politecnico of Torino	44	5.4%	73	9.0%	127	15.6%	207	25.4%
Other Italian University	47	5.8%	67	8.2%	80	9.8%	140	17.2%
Other European University	23	2.8%	37	4.5%	51	6.3%	89	10.9%
University of Torino	13	1.6%	26	3.2%	41	5.0%	102	12.5%
US university	7	0.9%	17	2.1%	33	4.0%	52	6.4%
Other foreign university	8	1.0%	6	0.7%	23	2.8%	43	5.3%
University of Piemonte Orientale	5	0.6%	10	1.2%	19	2.3%	40	4.9%

Note: Rare is 1 interaction every 2 years; not frequent is once or twice a year; frequent is 3-6 times a year; very frequent is every 1-2 months. There was also an alternative (not reported here) of no interaction.
Source: Bodas Freitas et al. 2014

The prevalence of interactions with the Politecnico may be due to an alumni effect since the Politecnico is an elite technical university that specializes in disciplines that tend to dominate inventors' technology classes (especially mechanical and electrical

engineering). Many (208) of the inventors in our sample were Politecnico graduates. Table 2 (rows) shows the share of inventors that graduated from each of the universities who subsequently interacted with each university (columns). Although some subsamples are relatively small, there is a strong correlation between the degree-awarding institution and the university with which the inventor interacts. This confirms the importance of networks of relationships, such as alumni networks, for driving university-industry relationships.

Table 2 Graduates by institution and interactions with different universities

	UNIVERSITY OF GRADUATION							
	University of Torino		Politecnico of Torino		Other Italian university		Foreign university	
No. of graduates	87		208		92		19	
No. interacting with the following universities:	N	%	N	%	N	%	N	%
• University of Torino	57	25.8%	36	9.8%	23	6.3%	1	4.3%
• Politecnico of Torino	59	26.7%	157	42.9%	41	21.9%	10	43.5%
• University of Piemonte Orientale	15	6.8%	11	3.0%	13	6.3%	0	0.0%
• Other Italian University	50	22.6%	93	25.4%	63	43.8%	4	17.4%
• Foreign university	40	18.1%	69	18.9%	42	21.9%	8	34.8%
Total no. of interactions	221	100%	366	100%	182	100%	23	100%

Note: The information on highest educational qualification was supplied by 708 inventors (almost 60% of whom said they had a tertiary degree); name of awarding institution was supplied by only 406 inventors. An inventor can have interactions with more than one university.
Source: Bodas Freitas et al. 2014

The PIEMINV survey allows us to explore in more detail the channels of interaction with academic research used by the inventors. Almost all the inventors who collaborate with the University of Torino also collaborate with the Politecnico (146 out of 182), while there is a substantial group of inventors (305) who collaborate only with the Politecnico.

Compared with the 265 inventors who collaborate with other universities, the 305 inventors who collaborate only with the Politecnico of Torino are significantly more likely to patent in mechanical engineering, machinery, or transportation (and significantly less likely to patent in instruments, chemicals and materials, and pharmaceuticals, and biotechnology). They are significantly more likely to seek solutions to technical problems, and less likely to seek information about other relevant sources of knowledge or to seek legal, marketing, or organizational advice.

Concerning their preferred interaction channel, they are less likely to attend academic conferences and read scientific literature, since these are not common ways of accessing academic knowledge in applied fields such as engineering. These inventors are significantly more likely to engage in direct contracts with individual academics — probably because collaboration is aimed mostly at finding solutions to specific problems. They are also significantly less likely to engage in institutional collaborations with a university institution (whether funded by the company or public funds), shared facilities with a university, recruitment of graduates, and staff exchanges with a university.

Compared with the 534 inventors who collaborate with other universities, the 36 inventors who collaborate only with the University of Torino are significantly more likely to patent in the fields of chemicals and materials, pharmaceuticals, and biotechnology (and significantly less likely to patent in mechanical engineering, and machinery, and transportation). They are significantly more likely to attend academic conferences and read scientific literature but significantly less likely to engage in staff exchanges with a university.

Finally, compared to the 424 inventors who collaborate with other universities, the 146 inventors who collaborate with both the University and the Politecnico of Torino are significantly more likely to patent in instruments, and less likely to patent in the process industries and in mechanical engineering, machinery, and transportation. They appear more likely to seek information about other relevant sources of knowledge, and to engage in all the forms of interaction considered.

5. Conclusions

This chapter provides an overview of the evidence on the knowledge transfer activities of Italian universities, and the evolution of the institutional setting in which these activities take place. Empirical studies using Italian data highlight the importance of private contractual collaborations between private companies and individual university researchers; they show the positive effects of academic excellence and university size on the success of research collaborations between universities and private firms. They show also that the overall success of knowledge

transfer practices increases with the size and quality of the KTO and depends crucially on the specific incentives put in place by each institution.

The chapter provides a careful analysis of the knowledge transfer activities at the two largest universities (the University of Torino, and the Politecnico of Torino) based in Piedmont, in North-West Italy. While these and most other universities in Italy, have only recently developed institutional infrastructures to support knowledge transfer activity, their profiles of engagement are different, due to their different scientific specializations, different research quality (the University of Torino is more heterogeneous), different histories of collaboration with industry, and different cultures.

Politecnico academics historically have engaged in interactions with industry, based mostly on personal contracts and informal contacts, although the university institution has also benefited from a large number of research contracts with industry. The Politecnico's former knowledge transfer infrastructure was directed to research contracts. Over time, the Politecnico has strengthened its knowledge transfer activities, emphasizing those that involve direct interactions with industry for R&D activities including especially creation of spinoffs and hosting of laboratory facilities. Patenting activities have increased but are not the main focus and have been rationalized in recent years.

The model of knowledge transfer in the University of Torino is more diverse and includes several activities that have produced mixed results, and successful strategies that are concentrated in a few disciplines (most spin-off activity is related to chemistry, pharmacy, and biotechnology, most collaborative and contract research is in medicine and the natural sciences). It is likely that the University of Torino's knowledge transfer activities are underrepresented since it is specialized in academic fields (the social sciences and humanities) whose knowledge transfer activities are less well captured by the indicators used.

The business perspective of knowledge transfer suggests that interactions with the University and the Politecnico are fostered by the presence of social networks generated through alumni connections (particularly important for the Politecnico).

Companies and inventors that interact with the two institutions have different sectoral and technological profiles, with the University attracting collaborations from the food industry and inventors patenting in chemicals and materials, pharmaceuticals and biotechnology, and the Politecnico attracting collaborations from the mechanical industry and inventors patenting in mechanical engineering, machinery, and transportation. Inventors seek the support of Politecnico to solve technical problems, and prefer direct contracts with individual academics. Companies that interact with the University do so for a variety of objectives. The few inventors that interact only with the University are more likely to access the scientific literature and to attend academic conferences. These findings confirm the more targeted approach to knowledge transfer typical of the Politecnico, focused on finding solutions to technical problems through direct, often personal interactions between academics and industry researchers, and the more heterogeneous model adopted by the University, characterized by multiple objectives – including business consulting activities – and a variety of channels of interaction due most likely to the more diverse set of academic subjects offered.

Since most Italian public universities are more similar to the University of Torino (a diverse range of departments and a traditional focus on teaching and research) than the Politecnico (focused on a few technical disciplines, and with a long tradition of interactions with industry), we would expect the model adopted by the University to be more prevalent in the country. The evidence at national level suggests that most Italian universities have only recently set up dedicated knowledge transfer infrastructures and policies, and that the system is immature, with few established organizational models, small dedicated structures still mostly managed by academics rather than by knowledge transfer professionals, and a dearth of knowledge transfer competences. This situation is compounded by the absence of coordinated policies at the regional and national levels; initiatives to support university-industry knowledge transfer are fragmented and poorly funded. However, in the last decade, progress has been made towards the establishment and consolidation of a university knowledge transfer infrastructure – including physical offices and facilities as well as soft skills and supportive regulations –largely due to the universities' own efforts.

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