Ca' Foscari University of Venice

Master Thesis

Technology Transfer: substituting universities with private organizations.

Author:
Martino Ongaro

Supervisor:
Prof. Vladi Finotto

A thesis submitted in fulfillment of the requirements for the degree of Economics and Business Administration

in the

Department of Management

February 17, 2017

Ca' Foscari University of Venice

Abstract

Department of Management

Economics and Business Administration

Technology Transfer: substituting universities with private organizations.

by Martino ONGARO

The economic literature on the Technology Transfer process has mainly focused on the university, as repository and distributor of knowledge. Today, however, this institution can be effectively substituted by various forms of private and publicly-funded organizations, especially for applied research. Therefore, there is a need for determining if, and how, the previous knowledge gained on the University-Industry Technology Transfer process can be applied also to private entities. This work aims to provide, initially, a review of the literature surrounding the phenomenon, with a specific focus on four different variables: involved actors, transfer channels, processes and mechanisms, governance and policy. Later, will be described various theoretical differences emerging when the University is substitute by a private organization, to inductively determine how peculiarities of these institutions may influence the process. Lastly, these theoretical differences will be tested against a case study, the Bruno Kessler Foundation, to confirm or refuse the hypothesis.

Contents

Chapter 1

Introduction

Definitions, perspectives, issues

In layman's terms, Technology Transfer can be broadly defined as the process that takes research results to end customers in the market. However, behind this simple definition, the topic has risen considerable attention in the last 25 years from many academics, institutions, and governments, leading to a substantial literature encompassing almost any possible perspective.

One side effect of such extensive literature is that even the technology transfer itself has no shared definition, and no unique notion can possibly comprehend every characteristic, angle and shade. Nevertheless, a simple and recognized definition can be taken from the Association of University Technology Managers: "the process of transferring scientific findings from one organization to another for the purpose of further development and commercialization" (Genshaft et al., 2016). Even Bozeman (2000), in his well-known review, recognized the definition issue, eventually citing Roessner (2000) for "the movement of know-how, technical knowledge or technology from one organizational setting to another"

Another definition, that focus on the aim of this process, is the one from Rogers et al. (2001): "the technology transfer process usually involves moving a technological innovation from an R&D organization to a receptor organization; it is fully transferred when it is commercialized into a product that is sold in the marketplace".

Often the object of transfer is not the technology itself, as a product, but the entire knowledge surrounding its conception, use, and application. In recognition of these cases, a broader definition can be taken from Argote and Ingram (2000): "knowledge transfer is the process through which one unit is affected by the experience of another". It can be considered at the systemic, organizational, and the individual level, either explicit or implicit. Similarly, Zhao and Reisman (1992) observed that the definition acquires greatly different shades according to the discipline it is considered in, i.e. among economists, sociologist, anthropologists.

Elsewhere, has been noted that the seek for a canonical and universal definition is futile, but it gains importance as long as it promotes a better understanding of the phenomena by the comparison of differences (Bozeman, 2000). This definition issue is not limited to the technology transfer, but it extends to the very fundamental topics this process is built upon: even technology has not a clear definition, but it is commonly seen as a "tool", further opening the issue for the qualification of this term.

Innovation, instead, is broadly recognized as the process of generating and recombining ideas: "the process of doing something new or adding value to old things by changing the way they're done" (Baskaran and Mehta, 2016). Its concept, however, greatly varies across cultures and contexts, ranging from a more radical and disruptive nuance in advanced economies to traditiovations and lateral thinking in developing countries.

Moreover, in a traditional perspective on innovation, firms acquire consulting service and built relationships with technology centers to foster internal R&D and to mitigate uncertainties embedded in the research activity. Nowadays instead, in a technology transfer setting, the benefit is reciprocal: Siegel et al. (2003a) reported that 65% of scientists experience positive effects on their experimental work, either in quantity and quality, even in basic research. It is safe to say that in a real-world scenario the technology transfer appears to allow information to flow in both directions.

Similar meaning have the concepts of University-Industry relationships, defined as "trusting, committed and interactive relationships between University and Industry entities enabling the diffusion of creativity, ideas, skills and people with the aim of creating mutual value over time", and R&D collaboration, as in "the cooperation within a group or teamwork both in organizational and individual levels with an objective to create a useful and valuable innovation to achieve the common goal set collectively" (Frasquet et al., 2012).

Rather than an evolutionary approach, Bozeman (2000) used a historical perspective. He divided policies regarding general technology development and exchange in three consequential paradigms. The first was the market failure paradigm, which identifies a historical moment with clear negative externalities, extremely high transaction costs, unavailable or distorted information, creating the opportunity for a government intervention. Its role was limited to removing barriers to the free market through appropriate policies (i.e. IP policies), leaving to Universities the role of source and gatekeeper of basic research.

Secondly, the mission technology paradigm recognized that private actors involved in "national interest" related R&D could not easily and effectively reach their objectives; this phase witnessed the redefinition and enlargement of (federal) government as R&D performer, due to its unique ability to gather resources and exercise influence. The third stage refers to a turning point in which each actor in the national innovation system stops working in isolation, and starts to act cooperatively, as part of a network of specialized entities. As stated, "the logic is simple: universities and government labs make, industry takes", sustained by an ensemble of policies to foster interaction, exchange, and collaboration.

For a more European-centered historical perspective of the phenomenon, a brief introduction can be taken from Geuna and Muscio (2009). They focused on the university perspective, observing the role they had in the shift to the knowledge-based economy. They stated that the main change resides in the new institutionalization of University-Industry linkages, aimed to increase the direct involvement of academic staff through a change in their activities.

In fact, in the past, the traditional interpretation of technology transfer heavily relied on the effort and the initiative of individuals. Balderi et al. (2007) used five stages to illustrate the shift in the university's approach to technology transfer. Firstly, the discovery of the phenomenon, with sporadic and localized initiatives to inspire researchers. Later, an acceptance phase and the appearance of spontaneous actions, proving the raising awareness and acknowledgment of this process. Thirdly, enthusiasm and expectations lead to a radical change in attitudes and the establishment of dedicated offices and policies. Fourth, a learning process takes places, with the experimentation of models and settings, exposing the need for a rationalization of the process and a change in national legislation. Lastly, this lead to the seeks for a significant and positive discontinuity, with a new comprehensive model.

These needs have been developed alongside more comprehensive economic theoretical frameworks; representative examples are the National Innovation System and the Triple Helix, which emphasize the role of the University in the new economy landscape (Balderi et al., 2007). This trend found a match even in the legislator will: most of the more developed countries, through their various institutional authorities and agencies, are actively rethinking the role of local research organizations (Geuna and Muscio, 2009).

As part of their strategy for the development of a knowledge-based society, governments are soliciting a more active role from universities in the national economic development, specifically through the demand for more industry-funded research (Geuna and Muscio, 2009) and university-based entrepreneurship (O'Shea et al., 2004). Needless to say, the greater the university research funded by firms, the smaller the government funds required (Yusuf, 2008). Elsewhere, government policies aim to increase economic returns from publicly funded research (Bercovitz and Feldmann, 2006).

Questions have been raised about the appropriateness of these aggressive policies. Specifically, budgetary stringency policies and the demand for more applied and contractual research (as opposed to basic, open science) besides academic themselves, has also been criticized by the public opinion. The answer resides in the evaluation of the impact that scientific knowledge in general and academic research, in particular, can have on the national economic performance.

A first, quantitative indicator comes from the Community Innovation Survey, in which universities has been found to represent the 9% of partners collaborating in any innovative activity (Muscio, 2008), even if elsewhere other surveys in industry ranked universities least as innovation partners (Yusuf, 2008). Other authors showed how about 10% of the new products and processes commercialized by firms would never be introduced without the university contribution (Bekkers and Bodas Freitas, 2008).

In a qualitative perspective, instead, a significant contribution comes from Bercovitz and Feldmann (2006). He investigated the driver for an increase in university-industry collaboration, highlighting the growing scientific and technical content of all types of industrial production and the new, high opportunities offered by technological platforms. Bozeman (2000), in earlier days, stated the rising importance of this trend through four different indicators: major policy initiatives, dedicated academic journals, technology transfer inserted into organizational mission statements, specific job titles and thousands of articles.

Another macroeconomic perspective can be taken from Markman et al. (2005), who observed that an increase in R&D expenditure and activity yield more inventions, thus producing a larger number of inventions; these have a positive impact on productivity and growth, leading to economic development and well-being. A microeconomic perspective instead has its root in the resource-based view (Wernerfelt, 1984) and the strategic value of organizational knowledge. In fact, as clarified by Argote and Ingram (2000), this should be the principal source of competitive advantage, pushing organizations to invest into internal knowledge difficult to imitate.

In this scenario, relevant contributes come from O'Shea et al. (2004) and Yusuf (2008) who referred to various forces that should enforce the university's role into the knowledge economy. Some of these come from the firms' demand for innovation, which is increasingly used as a tool for sustaining their competitiveness; in fact, more and more firms are taking advantage of new opportunities arising from scientific advancements.

Moreover, if knowledge and technology remain key factors in firm competitiveness, and if a significant part of this innovation continues to be generated by universities, three trends can be foreseen (Yusuf, 2008): a further increase in the demand for high-skilled labor force; greater investments in either basic and applied science, from both public and private entities; a growing importance of (technological and scientific) entrepreneurship and of intermediating entities.

This perspective matches the one of O'Shea et al. (2004) who recognized the growing importance of knowledge creation and exploitation, especially the one linked to new technological-based entrepreneurship. These firms already assumed a fundamental role in linking science to market, demonstrating themselves as the best-suited entities for converting new scientific discovery into market opportunities.

Empirical support for this trend has already been found. The dual benefit of collaboration, both for firms and universities, the desire of the latter to differentiate funding sources, the interest of government to developing contexts whose R&D capabilities attract multinational corporations' investments: they all drive to an intensification of university-industry interaction over time, sustained by a change in the economic and institutional environment (Debackere and Veugelers, 2005).

What is usually neglect by the literature, instead, is that even if this trend has its root in the university-industry cooperation, it refers to a larger perspective: the transfer of knowledge and technologies from research institution to firms as market gatekeepers. That is, while research on technology transfer has been largely devoted to the university as the source, little attention has been paid to other types of institution, i.e. private research centers, research foundations, development facilities, etc.

One of the reasons behind this narrowed focus may be an easily acknowledgeable bias: the actual association of many authors to universities; this association could have led to an over-study of the nearest and better-known realities, leaving overlooked less accessible institutions and contexts.

A very similar bias is recognized inside the very technology transfer literature: as reported by Muscio (2008) the great part of empirical research focus mainly on mechanisms that can be easily codified but have their limits in the weakness and limited information they provide on the magnitude of the phenomena. In other words, the easier is to gather data and information about a phenomenon, the better understood it will be.

The same author observed that this process “seems to have not dominant actor or mechanisms, clearly and directly identifiable”, reporting a difficult in finding an overall, general model that could guide institutions, a problem that arises from the difficult in the typification of the phenomena.

So, academics have a thorough understanding of the technology transfer between university and, ultimately, the market. However, the same literature has quite overlooked the technology transfer from other types of institutions, especially private entities. Contemporary, the changing economic environment is leading us to the knowledge economy, where all sources of newly developed knowledge and technology will acquire greater and greater importance.

Therefore, the main rationale behind this thesis is to understand whether or not the technology transfer, as in a perspective of mechanisms and processes, could be considered the same whether the source is a (public) university or a private institution. The main question is: does all we know about the technology transfer process, between university and industry, still apply to a private-market scenario, in which both the source and the receiver of knowledge are private institutions? Do we need to simply substitute the word “university” with the expression “research institution” in the literature, or do exists some major differences that will make the current knowledge of this process inappropriate, when referring to private entities?

To answer this question will be firstly constructed an organic review of the overall literature. Will be considered main authors and publications in the last decade and a half, in an attempt to cover the most significant contributions. There is no ambition to cover all the knowledge related to the process, given the vast corpus of scientific publications related; however, an attempt will be made to picture for the reader an overview of the entire process, covering actors, channels and evaluation perspectives. Later, will be discussed all the theoretical differences between university-to-industry and business-to-business technology transfer. Finally, these differences will be confronted with a real-world experience in the field, to gain an empirical insight on the topic.

Chapter 2

The University Perspective

Institutions, academics, and TTOs

The academic environment and the university organizational structure are the most influencing factors in determining the modalities through which the technology transfer takes place. The environment shapes the individual attitude toward commercial activities, while the organizational structure provides instruments and paths for the development of commercial ideas into successful endeavors. Moreover, these two factors constitute the strongest difference between public universities and private research organizations. In this chapter, firstly will be presented the culture that marks these institutions, and the individual perspective of academic researchers. Later, will be described the role of TTOs and faculties in the development process and the individual attitude toward technology transfer. The difference between the public and private environments and structures will be analyzed in Chapter 6.

2.1 University as institution

The first university was founded in 1088, but the "scientific" approach and role that is usually acknowledged them was shaped only in the 17th century. The "open science", that has largely characterized their activity until now, is a "widespread system of exchange based on the value of scientific priority and prestige" (Murray, 2005). It relies on a series of norms that facilitate full disclosure and diffusion of research results, where a set of economic incentives push toward a cumulative knowledge production, i.e. public research funding that recognize and reward the priority of the research outcome.

Lately, in the previous century, a new system has arisen oppositely to the open science: the "patent system", also called the "economy of inventions". In this regime, property rights on scientific discoveries ensure the potential stream of financial rewards, based on the ability to exclude others from the appropriation of newly created value and the compensation for commercial exploitation in exchange for the disclosure.

These two models clearly collide, a conflict that is enforced by the increasing focus of universities and public policies on commercialization activities, challenging the culture of open science. In fact, academic scientists' fundamental devotion to the open science paradigm shaped a third alternative to these systems, a hybrid economy with mixed elements from both parties. In this perspective, both firms and academic inventors use patents to protect and exchange new knowledge – even if it is believed to be "less efficient than the previous reliance on 'pure science'" (Geuna and Muscio, 2009). Similarly, Owen-Smith and Powell (2001) found a convergence toward a hybrid system of scientific and technological success.

An example is the phenomenon of "patent-paper pairs": starting from the same knowledge, a patent will be firstly applied for, then a paper will be published after the delay required by the patent process (Murray, 2005). In this model, both objectives will be satisfied: the publication, for academic purpose, and the IP protection, for commercialization. In fact, even scientists themselves are interested in protecting their ideas, since patents have become major bargain chips, a currency in the knowledge economy.

A different terminology is used by Stern (2004) who referred to a "science approach" quite similar to the open science approach. He defined it also (and most interestingly) through the peculiar reward system based on the scientific priority, which drives researchers to publicize their findings as quickly as possible, without retaining any right on the intellectual property.

There is a widespread debate on which paradigm should be adopted by publicly-funded institutions like universities, especially when considering the type of knowledge involved in these different approaches: basic science and applied research. Many organizations mixed these elements, but the tension between them lead to wide differences in objectives and administration, including significant difficulties in managing the conflicting goals of curiosity-driven research and commercialization activities, left alone the various shades between these extreme points (Rasmussen et al., 2006).

A first argument could be the one of Geuna and Muscio (2009), in favor to the new commercialization model, who stated that the mission of creating and disseminating "knowledge for its own sake" could drive university scientists away from real-world, practical problems that need to be solved. Rosenberg and Nelson (1994) and Nelson and Rosenberg (1998) also observed that the large part of disciplines that take part in the academic curricula was developed specifically to meet requirements of firms. Balconi and Laboranti (2006) noted that universities must be "intimately familiar" with industrial technology, to identify and perform useful research. Moreover, the technology transfer is a two-way knowledge flow, where academics can benefit too.

A moderate approach has been taken from Beath et al. (2003) who reported a trade off in the effort an academic scientist can devote to the creation and dissemination of knowledge and its commercialization, starting from a limited amount of time and energy. Therefore, the author seems to justify these last activities only if they have an actual financial impact on the university budget. He argued that due to its public good nature (Muscio and Pozzali, 2013), academic knowledge should be treated carefully: he referred to the case of the pharmaceutical industry, even if this topic relates more to the question of patent legitimacy in "greater good" matters.

Siegel et al. (2003a) instead defended the open science system. Firstly, he reported several interviews where the commercialization mission was seen as inconsistent, with the traditional public domain philosophy that should be endorsed by public institutions. Then, they referred to a trade-off from Nelson (2001) where "the shift away from open science might slow down technological diffusion". Also Stern (2004) stated that the priority system embedded into the open science approach seems relatively efficient, by discouraging shirking and encourages maximal knowledge diffusion.

Rasmussen et al. (2006) reported various changes in the government's control and administration of universities, nowadays widely aiming to greater autonomy and competitiveness through a performance-based funding. However, even if the shift itself has no positive or negative connotation, they seem to agree with others, arguing that academic freedom and basicness of university research may be treated by commercial activities. Others exposed their concern about the shorter time horizon, various tensions, and conflict of interests arising from a more applied research.

Murray (2005) took a case study as the exemplification of the real attitude and reaction of academic and industrial scientists to the new patent system: the Oncomouse case. Briefly, a company funded and patented a research that eventually led to one of the most recognized innovation in its field. However, the firm imposes strong limitations in the acquisition and usage of onco-mice, the informal exchange of the relative knowledge, and the appropriability of "reach-through" discoveries, leading to "a widespread infringement" from scientists.

Similarly, Stern (2004) empirically investigated the scientists' willingness to perform basic or applied research within these different systems, to get a better understanding of their actual preferences. He studied the relationship between wages and the scientific orientation of R&D organizations, founding a significant and positive correlation between the closeness of the employers' to the science approach and the premium wage they must pay.

Elsewhere, other authors criticized more directly the way universities are currently interpreting the phenomenon. Siegel et al. (2003a) considered the academic management of IP rights too aggressive and reported a conflict between the overall willingness to commercialize and tenure and promotion policies, which promote scientific publications and grants. Murray (2005) instead observed that a broad protection of intellectual property requires the negotiation of every exchange relationship, slowing down the transfer process.

Historically, the exploitation of research results has not been the first concern for most academic institutions. As reported by Balconi and Laboranti (2006), in the previous century the technology brought to the market was merely an application of previously and independently developed scientific knowledge. However, since the early 1980s, universities have witnessed the emergence and consolidation of a "third mission", alongside the research and dissemination objectives. This further aim requires them to bring research results into the market, both for fundraising purposes (even if it is usually pointed as the main reason) as well as the economic development, technical advancement, and wellbeing.

This setting led to the development of the concept of "entrepreneurial university". The term was originally coined by Etzkowitz (1998) to describe universities that have proven themselves critical to the economic development of their region. His idea was based on the academic entrepreneurship, defined in Louis et al. (1989) as “the attempt to increase individual or institutional profits, influence, or prestige through the development and marketing of research ideas or research based products”.

In this new economy landscape, this knowledge-based entrepreneurship has become one of the driving force of economic growth. Entrepreneurial universities act as a knowledge producer and disseminator, but also as a natural incubator where scientists and entrepreneur can explore, assess and exploit ideas, through the provision of an “adequate atmosphere” and a network of relationships necessary to the entrepreneurial activity (Guerrero et al., 2014).

To better understand this approach, it can be compared to the “research university”, whose primary purposes are to (1) conduct research and (2) train graduate students to perform research. While these universities have been considered more effective in the knowledge transfer, relatively to federal laboratories (Rogers et al., 2001), they still lack the acknowledgement of the growing role of know-how and technology advancement in this era, jeopardizing their opportunity to become fundamental actors in the economic development of their regions (O’Shea et al., 2004).

Nowadays, the importance of entrepreneurial universities can be evaluated through the extent of actions taken by governments and other institutions in administrating them, actively pushing universities to directly engage technology transfer activities, i.e. contract and collaborative research. At the same time, it can be seen as the recognition of the significant endowment of knowledge-based assets owned by universities, that is believed to be economically underexploited (Tijssen, 2006).

Balconi and Laboranti (2006) seen this recognition also in the trend of putting “institution of science” in charge for riskier explorations: their though was that the “ultimate sense” of these organizations should be to set the foundations for new developments. It is implicit that the necessary condition is for universities to possess the necessary knowledge and organizational climate.

2.1.1 The new millennia

What changed over time in a more operative perspective? Early in the days, when the third mission was not so firmly established, the technology transfer heavily relied on personal relationships of academics, and only a few institutions have units or offices to support these activities, usually with few non-specialized employees. New technologies for the market was developed prevalently in large companies’ laboratories, while small and medium enterprises have other choices, i.e. cooperative research centers. What Geuna and Muscio (2009) recognized later, instead, was the broad trend to professionalize the technology transfer and the third mission of universities, whereas industrial R&D was getting more and more directed toward commercial ends (Fritsch and Slavtchev, 2007).

What they acknowledged as the source of this discontinuity was a change in the context, especially in firms’ involvement. Specifically, the use of knowledge as a competitive advantage; the increasing demand for skilled employees; the availability of higher educational levels; the usage of universities as policy tools for economic development by public institutions; greater budget constraints and diminishing incomes from governments. Another perspective refers to the "scientificaton" of the industrial production process, in which universities and public research organizations represent the main knowledge producers, fundamentals to the economic development (Balderi et al., 2007). Lastly, already Thursby and Thursby (2002) found evidence to further support the importance of changes in faculty orientation toward commercialization and collaboration, in addition to a shift in industry R&D.

Baldini et al. (2007) reinforced this view stating some non-obvious factors that have driven to a greater involvement of universities. First, innovative technologies reduce the need for concentrating research activities in large facilities that can afford expensive machinery, allowing smaller centers to be competitive in performance and effectiveness. Secondly, the policy shift in the allocation of intellectual property rights acts as a motivation for researchers to get more involved. Third, they observed how these factors, unitedly to the declining amount of public funds, lead to increasing competition for any source of funding. In this perspective, the technology transfer process has become of "vital importance" for universities (Muscio, 2008); however, its use as a funding source is a secondary objective (Jensen and Thursby, 1998).

A relevant non-financial aim, for example, can be taken from Tijssen (2006): the willingness to achieve and maintain the leadership in scientifically relevant fields. Leitch and Harrison (2005), instead, cited as a driver the desire to develop, retain and acquire skilled graduates. Baldini et al. (2006) reported the importance of technology transfer to reinforce the university reputation.

In this setting, Wong and Singh (2010) investigated the impact of technological commercialization on publication activities: they found a significant and positive correlation between patent applications and publication output, suggesting a mutually reinforcing relationship. Lee (2000) listed other potential individual motivations: to test hypotheses, gain insights and knowledge on practical problems, for teaching purpose, students internships and placement, to look for business opportunities.

Closing the stakeholder perspective, governments use universities to accomplish various tasks, especially in referring to the regional innovation system framework (Fritsch and Slavtchev, 2007; Balderi et al., 2007). Examples are: to generate, accumulate and transfer knowledge to local actors, i.e. through R&D cooperation and innovation-related services; develop the local labor force; strength the absorptive capacity of the region and firms; incubate new technology-based companies. Azagra-Caro et al. (2010) specifically cited as advantages, among these, the develop of new technical instruments and methodologies, the enhancement of problem-solving capabilities in the local context, the formation and stimulation of networking activities and social knowledge. Another reported advantage is the spin-off formation, a highly prioritized area for governments.

In fact, universities have a "special attention" for matters of national interest: Rasmussen et al. (2006) observed that they "seem quite eager to satisfy public expectations, which in turn generates goodwill from research councils and ministries", referring to the issue of decreasing funding. Moreover, it exposes the need to show actual, short term results both in traditional missions (publications and students) and the direct contribution to the national economy, as described in Chapter 5.

These forces have led to a genuine change in the attitude of universities; Tijssen (2006) described this shift through 3 different phases of development. The first is the "application-oriented/science-driven" approach, that coincides with the rising awareness of a possible link between universities and companies for the resolution of industry-related problems. Second is the "product-oriented/utility-driven" approach, which consists in the emergence of activities such as prototyping, development services, etc. specifically aimed to the discovery and exploitation of opportunities. Third and last is the "business oriented - market driven", where IP rights are secured, relations with firms are established, and first products are sold.

In this perspective, great distance has been put between the traditional Ivory Tower image - usually associated with the 80s and 90s typical university - and the actual industry-friendly university involved in the solution of real-world problems (Baldini et al., 2006). However, must be mentioned Rasmussen et al. (2006), whose empirical findings still indicated "soft emphasis on commercialization".

What this historical perspective cannot illustrate are the challenges that universities are facing in this new system; elsewhere, instead, Rasmussen et al. (2006) divided them into three different groups. First, to increase the extent of commercialization activities and outcomes, to produce a greater impact on the innovation system and gain a better financial perform. Secondly, to visualize their contribution to the economic development, both at a local and a national level, to justify the university's funding requirements with the economic role and social impact. Lastly, to overcome the various difficulties in the management of the new fundamental activities: teaching, the exogenous (as driven by curiosity) and endogenous (market-driven) research (Debackere and Veugelers, 2005).

Summing up, universities must cope with multiple, considerably different mission required by various stakeholders for contrasting purposes. What is needed, to overcome these challenges, is ambidexterity: universities nowadays should not draw a clear line between exploration and exploitation activities. Instead, they should manage instead their relative tension, integrate them and take advantage of every potential synergy.

Chang et al. (2016) developed this perspective by suggesting two levels, or types, of ambidexterity. The first is the top-down, "structural" ambidexterity, which uses organizational tools to promote synergy exploitation, such as task partitioning, separation of tasks and units, an appropriate leadership. The second is the bottom-up, "contextual" approach, that aims to develop an appropriate organizational climate to encourage individuals in directly managing the conflict.

Referring to this ambidexterity capability, many authors assumed a historical perspective to identify, and evaluate, the most common constraints for its development: the very scientific method of universities. These institutions have developed over time a series of values, beliefs, norms of conduct and organizational practices devoted to the open science paradigm that can actually impede an effective push toward commercialization activities.

Argyres and Liebeskind (1998) referred to this problem as the "social-contractual commitment of universities to the intellectual commons", which constrains their ability to exploit economic opportunities. Muscio and Pozzali (2013) instead observed the tension between two extreme points of a continuum: the ideal norms of open science and the Mertonian ethos, which have long driven activities and evolution of the academia (the modern commercial approach), filled with business values.

In this perspective, every university has its peculiar historical path. In fact, many authors found them to be one of the most relevant factors in determining the technology transfer performance. As an example, O'Shea et al. (2005) identified the "uniqueness of historical conditions" as the basis for a sustained competitive advantage, especially when evaluating spin-off performances.

Empirical research support this point, confirming the greater importance of the previous performance in technology transfer in promoting engagement. Another relevant research on this topic is the one of Baldini et al. (2006), which linked the behavior of potential inventors and entrepreneurs to the historical performance, observing that processes as patenting can be "cumulative" in their performance, due to learning effects. Finally, past competitive performance can reinforce the institutional (and government) attention to the commercialization activities, further pushing them.

However, has to be remembered that there is also empirical evidence to discredit this correlation, at least in particular perspectives. An example is the results from Thursby and Thursby (2002) which suggest a little effect of past (licensing) performance on the propensity of the university administration in further promoting (patenting) activities.

2.1.2 Performance and attitude

Other factors make universities differ in the degree they engage with industry, and many authors have built formal models to uncover which of them are significant and evaluate their impact. While the econometric results will be reported later in Chapter 4, it is relevant to introduce now which university's characteristics play a fundamental role in determining the technology transfer performance.

As a starting point, the most recognized factor that influences the academic inclination to engage in such activities is its commercial orientation (D'Este and Patel, 2007), or the "catch-all phrase entrepreneurial culture" in Owen-Smith and Powell (2001). It is intended as the sum of its cultural legacy, its history and past performance, and to what extent these factors influence the nature of the academic research. In fact, the commercial orientation in its definition is so close to the willingness to engage in technology transfer, that it can be interpreted both as the dependent and independent variable. However, it is mainly recognized as an enabling factor that sets a fertile ground for commercial and business activities.

Strictly related to the this attitude, are a series of factors that refers the supportiveness of the university environment. Examples are various policies for academic entrepreneurship: leave of absence, access to laboratories and other infrastructures, entrepreneurial programs, senior members championing for entrepreneurial projects, on-campus incubators, investments in startups, earlier and easier access to venture capital (Baldini et al., 2007). Guerrero et al. (2014) used similar variables in his model, such as entrepreneurship education programs, the attitudes toward entrepreneurship of key actors in the hierarchy, a strong top-down oriented leadership, the availability of an entrepreneurial model.

Similar, but loosely coupled factors are variables linked to the perception of the university orientation, rather than influencing the context themselves as the environment supportiveness. An example is the contribution of D'Este and Patel (2007), on whether the founding mission specifically includes the university support to regional development; in fact, they found a significant and positive relationship with commercial engagement.

The literature has considered other university-level factors that refer to the actual, processual capacity to support the technology transfer process, rather than its ability to motivates academics and grow a supportive environment. Examples are the size of the research staff, the quality of the research production, a sizeable budget for entrepreneurial-related activities (Colombo et al., 2010), the university own financial, technological and social capital, the institution status and prestige (Guerrero et al., 2014).

Among these, many researchers aimed to uncover the influence of governance and organizational structures on the engagement probability, which has been found to have a significant impact on the ability to manage internal conflict between missions, thus on the overall performance. Siegel et al. (2003a) found in their performance analysis a deviation from the best performance that cannot be entirely explained by environmental and institutional factors, which should be attributed to organizational factors. Specifically, two level of organizational configurations has been studied.

The first is the internal organization of academics and research units. A specific structure that has been found improving the commercialization performance is the so-called research division (Van Looy et al., 2004): research personnel can decide to organize themselves and their research, alongside their contract research and other exploitation activities, in autonomous groups called research divisions, usually professionalized on a single topic or a particular industry. The performance of academics involved in such divisions has been found to be superior, and the gap widens over time.

The latter configuration refers to the presence, position, and role of a dedicated office to technology transfer, henceforth TTO (Technology Transfer Office), which effectiveness has been found to depend on organizational practices (Siegel et al., 2003a). Generically, the institution of dedicated units and the importance vested in them are found to be relevant; similar internal offices and external organizations are the Technology Licensing Offices, Industry Liaison Office, incubators, science parks, joint ventures, spin-offs (Tijssen, 2006). More information on the topic will be provided later.

A related topic that has gained an increasing attention refer to policies for the evaluation of academic researchers as personnel. Specifically, the reward systems, both monetary and not (Guerrero et al., 2014), criteria for career advancement, tenure policies, royalties allocation and alike. As a general rule, incentive policies should be promoted to raise awareness around the benefit in protecting and exploiting intellectual properties, to ease the perception of the patent process and increase the esteem that scientists have of TTO's competence. This either will be discussed later, but it should be recognized from the beginning that a major issue is whether researchers have sufficient incentives to disclose (Debackere and Veugelers, 2005).

Lastly, local and national contexts in which universities are located play a relevant role too. Examples are the relationship between annual public expenditure in university R&D (O'Shea et al., 2005), the national economic growth (Siegel et al., 2003a), national culture and academic socialization (Bercovitz and Feldmann, 2006), the extent of R&D activities of local firms (Siegel et al., 2003a), and the strength of ties between universities and industries developed in past projects (Powers, 2005).

2.2 Academic scientists

The development of new innovative knowledge and cutting-edge technology critically depend on the quality of human resources involved. Star scientists and academics from top-tier universities can reach discoveries faster, through an easier access to the personnel with the needed specializations rather than the necessary technical resources (O'Shea et al., 2005). Apart from the ability to reach innovations, academic inventors can also play a positive role in commercialization activities, i.e. providing surrounding knowledge or leading themselves the process through a spin-off.

However, scientists differ in their willingness to get involved in technology transfer. Various research has been performed to identify which factors can foster academics involvement, and what are their basic characteristics and traits. The basic framework for an appropriate categorization and understanding of these differences come from Stokes (1997). He divided academics into three different categories, according to their interests and orientations.

The first is what he called the Edison scientist: an academic who is interested only in purely applied research, oriented to the development of new products to meet people's needs. At the other end, there is the Bohr scientist that was intended to be a true, basic scientist who most strictly adheres to the open science approach. Between these extremes, Strokes identified the Pasteur scientists as the most relevant for the technology transfer process, whose main trait is the desire to advance scientific knowledge, but only in fields or applications that can have real-world, useful applications. Ideally, this academic employee authored many high-quality scientific papers, as well as applied for many patents; he should be a recognized expert in its fields, and both inclined to develop inventions and to gain a strong reputation in the scientific community through research activities (Baba et al., 2009).

Later studies use a binary categorization, useful even if simpler, in which scientific occupations have been divided into two distinct types (Beath et al., 2003). On the one hand, university scientists perform fundamental and basic research, motivated by the desire and the reward of establishing their priority on the discovery. On the other, private sector researchers who have no opportunity for fundamental research; they are financially motivated in keeping up with the scientific literature and transfer it into marketable products.

Both these perspectives match what previously was referred to as the difference between the open science approach and the IP protection system. Bohr scientists, "university" scientists (Beath et al., 2003), and partially Pasteur scientists share a common orientation toward the open science; Edison and again Pasteur scientists tend to commercialization activities. Therefore the peculiar and extremely relevant role of the Pasteur scientist, who is in the position to bridge interests, knowledge, and activities.

Specific to the dual perspective is the fundamental study of Stern (2004), who investigated the impact of the organizational orientation on scientists' wages, comparing public research organizations and private firms. He started from two different assumptions: researchers may have an intrinsic preference for the open science approach, while firms may have economic interests and benefit from participating to the same paradigm. He based his research on the tightness of control over IP, non-disclosure clause and similar variables.

His empirical results shown that once controlled for the relative ability of researchers, there is an actual premium wage paid by "closed" firms devoted to the protection of ideas, and that it is considerable in its extent, evaluated in a difference of about 27% in wages. In fact, scientists pay a compensating differential for participating in the open science system.

What seems to motivate and drive the academics in this perspective is their unique sensitivity to reputational awards: an increase in reputation among colleagues, in an open science system, open the path to better research projects, teams, and memberships, ultimately leading to employments in more prestigious institutions and access to relevant resources. This effect, as in other examples of the Matthew effect, seems to increase over time.

Owen-Smith and Powell (2001) recognized in their work this difference in a slightly different perspective, addressing two type of scientists from different areas: life science and physical scientists. These labels might correspond to basic and private researchers, respectively. The authors found that both types of scientists express concerns for various constraints due to commercial exploitations, and they still may engage with a similar probability but for very different objectives. The private scientist (including commercial-oriented academic) seek IP protection mainly to pursue commercialization activities while maintaining the original, unexploited value of the new technology. The latter category, representative of a purer researcher, may also seek IP protection, but with the very different intent of "shielding the environment of his lab from encroachment by commercial interests" and ultimately as a leverage to attract investments.

The open science approach, the most diffused today, shapes various factors that influence the academic willingness to engage in commercial activities. The main group of variables refers to career concerns: the system heavily relies on reputational awards, based on priority, novelty, and quality of the research, rewarding scientists with a greater access to resources and better personal networks. This drive scientists to construct their research agenda freely from external influences that might carry unwanted constraints in time and effort. It is partially due to the "ambiguous relationship of researchers to money" (O'Shea et al., 2004), that refer to the disinterested nature of university research and the seek for public funding that enables academics and teams to work completely unrelated and free from industry-related constrains.

A well-recognized factor related to this perspective is the unwillingness to delay publication of many researchers (Thursby and Thursby, 2002; O'Shea et al., 2004; Baldini et al., 2007). The main driver is the "publish or perish" rule, which requires academics to continuously publish in order to gain, and not lose, reputation. These delays may arise from: bureaucratic issues, i.e. time and effort required in disclosing the invention to the TTO; commercial issues, i.e. establishing a relation and to reach an agreement with firms; legal issues, i.e. the time required by the patenting process. Moreover, agreements with firms may require secrecy or a fixed-length publishing delay to allow the industrial counterpart to gain a first mover advantage; these requirements clearly threat publication activities, but also networking activities.

These factors ultimately drive faculty member to not disclose internally their invention, thus not engaging technology transfer, because of "their believe that commercial activity is not appropriate for academic scientists" (Bercovitz and Feldmann, 2006), referring to the norms of open academic science. In this perspective, the university administration acquires a relevant role: empirical findings suggest that a relevant part of the faculty resistance in disclosing is due to university-level policies focused on scholarly works, while commercial activities are believed to be perceived as mere, non-relevant "services" (Markman et al., 2005). Examples are factors considered for tenure and promotion decision.

Muscio and Pozzali (2013) expressed this duality of imperatives, the open science paradigm, and the commercialization need, as a cognitive dissonance that academic scientists may directly experience when trying to reconcile these conflicting aims and their own research agenda. They noted that even if the cultural environment and the organizational context do matter, scientists' decision on which research to perform may largely depend on their personal propensity toward a specific approach.

These factors may keep scientists from commercialization activities, but there are actual benefits that should positively influence the willingness to engage. In fact, even the impact of commercial activities on publication has been largely discussed in the literature. A fundamental study on this topic is the one from Lee and Bozeman (2005), which showed that researchers who collaborate with firms are generally more productive in terms of publication, and the quality of journals not diminished. Lebeau et al. (2008) found empirical support that industry collaboration increases academics' citation indexes when normalized by field, while at a first glance the average relative impact factor could be diminished; oppositely to Lee and Bozeman, however, they found that journals published in have a lower impact factor, while articles receive higher citation counts.

Many authors agree on this view. Meyer (2006) found that academic inventors tend to perform better in publications than pure academic scientists; Wong and Singh (2010) found a positive relationship between research performances and patenting activities, used as a proxy of commercial activities. Elsewhere has been found a positive relationship between the quality of research, measured through publications and citations, and the extent of collaboration with industries (Azagra-Caro et al., 2010) or the patent productivity both at individual and university levels (Baldini et al., 2007).

How to reconcile these views? On one hand, academics are afraid of constraints that commercial activities may impose, and the negative impact that could have on their career; these worries may arise from poor information and a scarce awareness. On the other hand, industry collaborations do have a positive impact on research activities and academic careers, even when it implicates some limits.

2.2.1 Individual characteristics

As previously stated, the open science culture may have a negative effect on scientists' engagement with industry; however, many factors have been found to influence their willingness. Apart from the institutional impact presented earlier, the literature analyzed many individual characteristics, while seeking for the determinants of researchers' entrepreneurship.

The first is a sort of cliché, which suggests that in order to have a good performance in commercialization activities, the academic should be "the entrepreneurial type", identified as "who have always wanted to start companies and who use their university inventions as a way of achieving their entrepreneurial goals" (Fini et al., 2009). In fact, D'Este and Patel (2007) found that the most significant individual characteristic is the previous experience in collaborative research – a proxy for past behaviors – suggesting the presence of a Matthew effect and thus the importance of the initial attitude toward industry.

Individual attributes usually associated with the academic entrepreneurship are: outgoing, extrovert personalities; a strong need for achievement; the desire for research independence (O'Shea et al., 2004); tenure and occupational skill level (Roberts, 1991); age and scientific experience (Audretsch, 2000); higher citation rates and publication performance (Zucker and Darby, 2001).

Elsewhere, academic life cycle models suggest that academics are more prone to technology transfer activities later in careers: in the early stages, academics work on increasing their reputation and to build more extensive and valuable social networks; later, once reached a satisfying level, they try to build legitimacy for their invention Fini et al. (2009). However, empirical findings from D'Este and Patel (2007) suggest a higher probability of engagement for younger academics, possibly due to the minor devotion to the open science system and a different need for network development (Bercovitz and Feldmann, 2006).

Obviously, an extremely relevant factor is the environment researchers work in; as previously noted, a supportive university organization and culture is fundamental to improve the commercial involvement. As an example, O'Shea et al. (2004) found that the decision to start a spin-off is socially conditioned by the consensus that commercialization activities gain and the relative behavior of colleagues, as proxies for social norms, expectations, and the presence of prior academic entrepreneurs.

2.2.2 Academic motivations

These characteristics describe what many empirical research have found as a typical academic scientist prone to technology transfer activities. But what motivates them?

Many authors agree that the main motive for engaging with firms is not the entrepreneurial attitude, as might appear from the individual-level characteristics stated before. Instead, the main driver should be the expectation of a positive influence on their academic position and their research (Fini et al., 2009; D'Este and Perkmann, 2011), according to the large adhesion to the open science approach.

Factors that directly influence individuals can be a gain in visibility, network development, prestige and reputation, recognition by peers (Baldini et al., 2007; Fini et al., 2009; Rizzo, 2015). In fact, a fundamental motivation for the academic scientists seems to be the recognition among the community and the reputation gain: collaborating with industry can help in publishing in top-tier journals, conferences, federal research grants.

As widely recognized, technology transfer positively influences the research performance through the bi-directionality of the information flow (Geuna and Muscio, 2009), even if often neglected (D'Este and Patel, 2007). Examples are the access to industry skills and facilities, opportunity for hypothesis testing, verifying the applicability of the research, keeping up with industry problems; new stimuli and new topics, etc. Generically, these reasons refer to the opportunity to interact with the external, real world (Baldini et al., 2007).

Other motivations refer to the environment. Leadership in example can be effective as guidance, as in altering what is perceived as socially desired through its actions. The cohort effect (Bercovitz and Feldmann, 2006) refers instead to the presence of a positive, previous experience of those in the same position, that act as a "case study" and affecting the willingness to engage. The same authors found relevant a previous experience, especially a formal academic training (i.e. the Ph.D. itself) in an institution which presents a good performance in technology transfer. Similarly, Murray (2004) and Link et al. (2007) demonstrated the importance of social capital in enhancing the probability of a successful cooperation with industry, therefore the importance of a supportive social network surrounding the scientist.

Different are the motivations that work at the individual level but refer to the overall university. Cooperating with industry can bring more research funds, laboratory equipment, federal and European funds and grants, even attract star scientists to the institute (O'Shea et al., 2004; Baldini et al., 2007; D'Este and Patel, 2007). However, the effectiveness of these motivations largely depends on the university reward system, i.e. tenure and promotion policies and royalty distribution formula; if not managed properly, this system could lead to an institutional conflict between basic and applied research.

This conflict is greater when disclosure is elicited and researchers are driven by exogenous motivations, rather than endogenous and indirect ones. Many authors addressed the issue by modeling the technology transfer process as a game between academics, TTOs, university administration, and firms, and found a significant moral hazard problem for inventors (Jensen and Thursby, 1998): their effort cannot be effectively monitored or enforces, which means that motivations for scientists should come from fine-tuned policies and the overall environment, rather than enforced by some internal regulation or by the hand of TTOs or administrations.

In this perspective, compensation forms differ in extent and direction of their impact on researchers' motivations; clearly, the preferred form is the sponsored research, which allows scientists to continue work as they prefer, i.e. in-house with their own teams, on self-selected topics. Another suggested compensation form is the equity share, that Jensen and Thursby (1998) found to be less distorting on firms' and academics' decisions. Further attention should be placed on the choice of the form, especially when it comes to the various, unwanted effect of each channel and the conflict between them: an example from O'Shea et al. (2004) is that higher royalties allocated to academics will decrease the spin-off activity, by modifying opportunity costs, their ratio, thus their appetibility.

Along with compensation forms, it should be noted that even if a key objective of academics is the recognition within their community, i.e. through papers, presentations, conference and research grants, they are also motivated by personal financial reward and additional funding for their research (Siegel et al., 2003a; Link et al., 2007; Fini et al., 2009). D'Este and Patel (2007) and D'Este and Perkmann (2011) agreed on the point, stating that fundraising performance can act as a signaling mechanism, positively affecting the reputation. Rizzo (2015) added two financial motives specifics to the spin-off path: funding for research and tax avoidance. Greater financial incomes for the researcher or his unit may also lead to a greater independence in research lines.

In fact, D'Este and Perkmann (2011) found a positive attitude of researchers to financial ties with industry (74.5% of interviewees), as long as funds are related to their research topic of choice and the open science paradigm is respected, i.e. when disclosure is agreed upfront and ideas are freely publicized. This study also confirms the priority of research-related motivations, thus the importance of a compatibility between financial and scientific rewards (Baldini et al., 2007; Link et al., 2007), and the need for a match between personal ambitions and the financial and business opportunity (Tijssen, 2006).

Finally, even if universities are seen as "professional bureaucracies whose members are relatively free to pursue activities that they believe are in the overall interests of the organization" (D'Este and Perkmann, 2011), there is a clear need for pushing inventors to actively engage in the commercialization process (Jensen and Thursby, 1998). Apart from the obvious intimate knowledge they can provide on the discovery and the surrounding scientific context, their passion in their work can make them assume the role of project champions, as well as helping TTOs in identifying and contacting companies, ultimately maintaining the relationship among the institution and the firm (Markman et al., 2005).

Summing up, also individual academics should demonstrate ambidexterity, as the attitude to simultaneously achieve publication and commercialization goals, starting from the ability to recognize exploitation opportunity from their research results (Chang et al., 2016). Individual motivation seems fundamental to accomplish both academic and entrepreneurial results, led by the comprehension of synergies and the mutuality of benefits for academics and firms. Similarly important seems to be the environment, which should balance the relative emphasis of activities and provide social support.

2.3 Technology Transfer Offices

Intermediaries between suppliers and users of knowledge progressively emerged as central in bringing academic research to market (Landry et al., 2013). Universities and firms belong to different communities and react to different incentives, establishing a social and cognitive distance that requires a specialized intermediator that can comprehend and effectively relates with both sides. The generalized acknowledgment and recognition of this problem led to a recent and substantial increase in investments, both from universities, firms, and governments (Muscio, 2010).

The main source of their importance is the potential market failure involved in the transaction of newly developed technologies and knowledge: firstly, it is hard to identify which of the disclosed invention is actually marketable, due to the intrinsic innovativeness of the research output. The fundamental question, at this stage, is whether or not the idea has enough appeal for the market.

Secondly, if the invention matches a potential market, there is no guaranty that the knowledge or the idea will grow in a functional prototype, due to high uncertainties embedded in the research and development process; even if this is available, it may not satisfy the industry requirement for a profitable production. In this case, the question to answer regard the feasibility of the project.

After these first, necessary leaps, the technology can be transferred to the industry. Two main issues may arise in this phase: to identify a potential, interested partner, and to establish a value for the transaction. Specific to the second issue, is the problem of estimating a new, unknown technology, which involves uncertainties and opportunisms and may lead to true market failures, i.e. great differences between social values and contractual prices, investments that fail to take places, failures in starting the transfer process.

Even if these issues arise from the generic problem of exchange and communication between research organizations and industry exponents, and even if a specialized organization can undertake any of these issues, the literature has mainly seen the resolution of the first two issues as "second order" topics, in researching the impact of intermediaries in latest problem: the focus is on their ability in, and the positive effect of, reconciling university and industry perspective, and to drive them to a mutually beneficial agreement. The implicit hypothesis is that the same factors that may allow a competitive performance on this topic, will be the same that allows the overcoming of all issues.

The specific interest of the literature arises from the recognition that the main and greater market failure come from the difficulties in, thus the imperfection of, estimating technology (Hoppe and Ozdenoren, 2005). This is mainly due to a problem of asymmetric information: firms usually cannot assess a priori the invention potential, while researchers have difficulties in identifying exploitation opportunities and evaluating their potential (Debackere and Veugelers, 2005).

In fact, researchers have the best knowledge on the technology, and firms about the market; both are required, to a successful and profitable transfer, but their match is constrained by limits typical of the agency theory. Similarly, Bercovitz and Feldmann (2006) observed that differences in estimation may arise from subjective expectations on the knowledge value, while Hoppe and Ozdenoren (2005) cited the uncertainty about the technology profitability. Debackere and Veugelers (2005) further identified the source of these constraints in the high-uncertain and non-codifiable nature of the scientific knowledge.

Within this perspective, intermediaries can enhance the overall system performance by reducing the asymmetric information issue: their professionalization, therefore their expertise in successfully locating and screening new ideas, can actively reduce the risks perceived by firms while providing indications to scientists on which idea develop (Debackere and Veugelers, 2005). Moreover, intermediaries can balance the low bargaining power of individual scientists (Bercovitz and Feldmann, 2006), and overcome the opportunism problem.

To uncover this last, specific benefit, some researchers modeled the activity of intermediaries (mostly TTOs) as repeated games. An example is the one of Hoppe and Ozdenoren (2005) who ultimately found that in a repeated licensing game, TTOs fully benefit only from high-quality inventions, inducing them to push toward an equilibrium in which intermediaries sell only profitable inventions – if the disclosure frequency is high enough. In this setting, rewards for scientists are strongly suggested to be success-based, because fixed payments will not sustain the equilibrium.

Macho-Stadler et al. (2007) come to the same conclusion: in a repeated game, intermediaries have the incentive to "behave honestly" to build a valuable reputation, while if the disclosing rate is insufficient or if the game is single and non-repeated, intermediaries may prefer to take advantage of the information asymmetry. Elsewhere, individual agents and small intermediaries may have the incentive to offer low-quality inventions, whenever potential investors outnumber profitable inventions: scale is an issue (Hoppe and Ozdenoren, 2005; Macho-Stadler et al., 2007).

However, there is a natural market force that pushed toward the concentration of intermediaries: first, a critical mass of inventions, thus the related research activity, is required to achieve a relatively good performance, therefore the survival of the intermediary. Secondly, the economic performance of these actors is tightly linked to the ability and the relative cost of personnel; the bigger the intermediary, the greater the opportunity to attract valuable human resources, reducing the marginal cost on this key element.

Third, even if specialization is common in markets with intermediaries, the same force may lead to inefficiencies: in this specific case, and limited to the specialization by thematic, its low effectiveness in offering a balanced share of opportunities among intermediaries will eventually lead to the waste of high-quality invention, thus a market failure, and the underutilization of other intermediaries' resources, thus a market inefficiency (Hoppe and Ozdenoren, 2005).

Moreover, intermediaries with a larger invention pool may have incentives to further invest in experienced professional, more capable of locating new and profitable inventions. Apart from the obvious, immediate comparative advantage they could generate, their deployment may be necessary and their costs more effective due to the size of invention pool (Debackere and Veugelers, 2005). In fact, economies on the costs of expertise generate one of the economic raison d'être of intermediation (Hoppe and Ozdenoren, 2005).

For specific forms of intermediaries, i.e. internal to the organization or participated by public research institutions, they are also required to manage the patent portfolio, entailing the need for additional personnel like patent attorneys. Empirical findings demonstrated the importance of these specific professionals (Siegel et al., 2003a), in order to protect and market inventions and secure additional funds; moreover, the patent portfolio comes with management costs, which require a proper valorization activity to make it profitable (Balderi et al., 2010).

Lastly, intermediaries can also support the creation of spin-offs, through their industrial linkages and by building a synergistic network between academics and venture capitalists, advisors and managers (O'Shea et al., 2004). Through these linkages, they have also the opportunity to identify business needs and to forward them to scientists; however, this activity will further increase the need for specialized personnel for additional marketing competencies (Geuna and Muscio, 2009; Muscio, 2008).

Summing up, intermediaries can overcome the main problem of universities: their bureaucratic organizational culture makes them inflexible in structuring deals (Siegel et al., 2003a), thus keeping them at a great cognitive distance from the market. In fact, intermediaries are becoming central, even if they may present some lack in effectiveness for most research institutions (Geuna and Muscio, 2009), being them universities, research institutions or private research organization.

2.3.1 Organizational forms

Intermediaries may assume different organizational forms, due to different purposes, property settings, internal configurations and other factors. Examples are universities' TTOs, including TLO, ILO, and other nomenclatures; colleges; public research organizations, publicly-founded agencies, knowledge intensive firms, professional associations, knowledge workers. Many researchers have investigated this issue, tackling it from various perspective, with the aim of establishing an ideal, effective form for every type of intermediaries. For the purpose of this work, apart from a general introduction, the focus will be centered on intermediaries strictly related to universities.

For a general framework, the starting point may be the work of Yusuf (2008) who divided intermediaries by purpose: general purpose, including universities, which aims to disseminate new knowledge; intermediaries specialized in helping various actors in the technology transfer process, as TTOs and alike; financial intermediaries, specialized in providing financial resources to projects, as venture capitalists and angel investors; institutional agencies, which provide incentives in order to promote the general economic development. Another useful classification comes from Landry et al. (2013), which identified as "emblematic types" university TTOs, community college TTOs, public research organizations and non-profit organizations.

Both examples have their roots in the same idea: different organizations need different services, therefore intermediaries must assume different forms based on specialized resources and capabilities. To gain a proper insight on these differences, Landry et al. (2013) turned to the knowledge value chain construct: the development of an idea can be divided into three non-linearly stages, namely exploration, technical validation, and exploitation. Each stage requires a different support from intermediaries, i.e. consulting on market needs, prototyping and patenting, commercialization activities etc. In fact, the author found significant differences in the level of engagement among institutions and intermediaries in the knowledge value chain stages: public research organization in exploration, community college TTOs on validation, non-profit organizations on exploitation, while university TTOs provide less customized solutions.

In the case of universities' dedicated offices, the previously cited Technology Transfer Office is, in fact, an oversimplification of the phenomenon. Other real-world examples are the Knowledge Transfer Office, Industrial Liaison Office, Office of Technology Licensing, the University Technology Transfer Office and many other. However, regardless of their specific labels, these offices all perform variations of the same activity, with minor changes in focus and processes (Brescia et al., 2016); the only major difference is that some of these support prevalently the licensing process, while others are more general purpose. However, the main tendency is to "resize the importance of licensing income, to rather increase the effort in maximize industry-funded research" (Balderi et al., 2010). In this perspective, this difference may not last long.

Instead, a significant difference among universities' TTOs is the organizational form, role, and position they assume in different institutional context. The organizational form is the first factor that has been found by many to be a fundamental in determining the TTO performance; specifically in the case of a public entity like a university, in which academics' devotion goes to the open science paradigm, an appropriate structure should allow the provision of both competitive mechanisms and adequate incentives to disclose.

In fact, Bercovitz et al. (2001) proposed that any transfer activity is "shaped by resources, relationships, autonomy and incentives of the TTO"; therefore, the process outcomes may largely depend on organizational practices. This view is reinforced by Debackere and Veugelers (2005), who stated that different organizational arrangements may lead to different propensities of academics to commercial activities, especially for the "professional bureaucracy" previously cited.

This traditional approach is based on a single, centralized office which employs a variable number of professionals, which can be organized by activities, projects, or none. In larger institutions, or where the attitude toward the market is greater, the office can grow enough to justify an internal divisional form, usually based on tasks' similarities. However, empirical research suggests that most universities employ only a few officers with almost identical tasks. This traditional model can be seen as a divisional structure in which a single unit, the TTO, is in charge of the exploitation strategy.

The second most common organizational form is the decentralized model, which is usually linked to a higher engagement in university-industry cooperation. Although there is no formal, shared definition for this model, it is mainly recognized as an ensemble of technology transfer officers located in the various research units, teams, faculty and alike. In this case, officers will be in charge for every aspect of the technology transfer, in respect to their research unit. This model refers to a matrix structure (Debackere and Veugelers, 2005), where the exploitation division became integrated within research groups while responding for their research activity to the central administration.

Both models have some limitations. On one hand, the centralized structure may induce the TTO to behave as a gatekeeper, to constitute a bureaucratic step toward the market instead of a supportive actor. The complex internal communication flows that come with a central structure, moreover, can slow down the process and make the university unresponsive to business and market needs (Litan et al., 2008). On the other hand, specialization and decentralization can ensure a higher responsiveness, positively influencing the academics' propensity through proximity and avoiding possible conflict of interests (Debackere and Veugelers, 2005). However, this last solution compromises the exploitation of synergies among activities and topics, other than the economies of scale embedded in a single office.

Anyway, an organizational form must be chosen. A comparative evaluation can be taken from Bercovitz et al. (2001), who analyzed the potential impact of various Chandler's organizational forms on the office performance, both theoretically and on a case study basis. He found that the matrix form (roughly corresponding to the decentralized form) provides a better coordination among internal actors while ensuring the best incentives alignment.

Later, a third possible model has been described by Brescia et al. (2016): the semi-centralized model, as a compromise between the previous extremes. In this case, activities are distributed among a central TTO, typically in charge of intellectual property and spin-off activities, and decentralized officers employed for grants, collaborations, and contracts. Theoretically, this configuration should allow the exploitation of advantages of both the previous models.

It should be noted that the TTO may not be internal to the university. Fisher and Atkinson-Grosjean (2002) differentiated between the fully integrated, internal model, and external entities which may assume the most different forms, ranging from a non-profit, participated organization to a consortial form of networked, interconnected TTOs (Brescia et al., 2016). These external entities are a particularly useful solution in the case of smaller universities and fragmented environments (Debackere and Veugelers, 2005).

2.3.2 Models and objectives

Even more important than the organizational structure, is the organizational role of TTOs: these offices must incentive researchers to engage in technology transfer activities, through their impact on the academic environment. Starting from Jensen and Thursby (1998), many authors modeled the TTO role as an agent of both the university administration, faculties, and researchers, involved in balancing the needs of every actor. In this perspective, the orientation and the activity of the office both improve the outcome of the technology transfer process and the raw material the office has to work with, the invention disclosure (Siegel et al., 2007).

More specifically, apart from the impact of university-level regulation and incentives, TTOs may also leverage their reputation to enhance the attitude of scientists to disclose. By demonstrating a deep understanding of both academics and firms, and by building a history of successes, TTOs can be perceived as professionalized and useful, acquiring credibility and gaining the trust of academics (Owen-Smith and Powell, 2001). Specific to the ability to understand firms and markets and its importance, Muscio (2010) empirically demonstrate that a non-academic background of the TTO leaders is linked to a greater use of the TTOs services.

Otherwise, faculty and academics may prefer to circumvent the TTO by establishing a direct relationship with the industry or refusing to disclose inventions, thus leading to a waste of resources and a possible underperformance driven from the non-use of professionalized services. The same result may be reached if previous collaborations with the TTO led to unsatisfactory outcomes, or if the TTO cannot offer a valuable service due to lack or inadequateness of personnel.

The way TTOs relate with academics largely depend on the goals set by the university administration. Two main models are recognized by the literature: the revenue maximization and the diffusion maximization models. The first, the most common, will make TTOs focus on short-term cash maximization, where a great risk aversion may lead to "suboptimal licensing strategies" (Markman et al., 2005). Moreover, Siegel et al. (2003b) identify a mismatch between this commercialization model and the motivations that drive the involvement of faculty and academics, thus a lower performance.

The second model, preferred by scientists, would be the natural path for technology transfer officers: a survey by Jensen and Thursby (1998), demonstrated that the main objectives of technology managers are the number of inventions commercialized and of licenses executed. However, this model does not fit with the university's actual need for research funds from other sources than the public institutions. This may be the main factor explaining why the technology manager interviewees see themselves as "juggling" between different interests, trying to maximize a weighted average of the administration's and the inventor's utility.

Fitzgerald and Cunningham (2015) used a quite different approach to uncovering drivers and models beneath TTOs activities: their mission statements, an instrument to signal to stakeholders the main, long-term mission of the organizations. In concept, they should be useful also as a guide for decision making, as a tool for the formulation and implementation of a strategic plan, eventually influencing the personnel behavior and their performance.

Their empirical research highlighted that even if quite every mission statement report the identification of main products, services, customers and markets, almost no one reported the desired public image, self-concept, expression of commitment or any element of the organizational philosophy. These results may suggest that the impact of the organizational role of TTOs, especially as motivator for academics, is still underestimated, or worse, poorly understood.

2.3.3 Activities and personnel

The office's objectives and model directly influence the type of activities it will perform, as well as the extent of the effort dedicated to each activity. In earlier days, Siegel et al. (2003a) recognized as main objectives licenses and royalties, from the patent activities, and the support to firms and scientists for economic and product development. Similarly, Owen-Smith and Powell (2001) reported that the resource constraint makes TTOs concentrate in the core activity, identified in the management of the IP portfolio.

More recent research reported a shift and enlargement of TTOs' main activities: Geuna and Muscio (2009) reported as main focuses patent, licensing, and the creation of spin-off. While they mentioned also contract research and consultancy, it is important to note that in his view the focus shift from the evergreen, well-known patent affair, to more generic activities that imply a commercial exploitation of university knowledge directly performed by internal personnel. This perspective was reinforced by Balderi et al. (2010) who identified as main activities patenting and licensing, spin-off and other activities complementary to the first ones.

A recent and useful framework can be taken from Alexander and Martin (2013) who linked TTO's core activities to four key objectives:

- Facilitate the management of activities and projects, which this require a continue assistance to academics and firms from the setup to the control of key stages and follow-up;
- Enabling the transfer of intellectual property and facilitate entrepreneurial activities, i.e. the management of the patent process, administrative and bureaucratic support for spin-offs;
- Promote and develop knowledge-based support services, ranging from contract and cooperative research to training and personal development;
- Establish knowledge-based boundary-spanning activities, both in terms of stand-alone knowledge and through mobility and networking.

A more debated topic refers to the disclosure eliciting activity. It is true that nowadays quite all academics engage technology transfer activities only through the TTO, letting the office managing and controlling the relation, but some researchers still not disclose inventions. It may be required by the university regulation or other external sources, i.e. the case of the Bayh-Dole act, but these rules are rarely enforced. On one hand, there is a clear difficulty in monitoring research activities and comprehend which results may be susceptible of commercialization, while on the other hand TTOs usually have to face constraints in resources and time, that impede the eliciting activity.

This scenario highlights the importance for TTOs of having highly skilled and trained professionals. Every activity requires specific knowledge and often interdisciplinary competencies: example are IP and contract lawyers, business developers, business analysts, marketing personnel. They must comprehend both the academic and the business world, preferably with experience in both, as well as be able to evaluate the technology embedded in each proposal. Skilled personnel may gain a good reputation and enhance the disclosure, while dissatisfaction may lead academic to circumvent the TTO.

To ensure a good performance, TTO may also consider the provision of specific services from external providers, both specialized in a single activity, i.e. patent attorneys and technology consultants, as well as specialized in the technology transfer itself, i.e. TT centers, consortia etc. Another alternative is to develop dedicated external support facilities, as business incubators and science parks.

2.4 Faculty

Faculty and departments may have an important role in the technology transfer process, both as a group of academics that share a common research theme and as an organizational intermediary between the central administration and scientists.

A first, relevant factor is the faculty leadership: as stated before, an experienced, supportive leader positively influence the academics perception of the university orientation toward commercial activities. Guerrero et al. (2014) reinforced this perspective by analyzing the importance of the attitudes of key actors, like faculty member and leaders.

Similarly, Muscio (2010) found significant the faculty leadership's (identified in the department director) trust in the TTO, which increase the probability of a successful exploitation – assuming a positive impact of the office's professionalization; he also found an inverse correlation between the leader age, as proxy of experience and previous involvement with industry, and the probability of trusting and contacting the TTO. However, faculty leadership is expected to execute policies in compliance with the university mission and objectives (Chang et al., 2016), therefore linking its supportiveness to general policies and the administration.

A fundamental study on this topic is the one authored by Owen-Smith and Powell (2001). They found three significant factors for the institutional success of patenting, as one of the technology transfer channels: (1) the faculty perception on potential benefits of patenting; (2) the perception of time and resource required to interact with the TTO, as well as its perceived quality; (3) the general opinion of the university on the technology transfer topic. Along with perceptions, faculty behavior is influenced by the institutional environment and its organizational structure.

Firstly, promotion and tenure policies may be shaped by the university mission and orientation, but are enforced by faculties and departments. Moreover, they are in charge for the evaluation of research personnel, both on scientific outcomes and commercial exploitation (Chang et al., 2016). Secondly, social norms and practices established at the university level may strongly influence the faculty attitude; should be remembered that, according to Bercovitz and Feldmann (2006), a shift can be made by setting the correct incentives, especially at the faculty level, regardless the university history.

Another relevant faculty variable is its scale, both in term of human and technical resources; as an example, empirical findings from Owen-Smith and Powell (2001) suggest that ceteris paribus, best performers have "more researchers and more resources devoted to research". Similarly, the size of the department is suggested to have a U-shaped relationship with the volume of industry interaction (D'Este and Patel, 2007), where small departments may have not enough resources and large departments tend to engage a more basic research, far from industry problematics.

Past performance is found to be useful in predicting future ones. A useful proxy is the departmental research income received from industry, per member, which has been found to be correlated with future engagement in commercialization activities (D'Este and Patel, 2007). Also Blumenthal et al. (1996) in earlier days found evidence that industry-funded faculty members are commercially more productive, suggesting a Matthew effect. Similarly, empirical findings from Thursby and Thursby (2002) indicate that a growth in faculty propensity to disclose inventions, itself one of the most significant predictors of technology transfer performance, is clearly linked to its past licensing success.

Of similar impact is the overall past scientific performance of the faculty (O'Shea et al., 2005). D'Este and Perkmann (2011) indicated that, apart from its effect on the volume of interaction, it influences also the preferred channel; specifically, they found that researchers in lower rated departments tend to prefer consulting, whereas departments with higher evaluations and incomes are more likely to engage in more frequent contract research.

Other authors studied the effect of the faculty's scientific field. Firstly, cultural norms across fields may be highly significant (D'Este and Patel, 2007); secondly, the nature of the research – its applicability to industries – is critical in determining the extent and volume of commercialization activities. In fact, some research fields easily meet specific market conditions, and O'Shea et al. (2005) found that faculties and departments involved in such research usually receive more funding, either from industry, government or the university administration.

Oppositely, faculties specialized in basic research may prefer to not disclose inventions, afraid or unwilling to spend time and resources on the successive applied research needed for a commercial exploitation (Bercovitz and Feldmann, 2006). Basic research also refers more strictly to the open science paradigm, leading such faculties to avoid commercialization due to possible delays in publication for patenting and marketing purposes.

Inside the basic and applied research areas, the literature is more divided around the effect of specific disciplines on the commercial engagement; different authors provide contradictory findings on whether the research topic, as in biotech, medical school or engineering, increase the attituDe toward technology transfer. However, Owen-Smith and Powell (2001) observed that in any case, the value of patents may vary significantly across areas, in terms of the protection extent, for leverage potential and as source of incomes.

Another significant research on this topic refers to the impact of research areas and the cognitive distance from the related industry: Muscio (2010) found that departments with greater cognitive distance from industrialists do collaborate more. This finding supports the theoretical literature that suggests an inverted U-shaped relationship between cognitive distance and university-industry collaboration.

Wong and Singh (2010) also found significant the impact of faculty internationalization on patenting performance, but results are ambiguous: in North America it has a negative effect, while positive elsewhere. These findings suggest further investigations on which faculty factors, among different institutional university systems, can lead to this contradictory result.

Finally, faculty's benefits from technology transfer usually refer to the individual benefits and the impact that these could have on the research performance of the personnel. Baldini et al. (2007), for examples, indicated as major benefit the direct access to industry knowledge, laboratories and funds, the positive influence on researchers' career and earnings, new and different ways to exploit the researchers' abilities, factors previously seen as motivations for academics.

Again, also departments should demonstrate ambidexterity in order to gain a good overall performance. It is also fundamental to note that this ambidexterity is largely influenced by the department perception of the institutional flexibility, and may have a positive, significant influence on the individual ambidexterity. This setting helps clarify the great extent of environmental and institutional impact on the probability to engaging in technology transfer.

2.5 Recap

In this hcapter has been described the academic sphere of the technology transfer.

In the first section, the historical perspective highlighted the two major cultures that characterize universities, the open science system and the knowledge economy and their impact on transfer activities, exposing authors' opinions to line out significant pros and cons. The second section describe the attitudes and preferences of academic scientists, including the research they may favor, incentives to foster and attributes linked to a greater commercial performance.

The third section provided informations on the technology transfer office, starting from its role of intermediator in the knowledge economy. Has been exposed the two main organizational structures and objectives that shape their transfer model, a view of their activities and the fundamental importance of employees. Finally, the fourht section outlined the infuence of faculties and departments in shaping the individual attitude toward and performance in transfer activities.

Each of these elements will be later compared with private research institutions in Chapter 6, which instead are characterized by an economic purpose, flexible and lean organizations, larger commercial strucutures, in which scientists are more prone to applied research and development for the market needs.

Chapter 3

The Industry Perspective

Firms, spin-offs and others

The technology transfer process connects the university and its researchers, discussed in Chapter 2, to industrial actors who will later exploit commercially the transfer object. While the counterpart is the same for both a public university and a private research organization, its major traits may influence the transfer process, once coupled with different characteristics of these knowledge generators. Specifically, an arrangement between private realities may take advantage of their commonalities in culture, organization, and missions. To better understand the differences among paradigms proposed in Chapter 6, this chapter will describe the most common counterparts and their major characteristics.

3.1 Firms

Advanced knowledge has been recognized as fundamental for firms' competitiveness since the 80s, from the seminal work by Wernerfelt (1984) on the Resource Based View. Investigating the ability of various types of resources to produce high returns in the long run, he hypothesized that the technological lead may be one of the strongest factors: it "will allow the firm higher returns, enabling it to keep better people and stimulating settings so that the organization can develop and calibrate more advanced ideas than market followers". In fact, despite the threat of followers, the author observed that firms which invest in and acquire cutting-edge knowledge and technology are the best suited to further their capabilities and stay ahead the competition: like "a high tree in a low forest; since it will get more sun, it will grow faster and stay taller".

The importance of being on the technological edge has been extensively studied and demonstrated; more specifically, many authors highlighted how innovation activities are necessary for competitiveness. Beath et al. (2003), for example, stated that firms do depend on continual improvement, either in processes and products, whose source is the applied research. Yusuf (2008) argued that firms need to sustain innovation processes, in order to sustain their competitiveness. Jimenez-Barrionuevo et al. (2011) referred to the knowledge base as the most strategic resource a firm can possess and deploy for obtaining a competitive advantage. Siegel et al. (2003a) observed the importance of a faster time to market for innovative products, which comes from their novelty and the collaboration with top notch organizations capable of transferring them in a timely fashion. Lastly, Azagra-Caro et al. (2010) noted that cooperation, especially in R&D, increases the firms' organizational learning capability, thus the innovation performance.

Nowadays, the resource-based view is still one of the fundamental concepts in building an effective strategy, but the landscape has become more complex since the shift toward a knowledge economy. Innovations now tend to be more complex, interdisciplinary, systemic and depends both on the scientific knowledge and the market knowledge. Dahlander and Gann (2010) recognized similar drivers, and made the strong observation that in the actual economic landscape "a single organization cannot innovate in isolation". One of the most useful tools in this scenario is the open innovation.

The open innovation is a concept initially described by Chesbrough (2003), as a paradigm that sees firms using both internal and external sources of knowledge and technology to make an innovative leap. In this case, firms can mix internal and external information, and decide to outsource or perform themselves the R&D necessary to overcome the technical challenges, where outsourcing means taking advantages from the increased division of labor and the new communication technologies. Different configurations are available to organizations: firstly, there is no clear division between open and closed innovation processes, thus every configuration represents a point in the continuum between these extremes; secondly, open innovation can be pecuniary or not, inbound or outbound.

This particular system, which has gained a considerable attention over the last 10 years, allows firms to access knowledge and resources with a greater flexibility, and to avoid sunk costs in specialized and larger R&D units. However, it is well recognized that any organization, to gain an earlier and more detailed access to innovations and scientific knowledge, may need to "purchase a ticket of admission" in term of internal R&D and knowledge. That is, firms should not limit themselves to acquire the technology, but to collaborate in their development and absorb the underlying knowledge. This should be tightly linked to the adoption of a science approach internal to the organization which, in fact, pay itself: as found by Stern (2004), the internalization of this approach allows the firm to acquire better research staff, pay them less (notably, 27%), employ more personnel, therefore raising the R&D productivity and the rate of technological innovation.

Regardless the cost of entering the innovation network, linking with other institutions has become a major factor in improving the innovativeness, thus the economic performance, of the firm. Relationships, cooperativeness, and blended social proximity give access to different, new knowledge that may be complementary to the previous technology portfolio, allowing the firm to develop innovations previously precluded. Bercovitz and Feldmann (2006) found this approach to be particularly useful for exploration activities, highlighting the importance of new knowledge from partners and neighbors.

So, firms have a double benefit from engaging in cooperative research activities with other institutions: a reduction in R&D costs and the access to more, high quality knowledge. A further explanation of firms' benefits can be taken from

Caloghirou et al. (2001), who found that when collaborating with research institutions, specifically universities, firms mainly aims at “achieving research synergies, keeping up with major tech developments, sharing R&D costs”. Therefore, what firms seek in research cooperation is a performance improvement, instrumental in gaining a competitive advantage over competitors.

A slightly different perspective is the one of Bekkers et al. (2002), who linked the domination of firms in a market characterized by an advanced technology (the GSM industry in the previous century) to their position in the alliance network and the ownership of essential intellectual property or patents. On one hand, the cooperation with other organizations may lead the firm to a central role in the network, increasing its influence on the direction the market will take; on the other hand, this perspective introduces another angle for firms: patents and intellectual property. These tools help entrepreneurs and companies to gain a control over the market and its future direction, other than the direct financial control over competitor and collaborators (Siegel et al., 2003a).

To reach these advantages, firms of every size are collaborating with research institutions and universities. Also small firms actively contribute to the innovation process, more than the extent that would be expected from their capabilities of investing resources (Audretsch and Lehmann, 2005). Larger companies, instead, balance their research agenda between short-term deliverables and long-term objectives (Tijssen, 2006). This trend led to a new “industrial ecology” of cooperation for R&D and flows of knowledge.

However, the role of universities in this scenario is not clear. While Thursby and Thursby (2002) reported a positive change in the faculty orientation and its receptivity for commercial and industrial projects, the university involvement has been found somehow weak. Specifically, Yusuf (2008) reported the results of an industry survey, which ranked universities least as innovation partners. These results seem even more negative when considering the importance of industry collaboration for universities, i.e. the facilitating role of industrial linkages for new spin-offs (O’Shea et al., 2005).

In a glance, knowledge derived from scientific research proves itself a valuable asset for innovation-oriented companies. However, firms are required to already possess a proper knowledge base, developed through their own R&D activities, in order to “absorb and appropriate” scientific know-how and new technologies: a concept named absorptive capacity.

3.1.1 Absorptive capacity

The absorptive capacity is a construct originally described in the seminal paper of Cohen and Levinthal (1990). They initially stated that is critical for firms to have the ability to recognize the value of, to assimilate and exploit external knowledge. More importantly, they hypothesized that this ability is mostly determined by the level of internal knowledge that the firm already possesses. At a basic level, a greater internal scientific knowledge includes skills and language capabilities, which allows firms to better comprehend and internalize external technology and relate with other innovative organizations and research institutions.

What firms need for increasing this ability is to perform their own R&D activities and to be directly involved in the concept, design, and engineering of the product they will later commercialize. The inner rationale, according to the original authors, is that "from a cognitive and behavioral science perspective, accumulated prior knowledge increases both the ability to put new knowledge into memory and the ability to recall and use it" (Cohen and Levinthal, 1990). In other terms, by conducting its own R&D, the firm may collect the prior knowledge, as in notions and experience, that will later be needed for understand and internalize other groundbreaking innovations and the science behind them.

In this perspective, learning is cumulative: it is easier and faster to absorb a knowledge that relates to the past background of the researcher and the firm. The same can be stated for the absorptive capacity itself: the greater the ability, the efficient the accumulation; the larger the knowledge base, the greater the ability. However, while a level of similarity is needed, suggesting a sort of path dependency, a diversity in the internal background is strongly advised, for assimilating a variety of external innovations instead of being locked in a single market.

Therefore, there is a trade-off between the focalization on a single topic, thus a narrow, better performance and the extensiveness of the disciplines the firm may internalize. A possible solution is what is known as transactive memory (Wegner, 1987), which states that nowadays, what is important to know is not the theory itself, but to know "who-know-what". In this case, the solution might be to engage relationships with entities and organizations that have a complementary knowledge to the firm's pre-existing one.

In a more operational perspective, the absorptive capacity can be divided into three different dimensions, according to the original authors. The first stage is the recognition of external useful knowledge, which depends on the prior related knowledge, on the characteristics of the counterpart and the relationship which link the institutions: cultural compatibility, trust, prior experiences and alike. The second phase is the assimilation: to bound external with previous internal knowledge; it depends on the organizational settings, such as flexibility, adaptability, specializations, objectives. Lastly the commercialization stage, which refers to the exploitation of both internal and the newly acquired knowledge, combined in a competitive configuration.

Later authors used a slightly different definition: "absorptive capacity can be defined as the organization's relative ability to develop a set of organizational routines and strategic process through which it acquires, assimilates, transforms and exploit knowledge from outside the organization in order to create value" (Jimenez-Barrionuevo et al., 2011). First, this perspective allows a better differentiation between assimilating the knowledge, as in a learning process, and the ability to use and reconfigure it for latter purposes. Secondly, this definition focus on the ability to create an organizational setting and an environment to better perform in the process, rather than the performance itself.

Patterson and Ambrosini (2015) instead studied the absorptive capacity in 4 dimensions, as a process; notably, they argued that these phases are not consequential, but occur in an iterative fashion. The first stage, the acquisition, may be decomposed in "search and recognize" and the actual "acquisition"; the latter depends on a preliminary evaluation of the technology, which requires an initial, even if simplified, assimilation. Similarly, the "transformation" process may depend on the results of the commercialization phase, which itself may require additional development of the technology, thus its transformation. Lastly, the "exploitation" stage creates new knowledge that can initialize the process again.

Some management practices can enhance the absorptive capacity of an organization. The first and most important is the human resource management: the selection and the organization of employees, the flows of communication between them, practices as rotating R&D personnel etc. In particular, they must possess different but overlapping backgrounds, and be familiar with the firm's specific needs. Other authors referred to the outsourcing of similar activities, in order to increase the internal absorptive capacity through external tools such as technology transfer centers and consortia, or directly via corporate acquisition. Should be noted that these alternatives do not overcome the need for at least a minimal internal R&D activity. A useful organizational tool is the creation of an internal technology transfer office similar to the university's one, which should act as a knowledge gatekeeper who actively seek for opportunities to exploit (Alexander and Martin, 2013).

Other authors provided empirical evaluations on the importance of this concept. An example comes from Nieto and Quevedo (2005): in their model, the absorptive capacity has, in fact, the greatest explanatory power for the firm innovative performance, and that a greater capacity will make irrelevant the presence and the extent of a technological opportunity. A second, more quantitative approach from Baba et al. (2009) suggests that the collaboration with Pasteur and Edison scientists enhance the R&D productivity, evaluated in an increase of 1.13% in patents.

3.1.2 Social capital

While the absorptive capacity refers to the internal ability to assimilate and exploit external knowledge, another concept describes the extent to which a firm can access and retrieve external resources: the social capital framework. The relevance of this concept arises from the findings of various authors, all pointing to the fact that the innovation performance mostly depends on the quality of relationships, measured as frequency, duration, emotional intensity or closeness, especially in the case of tacit and complex knowledge (Pérez-Luño et al., 2011).

The social capital is defined as "the sum of the actual and potential resources embedded within, available through and derived from the networks of relationships by an individual or social unit" (Pérez-Luño et al., 2011). It was initially described by Coleman (1988) as a particular kind of resource: social structures that facilitate actions by an agent within the structure. Like other types of resources, the social capital is productive and may be specific to the activity, the involved actors, and the context. In other words, it can be seen as a network of relationships that an individual or an organization can mobilize and use to a specific purpose, also individualistic; it is created by the participation to the network and the context itself in which the agent is located.

More specifically, the firm's embeddedness in a scientific network allows it to access a larger amount of knowledge and technologies, from an ensemble of different external actors, as in the mechanism of "localized learning". A secondary, but relevant mechanism is the "social comparison", through which an institution can use its role to influence the actions and behaviors of other actors (Slavova et al., 2015)

3.1.3 Networks and location

The absorptive capacity and the social capital have their root in the idea of gaining new knowledge through a network of partners and other innovative institutions; nowadays, these networks, in which the firm is embedded in, are recognized as one of the most important resources it can access, manage and exploit. As stated before, in the case of an innovation network the main benefit from participating are the access to more and valuable resources and knowledge, lower uncertainty and other barriers to innovation, to gain flexibility through macro-level specialization and to adapt faster to the market needs.

The most important, basic notion to consider is the Marshall's cluster theory (Marshall, 1890) and the impact on knowledge diffusion. In his view, a district was a place where "mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them, unconsciously", characterized by a specific "industrial atmosphere". These concepts led to the general recognition of the importance of localization to capture knowledge spillovers, mainly due to the availability of skilled labor and geographical and social proximity, which enable extensive flows of information among institutions. These flows allow a social innovation process, incremental and collective, which can take full advantage of these spillovers.

These networks and districts may include firms, universities, and any organizational configuration of research institutions, i.e. public research organizations, private research centers and alike. Specific to universities, a relevant contribution to cite is the one by Audretsch et al. (2004) who investigated the impact of universities on localization choices of firms. The rationale behind their research is that universities generate knowledge spillovers, that may be accessed by firms without a full compensation – thus lowering the research costs, increasing the expected profits. In this setting, the firm location can be considered a competitive advantage, even with differences in the field of knowledge.

Other information on the impact of universities can be taken from Cantner and Graf (2006) who applied social network analysis to the innovation network of Jena: in their perspective, social proximity has a stronger relevance than geographical proximity. They found that universities and other public research institutions, aided by government policies, are the core members, key actors in gather and distribute knowledge.

Following their approach, Giuliani and Bell (2005) applied both social network analysis techniques and the concept of absorptive capacity in studying the Chilean wine cluster. Firstly, they defined the cluster absorptive capacity as the relative ability of a cluster to absorb external knowledge, diffuse it among internal actors, and to exploit it externally. At the cluster level, they found significant differences among the re-distribution of new information to internal firms, providing support for the hypothesis on the correlation between absorptive capacity and the relative importance of actors. In fact, their results suggest that firms with a greater capacity constitute the center of the network, acting as gatekeepers, surrounded by active and weak mutual exchangers, external stars and isolated firms.

This study provides an initial, quantitative understanding of the importance that absorptive capacity has in shaping a network and the firm position. Zeng et al. (2010) instead, provided an insight into the relation between the network activeness of actors and their overall economic performance: they found a significant positive relationship between the cooperativeness of the firm and its performance, especially for inter-firm cooperation and SME. However, they found a weak support for the impact of cooperation with research institutions, universities, and governments, opening a quest for further investigations.

3.2 Spin-offs

Spin-offs are one of the most important and effective channels for technology transfer, but they also represent an external entity. In its industrial definition, a spin-off is a new entrepreneurial activity born from knowledge, technology or other activities of a parent organization. If the parent organization is a university, the new venture may be based on the licensing or acquisition of intellectual property from the originating institution (Lockett and Wright, 2005). In other words, their business is the exploitation of research results developed within the academic environment (Rizzo, 2015).

Their relevance arises from a peculiar ability to generate high economic returns for the local context, both in employment and financial terms (O'Shea et al., 2004), as well as their unique role in catalyzing knowledge and technology. They proved themselves fundamental also to the development and the performance of innovation networks (Pérez and Sánchez, 2003), through their ability to connect research organizations and industry (Rizzo, 2015) thus the natural impact on technological change and economic development. Similarly, Pérez and Sánchez (2003) suggested that these firms contribute to the dynamism of Regional innovation systems, by enforcing innovation and economic growth.

Many authors in fact recognized as one of the main drivers of their success their strong linkages with universities and research organizations. Assuming that universities' spillovers represent key resources in the knowledge economy, university spin-offs may have earlier access to them, and a greater absorptive capacity to exploit due to their origin. Therefore, a better economic performance. Even more, other actors may be located in the spatial proximity of the university, but the mere presence or availability of these spillovers represent only a necessary condition (Colombo et al., 2010), where the assimilation process need a social proximity.

For a comparative evaluation of these factors, thus the spin-off performance, a starting point is the "astonishing survival rate" (Balderi et al., 2007). In their empirical research, Leitch and Harrison (2005) found a failure rate of about 5% over 20 years, compared with the average failure rate of venture capitalists in about 21%. In fact, the survival rate is extremely high, especially if the firm aims to exploit a radical technology, possess broader patents and have linkages with investors (O'Shea et al., 2004). Studying the MIT case, Rogers et al. (2001) found that spin-offs created the 77% of induced investment and 70% of the employment, with respect to the overall MIT activities.

However, even if these new ventures seem a particularly effective channel for university-industry technology transfer, they require longer periods. As example, university spin-offs graduate later from their incubator, two years compared to one year from private incubators; this may be due to the embryonic and high risky projects they usually embrace (Rothaermel and Thursby, 2005), which increase the lead time between the establishment and the actual generation of economic benefits (Leitch and Harrison, 2005). Similarly, Pérez and Sánchez (2003) stated that a rapid growth is "both rare and often even unwanted among spin-off", due to the high uncertainties involved in the process.

At the base of the spin-off absorptive capacity, which allow them to gain such performance, there are two main factors: the employment of university personnel, as former scientists or active academic researchers, and the high proportion of turnover invested in R&D, evaluated in about 10% by Pérez and Sánchez (2003). In fact, even if the usual understanding of spin-off sees them as standalone technology transfer channels, they are separate entities: this will require a transfer between the original institution to the new venture, and later between the new venture and the market.

This means that every channel of technology transfer may be applied to the spin-off firm itself. In example, Pérez and Sánchez (2003) cited training activities in the initial stage, consulting and product development in latter phase between the new venture and the market. Other examples may involve the access to laboratories and other resources, testing equipment, the usage of the university's own networks, formal and informal consulting with prior colleagues, information services etc.

Other common characteristics among spin-offs are the size of the customer base and its great flexibility. For the former, they usually have only a few customers in initial stages of technology development, which will serve as lead users and validators. For the latter, these firms usually are smaller, flexible organizations which can adapt faster and efficaciously to new technologies and market needs.

Their peculiarities influence the types of activity they will perform. A generic framework differentiates among three strands of business activities (Mustar et al., 2006): consultancy; product oriented activities, i.e. product development; and assent oriented activities, i.e. R&D aimed to license and development of infrastructures. Druilhe and Garnsey (2004) further categorized spin-off activities among: consultancy and research, licensing, product related research activities, infrastructure development.

These activities result in specific benefits for universities and parent organizations: firstly, they represent an effective instrument in bridging universities and the market, capable of solving complex and difficult contracting situation between the research institution and other firms (Rizzo, 2015). Secondly, these new ventures are the best suited for obtaining the best exploitation for research results and new technologies. Lastly, they represent an employment alternative for researchers and students, as well as an income source for tenured academics.

3.2.1 Types and differences

Spin-offs are only a small group in the landscape of new technology-based firms, and as Franklin et al. (2001) observed: “spinouts company scenarios in practices are highly variable and defy any formulaic approach”. In order to get a better understanding of the phenomenon, a comparative approach can be taken.

First, corporate spin-offs are far more frequent than universities’. One of the most significant difference relies on the difficulties they may encounter during their development path: corporate spin-offs may lack the necessary linkages with universities and R&D institutions in early stages, slowing the development process; inversely, the ones arising from a university may lack channels for customers and suppliers in later stages, which a parent firm would have provided.

Widening the corporate spin-off concept, Colombo et al. (2010) considered the category of New-Technology Based Firms (henceforth NTBFs). The authors used this categorization to better uncover the advantages that Academic Start-Ups (ASUs) may take from the proximity to the university, in an absorptive capacity perspective. Their hypothesis was that these ASU, through social networks developed during the previous employment in the institution, would have a privileged access to university resources, knowledge, innovations and networks; at the same time, the research orientation of these firms should enforce their absorptive capacity. Once combined, these factors should allow academic spin-offs to perform better than other NTBFs, as suggested from their empirical results.

Mustar et al. (2006) used a similar category, Research-Based Spin-Offs (RBSOs) when investigating the different challenges that academic and industrial spin-offs may encounter. They found that the university type, born in “what is historically a non-commercial environment” may experience specific problems as the lack of commercial resources and conflicts in objectives among stakeholders. Lastly, Leitch and Harrison (2005) analyzed the case of second-generation spin-offs (a new venture generated by a spin-off) with mixed characteristics from both the industrial and the academic environment.

The same authors distinguished among university spin-offs, as new ventures based on the knowledge generated within the institution, and university founded companies, which refer to commercial opportunities exploited by university personnel that may be unrelated to the university knowledge base and research activity. Within the university’s category, however, a difference has gained far more attention from the literature: academic entrepreneurs versus surrogate entrepreneurs.

Radosevich (1995) in particular analyzed and compared these different approaches to the spin-off entrepreneurial leadership. The first kind, the academic entrepreneur, refers to an academic employee, i.e. researcher, lecturer or tenured professor, who takes the lead of the new venture both along with the previous occupation or by leaving it. The second type, the surrogate entrepreneur, is an external figure who is provided with the right to exploit a technology initially developed within the institution. Both alternatives have advantages and disadvantages either.

As an example, an academic entrepreneur may bring to the new venture a strong knowledge base, a wide network of personal contacts both in academic and industrial research environments, and a strong commitment to the technology. However, their lack of business experience and knowledge may negatively affect the firm growth, especially if they refuse to leave the previous employment. Their downsides can be overcome by a strong support structure, which will require a great financial effort from the institution.

On the other hand, a surrogate entrepreneur may solve the problem of an inventor unwilling to leave his position, as well as bring business knowledge and expertise and useful industry linkages. Moreover, empirical findings showed a faster spin-off growth, when external figures take the lead. However, they may require a payment, especially up-front if they are not serial entrepreneurs, apart from the obvious lack of technical knowledge.

Lacetera (2006) instead approached the differences between academic and industrial researchers in engaging the spin-off process, by modeling their activities as a game. Notably, he found that academic entrepreneurs may be both more reluctant to engage in the process or move faster, depending on the benefit they can derive from the pre-commercial research. On the other hand, industrial scientists focus on directly applicable research, lowering the cost of entering the market but possibly delaying the spun out.

3.2.2 Motives and factors

Academic and industrial entrepreneurs may be driven by two generic kind of forces: the opportunity, which arises from the individual level, and the necessity, mainly due to the external context. Therefore, the variety of influencing factors can be categorized in individual and environmental; other useful categories refer to the characteristics of the spinning university and the technology itself.

Individual motivation factors have already been discussed; however, specific variables have a have the greatest impact on the academic willingness to start a new venture. Apart from the generic entrepreneurial attitude, peer recognition, university culture and the need for research funding, Rizzo (2015) found relevant the seek for independence and tax avoidance, tightly linked to the fundamental independence of a new organization.

On this very topic, Pérez and Sánchez (2003) found the freedom to explore new ideas as fundamental, and more common among spin-off founders (against traditional new venture founders). Siegel et al. (2007) found determinant the involvement in local groups, especially the ones with a great entrepreneurial attitude, and suggested as an additional, possible motive the lack of academic recognition. The lack of prospect in the current employment may be significant (Rizzo, 2015); lastly, Ittelson and Nelsen (2002) found that the academic's willingness to actively participate significantly, and positively influence the success of the venture.

Similarly, some university characteristics, even if previously describe, should be cited for their peculiar impact. Lockett and Wright (2005) found, in their empirical research, a positive relationship between the university's stock of knowledge and the amount of spin-off generated, as well as for the availability and expenditure in the TTO and proper, professional advice. Other relevant variables are the linkages with other universities and the faculty involvement in the spin-off management, which however may delay, rather than facilitate, the spin-off graduation from the incubator (Rothaermel and Thursby, 2005).

Environmental factors instead have been studied by many authors in a variety of contexts; should be noted, in fact, that context peculiarities expose different and sometimes unique factors. Transversal variables may include the access to complementary resources, funding constraints, availability of venture capital funds, presence of a supporting policy and relative tools, government expenditure in R&D, patent regulation and effectiveness, legal assignment of inventions (O'Shea et al., 2004; Fini et al., 2009; Rizzo, 2015). Similar, but loosely coupled variables are the extent of knowledge spillovers from the university, the age of the spinning university, the number of local universities and the amount of educated human capital available (Audretsch and Lehmann, 2005).

Other factors seem to be peculiar to the local context, and do not appear as significant in every empirical research: these are rather linked to the geographical localization (O'Shea et al., 2004). Examples are the unemployment rate, a low demand for doctorate holders, a general dissatisfactory situation (Rizzo, 2015). A special attention has been devoted to the local and regional knowledge infrastructure: a developed infrastructure should increase the ability to access knowledge, competencies, expertise and relevant social networks (O'Shea et al., 2004), thus increasing the amount and extent of local entrepreneurial activities. Similarly, empirical findings from Audretsch and Lehmann (2005) indicate a positive impact of the technology capacity of the region.

Lastly, the characteristics of the technology itself may influence the process, i.e. its ability to constitute a platform, the extent of potential applications, the presence of a market (different) standard, and incumbents. An important factor is the stage of development of the technology: early stages are usually characterized by higher transactional costs, making the spin-off channel a suitable alternative (Rizzo, 2015).

3.3 Other external agents

3.3.1 Research organizations

Universities do not relate only with firms, nor the flow of knowledge and innovation is unidirectional. Some authors have studied various collaborative research organizations and in a minor extent other independent research institutions. For the former, examples are collective research centers, consortia research centers, university-based research centers and R&D alliances.

Firstly, Spithoven et al. (2011) studied the different approaches that SME and firms in traditional industries might take on the technology transfer; they hypothesized that these firms may need assistance in building their own absorptive capacity, uncovering a potential role for collective research centers. As previously stated, R&D performances are the most common proxy for the absorptive capacity: empirical research shows that over a half (51.6%) of SME do not have internal R&D activities at all. In this scenario, collective research centers can perform three types of useful and relevant activities, from which firms can take advantages: identify and monitor relevant technology, as a proactive knowledge intelligence unit; assimilate and transform the incoming knowledge, as a knowledge agency on demand; disseminate information, as a knowledge repository for firms. Their ability to perform these activities comes from the effort they devote to R&D activities, usually about half of their operations. Research related activities may involve collective and contract research and technology advisory services.

Collective research centers may be founded and financed in equity by the various organizations involved, while consortial research centers are the non-equity flavor of the same organization: all participants typically pay a membership fee or subscription and receive access to the knowledge output (Hayton et al., 2013). It is important to note that both these organizations may perform internal research activities, taking an active role and distinguishing themselves from a mere intermediary actor, such as a technology transfer center. In this perspective, they are a mechanism for sharing the risks of the development, especially for truly innovative projects. Other potential benefits include economies of scale and scope, reducing the required investment, and the convergence of new technologies toward a unique standard for the entire market. Therefore, their role as source of competitive advantage.

R&D alliances are similar in spirit, but have a very different purpose: instead of serving as a channel for the absorption and diffusion of new, external innovations, these organization rather aim to recombine previously available knowledge to actively create new technologies (Lin et al., 2012). In fact, these institutions are usually created by an ensemble of actors with the explicit purpose of exploring and develop new technologies. As the former examples, they also reduce required investments and risks, speed up the development cycle and reduce the lead time, give access to external knowledge and technology previously unavailable. Should be noted that of peculiar importance, in this case, is the cognitive distance among participants: the literature suggests a U-shaped relationship between the R&D alliance success probability and the cognitive distance, exposing the need for different but overlapping knowledge bases.

Rogers et al. (2001) studied instead the university-based research center, which is a similar co-participated organization but characterized by a stronger orientation to the science approach, possibly due to the larger involvement of a participant university. They may be more effective than the single research university, due to the interdisciplinary nature of their research activities, but they do not have an intermediation approach, thus not very effective in bringing research outcomes to the market.

Other authors investigated the difference between universities and other public research organizations. In the most generic framework, Teirlinck and Spithoven (2012) suggested that the latter may possess more practical knowledge and a mission more focused on technology transfer, but they usually rely on more large-scale and complex research facilities. However, their business orientation, practices, experience, and linkages (Debackere and Veugelers, 2005) unitedly to private management schemes, may help respond more effectively and quickly to specific industrial needs. Similarly, federal labs are characterized by a more interdisciplinary research and the ability to gather more resources (Bozeman, 2000).

3.3.2 Technology transfer organizations

As stated before, technology transfer offices and organizations may be external to the knowledge production institution. Some authors, in fact, found empirical proofs of the increasing relevance of external organization, being them private, public or government ventures.

A first example can be taken from Geuna and Muscio (2009), who observed how European and national governments' approaches to the technology transfer have endorsed the formation and growth of TTOs associations and networks. Their main goals are to develop best practices and to diffuse them toward any associate, to provide training support and international connections, to collect data and influence national and European policies on the topic. Two examples are the Knowledge Integration Community, created by the Cambridge-MIT Institute (CMI) and financially backed by the UK government, and the NetVal, the Italian network for the valorization of the university research.

Similar entities are the technology transfer centers, which aim to promote cutting-edge research projects and help in transferring the results also to SME and firms in low and medium technology industries; moreover, they are significantly useful in bridging organizations with different backgrounds, in the case of multi-disciplinary projects, thus promoting cross-fertilization activities. Comacchio et al. (2012) found qualitative indications of the relevance of these actors based on their boundary-spanning activities: following a social network approach, they found a positive impact of such organizations on the network density, besides covering structural holes. Moreover, they act as an interface between institutions and private firms, translating not only needs and objectives but also the very knowledge that is transferred. These results should be applicable to other intermediaries.

3.3.3 Incubators and science parks

Other external entities acquire a great relevance specifically in the spin-off process. The two main institutions considered here are incubators and science parks.

Even if incubators can be found inside the university organization, they are usually external, independent entities. They provide several advantages, relatively to the new venture: to conserve cash, accelerate the commercialization process, give access to professional advice and laboratory facilities, help academic founders to shift from the university culture and perspective to an entrepreneurial one (Ittelson and Nelsen, 2002). Additionally, their involvement increase the confidence of investors, helping spin-off in accessing financial resources.

Clarysse et al. (2005) analyzed incubators' activities to uncover any difference in their approach; they found three different models. The first is the "low selective mode", centered in advising and occasionally finance projects at a very early stage; they do no seek opportunities and rely on a natural selection process instead of evaluating and selecting the various proposal; due to the large number of spin-offs and firms they usually are incubating, the funding is typically seen as a mean of subsistence for founders, until later stages.

The second is the "supportive model": entry barriers to this type of incubators are higher, due to clear selection criteria and an active screening. They provide an extensive support up to the validation stage, through their professional staff; they may also provide financial support acting as a venture capital fund. Lastly, the "incubator model" have the clear, specific intent to create financially attractive spinouts: this needs an active opportunity seeking, a full and integrated support and the large use of external linkages with industry and venture capitalists.

In any case, rather than simply intermediate between industrial and financial partners and the spin-off, incubators provide access and integrate new ventures in their network, ultimately aiming at assisting new ventures in developing their own. In fact, both incubators and science parks are considered "intermediate organizations that provide the social environment, technological and organizational resources, and managerial expertise" (Phan et al., 2005). In a sociological perspective, as an example, incubators can be seen as micro-communities, where startuppers can develop and test business models under a protective umbrella.

Science parks, in fact, are more oriented to provide this kind of asset. As stated by Siegel et al. (2003b), their main missions are: to foster the formation and growth of innovative firms; to provide an environment which promotes collaboration between large and new, innovative firms; to promote the establishment of linkages with research centers and similar institutions. Similarly to incubators, the main mechanism is to provide the necessary business skills and knowledge, physical resources and financing.

What makes incubators and science parks differ, instead, are the objectives their mission is mapped to; science parks may be seen as an intermediary combining a technology transfer organization and a business incubator. According to Siegel et al. (2003b), their objectives are: to facilitate the university technology transfer; to foster the formation and growth of NTBFs; attracting external firms; promote the formation of strategic alliances. They may be functional also to the local and national institutions, by aiming at the economic development, job creation, and the enhancement of the local innovation system and entrepreneurial environment.

3.3.4 An endless list

These are only examples of the ensemble of institutions and entities that may surround the university in its technology transfer activities. In fact, any actor can be involved, due to the pervasiveness the university's third mission; however, many of them have been overlooked by the economic literature. As examples, some authors cited graduates and students as channels for technology transfer (Segal, 1986; Audretsch et al., 2004; O'Shea et al., 2005; Guerrero et al., 2014), but seems to lack a proper, dedicated and quantitative study on their impact on the innovation system. Another example, found cited only in Balderi et al. (2010) is the existence and usage of external firms specialized in very narrow activities, such as patent attorneys, firms specialized in patent valorization and patent infringement. These, however, are only examples, in the wide economic landscape of specialized businesses, and the more competitive will grow this phenomenon, the more specialized will be supporting firms.

3.4 Recap

Chapter 4

Channels

Mechanisms and processes

Channels constitute the bridge, as in infrastructure, between the academic environment (Chapter 2) and the industry (Chapter 3). They may differ for actors and activities involved, contractual forms and bureaucratic issues, but they all eventually represent a path through which delivery a new knowledge or technology to the market. Considered their influence on the effectiveness of a transfer and the influence that the originating environment has on them, an overview of the main channels is a necessary condition for a proper evaluation of the differences later described in Chapter 6.

4.1 Channels and categories

A technology transfer channel can be defined as an instrument or a mechanism through which knowledge can flow from the academia to industry (Gilsing et al., 2011). In other words, it is a set of actors and activities specifically configured and aimed to a peculiar objective – the transfer of newly developed innovations, technologies, and knowledge. The specific configuration and the objective, rather than the basic building blocks of actors and activities, are what differentiate channels the most: eventually, the process will involve a research organization and another institution, sharing information through training, meetings, documentation and alike, but with greatly different objectives and organizations. It is important to note, moreover, that channels are not mutually exclusive: they may complement each other, and cover the respective limits.

What is implied is that exists a wide range of possible configurations, and every channel is meant to satisfy a specific need and purpose. According to D'Este and Patel (2007), technology transfer processes, in fact, have an idiosyncratic nature: they depend on the specific context, the nature of the knowledge to be transferred, the receiver firm and various other factors. Therefore, different configurations will require different arrangements among organizations; examples of variables to consider are the innovativeness and the stage of development of the technology, frequency, and intensity of exchange, resources involved, the need for contractual rules and arrangements (D'Este and Patel, 2007).

Alexander and Martin (2013) gave instead more emphasis to the type of governance. They categorized each channel by five variables: the degree of formalization, the extent of the effort to minimize risks through a contractual approach, the level of previous engagement, knowledge tacitness and media richness. More importantly, they found that no channel is completely relational in nature, due to the need for risk management and knowledge codification. Similarly, Bercovitz and Feldmann (2006) observed that knowledge is both difficult to evaluate and to appropriate, creating the need for market transactions in the form of contractual mechanisms, voluntary and negotiated. As recognized by Rogers et al. (2001), also the external environment and its characteristics should be considered in modeling the process.

Other authors use a dualistic approach in their perspective: science-based and development-based, formal and informal, contractual and relational. Should be noted that in these perspectives there is never a clear cut between opposites and that these, while significant, are only examples.

The first of these perspectives come from Gilsing et al. (2011). In their view, the science-based regime relies on the importance of basic knowledge, non-cumulative and universal, which makes firms strongly depend on external sources through publications, consultancy, collaboration. The development-based regime, instead, uses a more applied, systemic and interdisciplinary knowledge, specific to the industrial application; in this case, there is a lower dependency of industry on external sources, shifting toward channels as R&D projects, collaborations, and contracts, professional networks, the flow of students and PhDs.

Link et al. (2007) separated formal and informal mechanisms. In this case, formal technology transfer prefers contractual and other legal instruments, based on the allocation of property rights and obligations. Informal processes instead are based on more relaxed and informal flows of knowledge, such as technological assistance, consulting and collaborative research. While the property rights and obligations are still present in this latter perspective, they assume a secondary role, more normative in character.

Lastly, transactional and relational perspectives, or "buy-sell transactions" and the "technology transfer at the arm's length" according to the original author (Harmon et al., 1997). In the first case, the process is formal, contractual and usually involves an intermediator; the information flow tends to be unidirectional, linear, driven by contractual rules. In the latter case, instead, the relationship and collaborative aspects acquire a central importance, the exchange is mutual and the barriers to the information flow decrease. The author also considered the existence of a third, hybrid model.

Other authors sorted the ensemble of mechanisms in different channels and groups, following different perspectives. A first example can be taken from Rogers et al. (2001), who simply listed the main channels: spin-offs, licensing, publications, meeting, cooperative R&D. Debackere and Veugelers (2005) further differentiated contract research from collaborative research, and includes a residual category for cooperation in graduate education, exchange programs, informal contact and individual networking. D'Este and Patel (2007) focused on less commonly studied channels, grouping the processes into: industry sponsored meetings and conference, consultancy and contract research, new companies and new physical facilities, training, joint research.

More recently, Muscio and Pozzali (2013) individuated 12 different types of collaboration, dividing them in: physical facilities, consultancy and contract research, collaborative research agreements, training, meeting, and conferences. Alexander and Martin (2013) instead differentiated between: transactional, i.e. patents, licenses, spin-offs, joint ventures; mixed governance, including collaborative research, research contracts and consultancy; mainly relational, such as shared facilities, journal publication, training, joint supervision; and relational, meaning joint conference, networks, student placement and alike.

Elsewhere, Balderi et al. (2010) categorized the main channels, licensing, spin-off and research contracts by modeling the choices that public institutions can take. The two main alternatives, in their view, are to diffuse the new technology through publications, congress, and other non-contractual mechanisms, or to protect and privatize the research results. In the latter case, the underlying knowledge can be either codifiable, resulting in a patent, or tacit in nature, thus requesting a more participative channel. Again, in the first case, the choice is between selling or licensing the patent, to another firm or a spin-off, exclusively or not. In the latter, should be preferred mechanisms such as training, consulting, collaborative research and alike.

Lastly, the literature mainly refers to two main channels: patents and spin-offs. As previously stated, the concentration of research on these topics arise from the relative greater availability and easier access to information and data; however, many of the hypothesis and findings regarding these channels can be successfully transferred to other mechanisms. Therefore, the following review will start from patents and spin-offs, to later describe other contractual and informal mechanisms.

4.2 Patents and licenses

The technology transfer process has its roots from the research activity performed by scientists. In the case of patents, as for spin-offs and other proactive approaches to the market, the outcomes of this activity are considered as fixed, unchangeable and with no margin for intervention.

The successive step, which marks the entry in the true transfer process, is the invention disclosure. It requires researchers to report a discovery that is believed to have a commercial potential; this disclosure should provide the dedicated office with information regarding the invention itself, various relevant market conditions and other data (Thursby and Thursby, 2002). As previously stated, this leap can be an issue for scientists, involving various factors as incentives, opportunity costs and the personal attitude (Owen-Smith and Powell, 2001). However, these invention disclosures are the “key intermediate input”, or rather the raw material, for TTOs and their officers. Some authors suggest a need for disclosure eliciting, including proper organizational incentives (Siegel et al., 2003a), but empirical research indicate that this may be unnecessary, and the institution unwilling or unable.

Jensen et al. (2003) investigated this issue by modeling the behavior of inventors, the TTO and the university administration as a game, which "rules" are set by the administration, i.e. contract terms, incentives and TTO's objectives. The inventor has 3 choices: to disclose the invention, further develop it or switch to another project; more specifically, he may decide to dedicate a greater time and effort to the idea further developing it, thus increasing its probability of success and appetibility for the market. However, his attitude toward this last alternative largely depends on various factors, among which policies and the TTO's ability to execute an attractive license.

McAdam et al. (2005) focused instead on a relevant topic related to the invention disclosure: many scientists initiating a technology transfer process have an "overly simplified view of business and management issues". More specifically, they tend to be over optimistic and underperform activities such as specifying the customer target, assessing the market potential, validating the technology and the business project, and other basic business activities for startuppers. The authors suggested as possible solutions a relevant management training for the TTO employees and specific training activities for academics who want to engage the technology transfer.

The next phase requires the TTO to assess the disclosure. The office must comprehend the technology potentiality, if it truly corresponds to a market, if there is an interest from the industry and if the potential revenues can sustain the relative costs. This activity involve the management of uncertainties and the ability to evaluate the new technology, a difficult task in this phase: most inventions, at this stage, are only proofs of concepts; and only a few companies may be interested in licensing in early stages, providing a market feedback (Jensen et al., 2003). In this phase, the TTO is also required to choose which channel to use for the technology, among which patents are only one viable alternative. The evaluation also depends on the general tendency to a revenue-maximization or a diffusion-maximization model. Lastly, according to McAdam et al. (2005), a positive decision should be linked to the intention to endorse the project, also financially, in later stages.

If the technology is positively evaluated, other minor decisions must be taken: the choice of which patent type apply for, whether to use external patent attorneys and specialized firms and alike. Another relevant preparative is to write the technology description and claims for the patent application, which will later determine the extent and the degree of protection the patent will grant, thus its value. This phase may require a continuous interaction between inventors, TTO and patent attorneys and other dedicated staff. After these additional steps, the patent can be filled.

At the same time, concurrent with the project evaluation, the TTO usually starts seeking for a potential licensee (Markman et al., 2005). In fact, as reported by Siegel et al. (2003a), these steps do not occur in a linear fashion, and many firms will license even before the patent will be granted. These attempts require the involvement of the inventor and the faculty, in order to identify potential licensees through experience and knowledge of the field. An alternative is to outsource this activity to a firm specialized in the patent valorization: the patent portfolio has its management costs, which will require proper and professionalized competencies to make it profitable (Balderi et al., 2010).

If a firm appears interested, the counterparts will start negotiating the license agreement. In the case of a negative result of the negotiation, and in the case of a successful one which comprehends a non-exclusive license, the process may continue by seeking another potential partner. In any case of a successful negotiation, the newborn relationship among organizations may require maintenance and, occasionally, the re-negotiation of the agreement (Siegel et al., 2003a).

4.2.1 Performances, laws and approaches

Some authors performed quantitative, empirical analyses. One of the most interesting findings regard the stage of development of the average licensed technology: most university inventions are licensed as proof of concept (45%), with only a prototype available (47%) but the largest part requires further development (85%); only the 12% are ready for commercial use, and even less have a known manufacture feasibility (8%) (Thursby and Thursby, 2002). In fact, many TTOs start seeking for potential licensees already before the patent application, and only if the license is expected to be "easy": only the 20% of inventions disclosed will become a patent.

Regarding the probability of a successful exploitation of a patent, incomes are significantly concentrated in a few patents: Thursby and Thursby (2002) reported on average a 76% of incomes attributable to the top 5 inventions, little more (78%) according to Jensen et al. (2003). The same authors found an inverse correlation between the financial success of a patent and the relative shares or royalties allocated to the faculty. These patents are funded by federal research grants (63%), industry (17%) or unsponsored (18%). Elsewhere, has been found a concentration of inventions in a few areas, specifically arising from engineering, medicine, and nursing. However, this concentration around specific topics has been largely discussed, but the most part of the literature agrees on the better performance of applied sciences.

Jensen et al. (2003) specifically studied the optimal license contract. Firstly, inventors cannot be effectively monitored during the further development; the resulting moral hazard issue, unitedly to the asymmetric information issue, requires the usage of a mixed payment, i.e. a mix of fixed, up-front, and license-issued fees, royalties, milestone payments and alike, which may positively influence the inventor's effort; equity payments should be preferred. The financial value of these incentives should outweigh the inventor's' disutility from the further effort required and other disadvantages, like the publishing delay.

In the specific case of a royalty payment, other technology transfer models suggest that any distribution scheme which does not allocate the entire sum to the inventor is suboptimal, and will negatively influence the academic attitude toward patents and licensing. Three other important characteristics of the optimal license agreement are: to grant exclusive rights, as preferred by the firm; to clearly specify the focus and contents of the underlying research project; the provision of equipment and personnel by the industrial counterpart.

Other authors analyzed the legal perspective, since universities have become more and more aggressive in securing and protect their patents (Wysocki, 2004). This point of view, in fact, allow a better understanding of how critical has become the issue over time, and which is the true attitude of universities and their administration toward their knowledge assets.

Basically, the intellectual property protection embedded in patents is intended to be beneficial for both inventors and the society: the former receives the exclusive right to exploit the patented technology and knowledge for a limited period, while the society receives a knowledge that might not receive otherwise.

Earlier in the latest century, governments and courts recognized the unique role of universities as knowledge producers and repositories, giving them a peculiar ability to overcome, or simply ignore, the intellectual property rights of other organizations, at least in specific cases. This rule was known as "academic exceptionalism", and allowed universities to use external intellectual property in the case of experimental or fair purposes, without licensing it.

However, with the Madey v. Dukes case (Hayter and Rooksby, 2016) American courts engage a different line of thinking. As the court stated, "like other major research institutions of higher learning, is not shy in pursuing an aggressive patent licensing program from which it derives a non insubstantial revenue stream". The changes in universities" attitude and behavior in patenting and licensing, in conflict with the open-science approach previously associated with these public institutions, made the non-profit status of the Duke university immaterial to the court. In a legal perspective, it can be considered a milestone in the shift of university objectives, and the relative importance of the third mission.

Other authors focused on the analysis of the Bayh-Dole act and its effects. Promulgated in 1980, this law focused on the intellectual property arising from federally funded research: at the time, only few research products were being patented by universities, as an underutilization of federal funds, thus paid taxes. The new legislative approach assigned to universities the ability to patent and possess research results, in order to use the potential financial outcome as a secondary incentive to firstly patent, then commercialize.

The effect of the Bayh-Dole act and similar legislations in other countries has been profusely studied in the economic literature. One of the most significant results is the one of Leydesdorff and Meyer (2010), who found an increase between 250% and 500% of patenting activities performed by universities when a Bayh-Dole type legislation is introduced. However, the same authors found a relative decline in their effects since the 2000s: while at a global level the university patenting activities are still increasing, in most advanced economies the effect of such legislations has "faded away", possibly due to learning effects or differences in incentives and evaluation policies.

Apart from the positive impact on patenting applications, the Bayh-Dole act influenced other types of patent-related activities, especially their enforcement: "the act of threatening to sue or actually suing third party companies for patent infringement". Specifically, even if most universities report to be conflicted on the topic and to decide on a contingency base, the number of patent infringement lawsuits which involve universities has significantly increased (Hayter and Rooksby, 2016).

A last perspective on patents should be considered when it comes to the evaluation of universities' patenting activities: the home advantage effect, which states that a patent applier tends to fill more patents in their home country than abroad (Criscuolo, 2005). Causes can be cognitive in nature but also based on economic evaluations on potential and existing markets, i.e. due to the technological specialization of countries.

4.3 Spin-offs

As previously stated, spin-offs are new ventures founded in order to commercialize a technology or a knowledge developed in a research organization, as a university, a federal or government laboratory or a private organization (Rogers et al., 2001). Again, the spin-off can be intended as the firm itself, but also as the process that will lead to the firm formation. Following this last perspective, many authors proposed different models, but the fundamental ratio can be easily understood by comparing them.

A first, simplified stage model is the one proposed by Druilhe and Garnsey (2004). They divided the generic entrepreneurial process, with no direct reference to the spin-off process, into 3 different stages. The first is the opportunity recognition, from the research result to the identification of a commercial project; the main issue in this stage is the ability to unconsciously and immediately perceive the potentiality of an idea: in the author's view, opportunities are "objectively identifiable", but their "recognition is subjective". The second stage refers to the mobilization of resources and their (re)combination to achieve the expected outcome; difficulties in this phase arise from the scarce expertise of academic scientist in this kind of entrepreneurial activity. The last stage is the ongoing organization of the resource base, in order to enable and increase the revenue generation.

Clarysse et al. (2005) proposed a different three-stage model for the spin-off process, focusing on the activities that lead to the creation of an independent venture. The first is the invention phase, the act of creating a new technology or knowledge; its main issue is the technology uncertainty. The second stage is the transition phase, in which the entrepreneurial idea is validated through small market experiments. Lastly, the innovation phase refers to the creation of the new venture and the growth of the project. This model, however, places a little attention into the opportunity recognition.

Degroof (2002) instead suggested a six-stage model, which requires a more direct involvement of the university and its dedicated offices. The process starts with the seeking for a technology opportunity, both from TTO's officers and scientists; later, the office will assess and evaluate the intellectual property involved in the idea, and select the projects based on their feasibility. The selected spin-offs will be supported in the development of a business plan, and later in the seek for funding. Lastly, the new venture will be founded.

Another well-recognized approach is the one of Ndonzuau et al. (2002), who modeled the spin-off process into 4 different stages focusing on the relative issues. Firstly, the business idea generation (post-recognition); it can be inhibited by the academic culture and poor internal competencies in opportunity recognition. The second stage refers to the finalization of the new venture project, structuring a coherent and feasible plan; in this case, issues may arise in the identification of owners and the most suitable method to protecting the idea, how to exploit it, and how to finance it. Thirdly, the spin-off launch: ideally, the creation of a firm which (1) exploit an actual opportunity, (2) managed by a professional team, (3) supported by available resources; the main topic, in this case, is how to gather the necessary resources. Lastly, strengthening the creation of economic value; in this phase, attention should be paid to the relocation risk and a change in the business trajectory.

Similarly, Lockett et al. (2005) used a stage model to uncover the key process issues; as other authors, they found relevant the opportunity recognition, but they focused on two other topics previously overlooked: the decision to commercialize and the choice between channels. For the first, they observed that the decision relies on both the technology and the academic involved, but much reliance is placed in the academic and his motivation. For the latter, the authors recognized the independence of the technology from the channel: in theory, the idea can be exploited in several different ways; however, an exploitation mechanism must be chosen. They used as a milestone the licensing and the spin-off channels, based on the estimated financial returns, academic willingness, the extent of the TTO's involvement and similar factors; however, it should be remembered that these are not the only available channels.

Lastly, one of the most recognized models has been described by Vohora et al. (2004), who used 5 stages separated by 4 critical junctures. The process starts with the research stage, which ends with the opportunity recognition: the authors described this critical juncture as "the match between an unfulfilled market need and a solution that satisfies the need that most others have overlooked"; its overcome requires the ability to synthesize academic knowledge with market and industry knowledge, thus high levels of social capital. The second phase is the opportunity framing stage, in which researchers and technology transfer officers assess and evaluate the identified opportunity, and try to frame it in a commercial project. At the end of these activities, the issue regards the entrepreneurial commitment of researchers; the authors identified four key obstacles: lack of a successful entrepreneurial role model, of prior business experience, of self-awareness over personal limitation and difficulties in accessing surrogate entrepreneur.

The successive phase regards the pre-organization, in which will be established how to exploit the opportunity and the involved researchers and TTO's officers start implementing the strategic plans. At this stage, the main problem arises from the (lack of) credibility of the new entrepreneur, which jeopardize his ability to access and acquire the necessary initial resources; a solution may come from the relationships established by the TTO during its networking activities. Fourth is the re-orientation phase, the attempt to generate returns from the new technology; this stage is highly characterized by the need of effectively reconfigure the resource base in a competitive setting. If achieved, the new venture can overcome the "last" issue, and reach the sustainable returns phase. In this last stage, the spin-off finally leave the umbrella of the originating institution and enters a pure commercial environment.

4.3.1 Entrepreneurs and teams

The spin-off process involves a multitude of different individuals and institutions, from the inventors, the parent organization, external and surrogate entrepreneurs, venture investors and many others (Djokovic and Souitaris, 2008). Two of the most important contributions to the technology transfer literature refer to the entrepreneur itself and the composition of his venture team.

Firstly, Shane et al. (2015) investigate the “typical” academic entrepreneur. More precisely, they begun from the hypothesis that TTO officers, venture capitalists and other actors tend to support spin-off and entrepreneurs that meet specific characteristics, recognized in previous successful cases: “the representativeness heuristic means people tend to favor those examples which look like the standard case”. In fact, previous studies show the typical inventor-entrepreneur usually as a male immigrant, with industry experience and “easy to work with”; the authors empirically confirmed that this is actually the kind of inventor that TTO officers tend to favor.

Secondly, Der Foo et al. (2005) studied the impact of the team composition and its internal diversity on the external evaluation from venture capitalists and other investors. The underlying hypothesis is that larger teams may not increase the amount of information and capabilities embedded into to the new venture, rather dependent on the marginal ability of individual employees to bring new experiences and fields of knowledge. They differentiated between task-related and non-task diversities, i.e. education, work functions and company tenure versus personal and psychological attributes. They found a little empirical support for a positive correlation of task-related diversity and investors’ evaluations, and a negative one for non-task diversities, suggesting the relatively superior performance of a team whose composition include different but overlapping competencies and backgrounds, of individuals otherwise similar.

Related to this topic is the contribution of Zhou et al. (2014), who investigated the impact of immaterial assets on the external investors’ evaluation, specifically the ownership of patents and trademarks. The starting point is the presence of an information asymmetry between the new venture and external venture capitalists, a scenario that the latter tend to overcome through the usage of proxy variables for the startup economic performance: patents and trademark. The hypothesis, strongly supported, is that these portfolios signal to VCs the willingness to engage and commit to the new venture, which will positively influence the evaluation until the growth of an external, autonomous evaluation capability from VCs. The authors found significant and positive coefficients for both patent applications (B = 0.35) and trademarks (B = 0.40), even greater for the interaction term of these (B = 0.35, up to 0.61 for early rounds).

4.4 Contract and cooperative research

While the economic literature focused on licensing and spin-offs, the sponsored research channel is reported to be the preferred by faculty inventors (Jensen and Thursby, 1998). As stated before, this type of mechanism allows the academic to continue his research activity with a higher degree of freedom in respect to the previous channels, which represents at the same time as a compensation mechanism. It is important to note that the various forms of sponsored research are not mutually exclusive, and may take place alongside other channels, i.e. contract research financed by licensee firms. Moreover, this category refers to various mechanisms, including collaborative research, cooperation agreements and research contracts.

Collaborative joint research is a formal agreement of collaboration between research institutions and firms; it may include several actors, up to a consortium. In this mechanism, different organizations confer their knowledge and backgrounds to a unique research activity, in the form and for the objectives established by the initial contract. The form and contents of the process itself may vary greatly, i.e. the location of research activities, infrastructures, resources and human capital provided by actors, the legal protection adopted. The aim, however, is usually a "precompetitive" research: to gain a better understanding of a scientific field before any kind of industry application (D'Este and Perkmann, 2011).

Collaborative research projects are usually based on a cooperation agreement, which constitutes a legal framework for later contractual forms of cooperation. In these agreements are described the legal boundaries of every forthcoming activity, i.e. the appropriation of research outcomes, the usage, and propriety of scientific backgrounds, who will oversee patent applications and its fees, and alike. The aim is to reduce later coordination costs and information leakages with partners. A preparatory legal agreement is particularly useful in the case of a great distance in attitudes, approaches, and priorities between organizations, as between an open science academic institution and a firm operating in a highly competitive market.

A related mechanism is the research contract, in which a firm outsources the research activities to an external organization. In this case, the firm usually provides only the financial means for the research activity or a previous protected intellectual property, while the research organization provides human resources, laboratories, and knowledge. The aim of this contract is usually the development of a product or a new specific technology, rather than exploring a scientific field and creating new knowledge. In fact, D'Este and Perkmann (2011) referring to its objective as research and development with a direct commercial relevance, more applied than collaborative research.

Sohn and Lee (2012) specifically investigated which is the most diffused research contract form and its standard clauses; they focused on publication of outcomes, indemnity responsibility, ownership of outcomes and compensation forms. They found the optimal combination in a contract that (1) allows publication after the firm's consent, (2) in which the results are owned by the firm or together with the research organization, and the former is responsible for patents application and maintenance, (3) the responsibility of indemnification is shared or on the firm only, and (4) compensations to researchers are in the form of incentives and benefit from both parties.

Many authors seemed to favor cooperation over contracts, due to the better opportunities offered by the complementarity of knowledge and resources between organizations. In an attempt to understand these partnering decisions, authors investigated the characteristics of firms and their impact on the probability of establishment and success of cooperation and research contracts. Powell et al. (1996) found relevant the following attributes: size, position in the value chain, degree of sophistication, resource constraints and prior experience with alliances. Similarly, Aristei et al. (2016) individuated as firm's relevant characteristics its size, industry affiliation, previous experience, its absorptive capacity and R&D intensity. More importantly, their empirical results indicate that the typical firm engaging in research cooperation is R&D intensive, makes a wider use of IP rights, takes benefits from public R&D support and generically relies more on external sources of finance.

Cantner and Graf (2006) instead found that the cooperation between organizations strongly depends on different forms of previous linkages other than the past experience, i.e. job mobility and other informal linkages. In fact, their results showed the presence of "definitively more linkages between innovators than documented in patents". While these informal channels of technology transfer are often overlooked, due to the relative difficulty in gather information and data, it is important to get at least an overall understanding of their extent.

4.5 Informal channels

The informal exchange of information between organizations has always been a relevant phenomenon, and many authors investigated its extent and impact. One of the most important contributions on the topic comes from Schrader (1991) who investigated the information trading, defined as the "informal exchange of information between employees working for different, sometimes directly competing firms"; he found that the 83% of employees has already provided information and a significant positive correlation of this exchange and the overall firm performance.

In fact, flows of tacit knowledge and informal relationships are fundamental to the technology transfer (Geuna and Muscio, 2009). Despite the typically narrowed focus of TTOs on patents and spin-offs, only a part of university knowledge and research can be codified into patents, while spin-offs are limited in number, thus in potential impact. Informal channels, instead, can transport a large amount of information to the industry, independently from its tacit nature: in this perspective, informal channels can be considered as an alternative route, a fallback when contractual mechanisms fail to take place.

Another reason for the existence and usage of informal channels of knowledge exchange is that "transactional mechanisms do not occur in isolation" (Bercovitz and Feldmann, 2006): licenses, spin-offs, contracts and alike will eventually require the establishment of a relationship between university and industry, in a long-term perspective, to allow more complex interactions, feedbacks and cooperative behaviors. As an example, a cooperative research project or a license agreement expose an information asymmetry, to overcome through trust, thus the building of a durable relationship. If the university is not willing to fulfill this need, firms may be interested in directly contact the scientist and arrange an informal technology transfer (Siegel et al., 2003a; Link et al., 2007).

Examples of informal channels are non-contractual consulting, sabbatical leaves, participation in events, congresses and meetings, publications and alike. Apart from the transfer itself, these mechanisms also allow researchers to perform boundary spanning activities, connecting the various networks they are embedded in, further helping in the establishment of new relations or "bringing together entrepreneurs and professionals for face to face encounters that can forge other university-industry linkages" (Yusuf, 2008).

A specific but relevant case is the role of star scientists in cooperative and informal technology transfer. Zucker and Darby (2001) studied the impact of the collaboration with star scientist on the firms' innovation performance in the Japanese context, characterized by two institutional features: the tendency of collaborating through the deploy of a firm scientist toward the university laboratory, and the keiretsu membership. Empirical findings indicate that two co-authored articles led to a 77% increase in patents, 60% more products in development and 18% more products on market, indicating a great effectiveness and productivity of the collaboration.

This case highlight another important source of knowledge spillovers and technology transfer: the researcher mobility. According to the previously cited Marshall's district theory, a higher workers' mobility, including both academic and private researchers, should increase the web of relationships linking individuals and institutions, allowing greater flows of knowledge and innovations, thus a greater overall technology progress (Cantner and Graf, 2006).

To better understand this mechanism, Argote and Ingram (2000) decomposed a systemic source of innovation in three different repositories: people, tools, and tasks; together, they form a network which embeds knowledge and competencies. Moving the entire network could be difficult, due to the internal interdependencies and their linkages with the context they are born in. However, moving only the involved human resources may be an effective, even if partial, solution: individuals can adapt and reconfigure their knowledge, both explicit and tacit, to the new context and the new local group they would refer to; their reallocation may be also a preparatory step to the later transfer of tools or technologies.

Slavova et al. (2015) conducted an empirical analysis of the effect of inbound mobility on the firm performance: he found a positive, significant effect on the recruiting of high-quality researchers on the performance of the internal incumbent scientists, thus the overall innovation performance. The extent of the effect, however, depends on the social dynamics internal to the organization, knowledge sharing, and collaboration practices. The outbound mobility, especially toward spin-offs, has been found instead to be a side effect of the technological advance of the organization: according to Franco and Filson (2006) firms with higher technological know-how are more likely to survive the competition and inevitably generate spin-offs and new startups.

Researchers' mobility takes a fundamental role also in the social capital framework: by employing an academic researcher, a firm does acquire his knowledge and capabilities, but also his network of prior relationships that may be translated into the employer's social capital. Murray (2004) identified two different categories of social capital through which the prior academic career of the scientist can affect the new environment. The first is the "current laboratory affiliation", that refers to the team of research, i.e. colleagues and students; the second instead, the "cosmopolitan network", broadly includes all the relations the scientist had built, even in conferences, co-publications, grants, committees and alike. In fact, the acquisition of external human and social capital through the employment of researchers can play a critical role in the competitiveness of firms.

4.6 Relative importance

The literature largely debated on the relative importance of these channels, mainly in order to identify the most effective in which focus the university resources. Inside the university perspective, TTOs are usually focused on patenting, licensing and spin-offs activities: Chapple et al. (2005) referred to licensing as the "most popular mode of university technology transfer", based on the empirical analysis from Siegel et al. (2003b). However, from the industry perspective, different channels might be more important.

Starting points are various contributions which indicate that patents, independently from the TTOs' approaches, are of lesser importance and smaller entity in respect to other channels like contract research and joint research programs (D'Este and Patel, 2007). Link and Siegel (2005) stated that the firms' willingness to license technologies even before the patent application (if patented at all) suggests that the importance of patents is "often overstated". Patents, in fact, represent inventions that may or may not be transformed into a commercially viable innovation: only a portion of the university innovation output, once compared with what can be transferred by other means to the market. As a matter of fact, a consistent share of university research activities focus on basic research which outcomes cannot be patented (Fritsch and Slavtchev, 2007); the main university activity, in fact, is focused on publishing articles in scientific journal, a transfer mechanism recognized for its relative inefficiency Rogers et al. (2001).

Balderi et al. (2007) reported instead a relative increase of the effort directed toward spin-offs, with respect to the resources devoted to licensing activities; they are preferable, due to their ability to generate more revenue than licensing and visibility than grants (Rasmussen et al., 2006). However, the extent and the scope of their impact on the society is intimately connected to their business models and products: they may represent an expensive choice in terms of time, human and financial resources, with a high opportunity cost if compared to other alternatives. Moreover, patent licenses and spin-offs do not represent a stable source of income.

While codified output seems not so important, collaborative and contract research appear to be more important channels (Bekkers and Bodas Freitas, 2008); along with consultancy, they account for the largest part of technology transfer activities (Muscio, 2010), more frequent and highly valued (D'Este and Perkmann, 2011). As an example, Rasmussen et al. (2006) reported that a consistent part of the departmental R&D is already "carried out in close co-operation with firms" who will later commercialize the technology. This perspective is linked to Link et al. (2007) who found that tenured faculty members spend about the 24% of their time seeking for grants, which can be effectively substituted by private funding in the form of research collaboration and contracts.

Similarly important are also employment, researcher mobility and personal contacts (Bekkers and Bodas Freitas, 2008). In fact, interviews conducted by Siegel et al. (2003a) reported personal relationships more often than contractual ones; elsewhere, Sohn and Lee (2012) considered university spillovers a “disproportionately large source of technology transfer” referring to informal knowledge exchanges typical of a Marshall’s district perspective. Lastly, Link et al. (2007) suggested the potential prevalence of informal technology transfer, thus the need for its comprehension.

4.7 Barriers

Comparing the relative effectiveness of each technology transfer channel, a larger and more precise perspective can be obtained through the consideration of the various barriers which can obstacle, slow down or reduce the effectiveness of the process. These barriers can be categorized intp three different types: cognitive, as in the distance between “open science” and entrepreneurial academic mindsets, as well as between the institution and firms; the lack of a supportive environment, including ad-hoc supporting mechanisms; the characteristics of the research outcome, the technology field and market needs, and the distance between them.

4.7.1 Cognitive distance

The cognitive distance is a broad concept, which generically defines the difference that actors perceive between themselves. In the specific case of the technology transfer among different types of organizations, the cognitive distance refers to the difference in cultures, missions, objectives, activities, methodologies between firms and researchers. This difference may present itself in various forms and in different context.

One of the largest differences is perceived between the nature of the university research and the industry needs and interests. Muscio (2008) linked this distance to the diversity in “research methodologies and in the use and interpretation of knowledge”; in fact, his interviewees in the industrial environment indicated the academic research is “too advanced”, with little or no practical value. Similarly, Gilsing et al. (2011) described the problem as a “scientific knowledge being too general to be useful”, too theoretical and rooted into the science-based regime. Muscio and Pozzali (2013) evaluated this distance as significant on the intensity of interactions (13.2% for step, in a 5-point linkert scale) but apparently with no effect on the probability of the establishment of a relationship.

Apart from the different views on the role, type, and importance of knowledge, firms and universities also lack an appropriate mutual understanding when it comes to the respective norms, environments, expectations, objectives, priorities (Siegel et al., 2003a; Link and Siegel, 2005; Muscio, 2010). Potentially leading to a conflict of interests, this misunderstanding represents a true cultural barrier, that limits the interest of industry in academic research and the university involvement in the technology transfer. A first example is the need for academics to publish research outcomes versus the fear of information leakages and spillovers for firms (Gilsing et al., 2011).

Siegel et al. (2007) approached this topic by analyzing the different objectives of the three main agents involved: scientists, technology transfer officers, and firms/entrepreneurs. Academics seek technological and knowledge breakthroughs and a rapid dissemination of their results; TTOs and administrators try to valorize the intellectual property portfolio while safeguarding the academic environment; firms seek to commercialize technologies to reach a competitive advantage, ultimately seeking a profit gain. Independently from being compatibles or not, these differences are perceived as an obstacle, thus impeding the establishment of new relationships and new flows of knowledge.

An example arises from the concept of innovation speed, defined as the elapsed time between an initial discovery and its commercialization. A shorter lag between the two events implies a greater ability to leverage research-related assets, to amortize the project costs and experiment with a greater number of ideas; in other words, it results in a greater innovativeness and efficiency, thus a sustainable competitive advantage (Markman et al., 2005). However, even if managers stress the importance of a faster time to market and the first mover advantage, the entire process of technology transfer is reported to require truly long periods: Heher (2006) evaluated the delay in the knowledge value chain in 6 to 10 years. Link and Siegel (2005) suggested as roots of this issue the low responsiveness of universities to the need of firms, even if exist a premium price for a faster transfer (Markman et al., 2005).

Considering the single research institution, a cognitive distance can be found between the open, science-based approach and the need for commercial activities, both for funding and a greater impact on the society. Examples are the issues found by Baldini et al. (2007): lack of time, i.e. due to teaching and administrative role; information-related problems, i.e. a scarce knowledge of the national and the university patent regulation and the lack of business experience; cultural issues, as the fear of opposition within the campus. Moreover, Jensen et al. (2003) reported that researchers may not disclose because they do not want to engage later transfer activities, otherwise necessary to the commercial success of the endeavor, a requirement for about the 71% of inventions licensed.

An example of this issue is the problem of invention disclosure: as previously stated, various authors discussed how researchers fail to report new technologies and inventions. According to Jensen et al. (2003), TTO directors believe that only half of inventions with a potential market are disclosed, thus making the disclosure eliciting “one of the major problems”.

Similarly, a distance resides at the administration level of universities, as a tension between the various missions of the institutions. Specifically, Guerrero et al. (2014) cited the collegial structure and the typical decision-making pattern as common constraints. An example is the attitude toward surrogate entrepreneurship: many institutions show an aversion to externalizing the exploitation activity, due to lack of supporting evidence and positive cases, experience, information, uncertainties about the process and a reluctance to recognize the value of an external entrepreneur to the university activities. Franklin et al. (2001) suggested that surrogate entrepreneurs may be “at odds with the current way of thinking”, bounding the university to a more usual, but potentially obsolete, process design.

4.7.2 Supportive mechanisms

The cognitive distance among universities and firms can be effectively bridged by an appropriate set of supporting policies and mechanisms. However, many authors have found issues also in this topic, distancing actors instead of getting them closer: the very organization, through its bureaucracy and inflexibility, act as a barrier to the technology transfer (Siegel et al., 2003a). Moreover, inefficiencies of administrations and organizational procedures (Baldini et al., 2007) suggest that the very “key impediments tend to be organizational in nature” (Siegel et al., 2007).

The center of this organizational issues can be identified in the TTO. Even if it was initially conceived as a facilitator, its position and the usually restricted availability of resources and personnel pose a threat to its activity. First of all, TTOs must balance the different objectives of the central administration and academic inventors (Jensen et al., 2003), which can be incompatibles rather than different, as previously stated. TTOs also have internal agendas, especially regarding the external context, which includes in example the need for the build of a solid reputation in the industry, eventually shelving some under-achieving inventions in contrast to the interest of administrators and academics (Siegel et al., 2007).

Potential issues regarding the TTO participation eventually refer to an underperformance due to a lack of human and financial resources. Examples are: lack of the time necessary to engage disclosure eliciting activities (Siegel et al., 2007); lack of officers that can effectively assess the commercial potential of projects, and a more generalized lack of business knowledge and experience (Hertzfeld et al., 2006); lack of employees specialized in the patent process (Baldini et al., 2007), its speed and costs (Fini et al., 2009); difficulties in identifying and securing contacts within industry, along with business representatives (Markman et al., 2005) and suitable partners (Muscio, 2010).

It is also important to note that a low performance or an improper behavior, i.e. inflating the commercial potential of a patent, affect both the firms’ and academics’ willingness to cooperate with TTOs, through a loss of credibility and reputation. Similar issues usually result in the attempt of firms to by-pass the office and deal directly with the academic scientist (Link et al., 2007), leading to an unbalanced settlement. In fact, Baldini et al. (2006) referred to a low bargaining power that European universities might have in respect to industry. Lastly, the presence and active participation of TTOs is still considered fundamental to the engagement and the success of the transfer (Muscio, 2010).

Other issues on the supporting mechanisms topic may arise from various policies adopted by the university administration. The most cited are the insufficiency of reward for academics, both pecuniary and not (Siegel et al., 2007), especially for the royalty scheme of licensing revenues. Similarly, largely discussed have been other policies, as incentives, staffing and compensation practices (Baldini et al., 2007), the presence of a clear collaboration policy and a patent policy internal to the university (Muscio, 2008; Muscio, 2010; Muscio and Pozzali, 2013), for the resolution of dispute with firms (Belenzon and Schankerman, 2007), and more generally for knowledge and relation brokerage. Other areas of possible intervention are formal and informal activities of information among researchers: outside the US, national and internal patent policies are still fairly unknown to academics (Baldini et al., 2006).

A last important strand of support mechanisms refers to the financing issue: the lack of financial sources and resources has been repeatedly reported as a problem, in various shades: low incomes due to small markets for new ventures (Pérez and Sánchez, 2003) seed and venture capital (Rasmussen et al., 2006), governmental programs (Muscio, 2008), for joint research projects (Muscio, 2010), and generic industry funding (Muscio and Pozzali, 2013).

4.7.3 Compatibility and complementarity

Other authors focused on the characteristics of the research outcome, the technology, and the market. As a starting point, Tijssen (2006) found empirical support for significant differences among knowledge fields, while evaluating the university-industry cooperation intensity and outcomes. Indeed, the complementarity and compatibility between academic research application are of fundamental importance (Geuna and Muscio, 2009).

The first element to analyze is the field of research which generate the new knowledge or technology. In the largest perspective, the main difference is between basic and applied sciences (D'Este and Patel, 2007), especially when it comes to the selection of a channel for the technology transfer: as previously stated, some channels are more suitable than others for transmitting basic knowledge (publications, consulting, cooperative research) while others aim to the transfer of a more applied technology characterized by a higher readiness (licenses, spin-offs, contract research).

Similarly, another important difference separates codified and tacit knowledge, exemplified in two major fields: natural and social science (Audretsch et al., 2004). Again, the type of knowledge involved affects the channel of choice, preferring more direct and participative mechanisms for tacit knowledge, i.e. spin-offs and cooperative research. Tacit knowledge may also limit the very geographical extent of potential university spillovers, by the need of oral communication and reciprocity, while influencing at the same time the location choices of firms.

Lastly, significant differences arise also between disciplines and faculties: many authors investigate the influence of an engineering department, rather than a medical school or biotech, information technologies and advanced materials (D'Este and Patel, 2007), especially when evaluating the overall TTO and university performances. Eventually, the most significant disciplines are included in the so-called "science-based technologies", in which the importance of the underlying scientific knowledge can be attested through the high frequency it is referenced (Debackere and Veugelers, 2005).

While the research field may determine the relative availability of a technology to transfer, the technology characteristics and its industrial field of applicability will influence the level of interest of firms and the probability of a successful transfer. Among the many perspectives that authors have taken, 3 contributions have been considered particularly interesting.

Firstly, Shane (2001) found 4 significant variables while determining the impact of different technology regimes, especially in new firm formation. First, the age of the technology field: younger fields favor new, flexible and adaptive organizations, while larger firms find the market too small to justify their investments. Secondly, the market segmentation: the more segmented and the more specific the market niche, the more favorable it will be for small firms. Third, the appropriability and the protectability of the new technology. Fourth, the need for complementary assets in order to build a competitive advantage, which may overcome a problem of low appropriability of the technology itself by making harder the imitation of new products.

Apart from influencing the rate of new firm formation, as intended in the original research, these relevant technology characteristics also influence both the channel that will be used and its performance. In example, younger fields with less scientific publications may prefer channels that allow the flow of tacit knowledge, directly from the academic to other human resources; a lower level of appropriability instead will push firms toward contractual forms, where their interests and activity can be covered by a non-disclosure agreement and alike. A greater market segmentation can favor the establishment of new academic spin-offs, while universities can provide little financial and industrial support, limiting the success probability of internal spin-offs in fields with a higher need for complementary assets.

On a similar topic, the second contribution of Bekkers and Bodas Freitas (2008) aimed at clustering technology attributes and linking them to different transfer mechanisms, eventually identifying six different groups. The first encompass pure scientific outputs, especially publications, students and other informal contacts, to be preferred for fields in which knowledge is fundamental, mainly codified and interdependent. The second group is centered around the labor mobility when knowledge is more tacit in nature. The third group include collaborative and contract research, for codified, systemic and interdependent knowledge to be transferred to large firms. The fourth refer to more formal and direct contacts, i.e. through alumni and professional organizations, especially useful for social science. Similarly, the fifth group of specific, narrow activities organized for academics should be preferred for systemic and interdependent knowledge. Lastly, patents and licensing are more suitable for interdependent knowledge with an applied nature.

Nerkar and Shane (2003) focused instead on the impact of the nature and level of industry concentration, specifically to the spin-off channel. They observed that while the ownership of broad patents on radical technology may positively affect the success of the spin-off, a high industry concentration may inhibit the survival of new firms. Thus, the higher probability of success relies on a more fragmented market, where the concentration and the level of competitiveness are moderated by the size of the market.

Other relevant technology and industry variables are: the rights of the licensee or contractor on the technology, the time to market, the presence of know-how associated with the patent, regulations, residual lifetime of the innovation, the presence of an established industry standard, ability to defend from imitation(Balderi et al., 2010). Lastly, Geuna and Muscio (2009) also considered fundamental the composition and structure of the local industry and the existence of a critical mass of firms.

4.8 Recap

Chapter 5

Policies and evaluation

Improving the performance

The previous chapters described both the ends of the transfer process, university (Chapter 2) and industry (Chapter 3), as well as the channels that connect them (Chapter 4). However, the technology transfer can also be seen as an organizational process, performed by every institution part of the knowledge chain. The process perspective entails the need for its management and control, to foster its performance: fundamentals are the evaluation and the design of policies aimed to improve its efficiency or effectiveness. These issues arise a greater significance in a private environment, as Chapter 6 and Chapter 7 will later highlight and discuss following the same approach.

5.1 Evaluation

Before the various policies implications and suggestions, it is useful to consider the evaluation of the technology transfer process, along with its issues. As a starting point, the evaluation can be conducted on two different levels: efficiency and effectiveness. The former refers to the relation between the process costs and the general outcome, as in the number of patents, spin-offs, and contracts, and the revenue stream they generate; the last describe the ability of the research organizations to modify the innovativeness and the overall economic performance of its context.

While this simplified perspective may picture the evaluation as easy and straightforward, the availability of codified data and the identification of the true impact of research organizations make "the measurement of the knowledge transferred from a public research institution towards other actors [...] an impossible objective", according to the European commission (Balderi et al., 2010).

The data collection is the first issue. Quantitative and financial data are available only formal technology transfer, but even these codified information may be incomplete: in example, data on patents usually refers to university-owned, rather than university-invented technologies (Geuna and Muscio, 2009), while formal channels do not include direct transfers between academics and firms, where universities do not take part in the agreement. This issue uncovers the need for the usage of a dataset which considers both the institutional and individual levels (Wong and Singh, 2010), including activities rather than the simple outcomes.

The second issue refers to the seek for viable indicators of the organizational impact on their context. A first problem is to identify the true effects of the technology transfer on the society, including i.e. the level of innovativeness, employment, economic performance, as well as numerous other socio-economic indicators. The second problem is to isolate the impact of the single organization on these indicators from the presence and activity of other organizations in the context, i.e. other universities and public research institutions located in the same city or district. Again, a related issue is to gather data on the entirety of the phenomenon, including informal technology transfer.

Moreover, there are divergences in the literature around the indicators, especially the ones used to evaluate the TTOs' performance (Muscio, 2010). Crucial indicators identified by the European commission include: numbers of identified inventions, patent applications, granted patents, licenses and their income, the number of spin-offs and of industry-funded research contracts (Balderi et al., 2010). Other relevant variables, used by Guerrero et al. (2014), are: co-publication of scientific papers, co-invention of patents, new enterprises generated (which include, but is not limited to, spin-offs) and the increase in the rate of employment.

Should be noted, however, that similar indicators constitute only a proxy of the extent of the technology transfer activities carried on by universities (Leydesdorff and Meyer, 2010): the measurement of formal or contractual channels do not assess the entire technology transfer, nor the ratio of formal and informal mechanisms will be the same for every research organization. This is particularly true when considering the effectiveness, rather than the efficiency of universities, due to the presence of significant indirect effects of the local system and the society more in general.

Lastly, the two dimensions of efficiency and effectiveness refer to two different levels of analysis: the organizational level, as in the single institution and its internal mechanisms; and the macroeconomic perspective, to include the effects on its context, local system or other measures of choice. Similarly, in the first case results can be used to improve the internal policies and processes; in the second case, results may drive instead to suggestions for government and local policies.

Given the relative availability of shared, quantitative methods of analysis, a considerable part of the literature has focused on the evaluation of performances at a micro level, mainly using the production-function framework, especially the Stochastic Frontier Estimation and the Data Envelopment Analysis (Siegel et al., 2007). The macro-level analysis, instead, has long been restricted to more qualitative analysis, given the difficulties in comparing greatly different contexts and countries; however, the social network analysis nowadays constitutes a viable and effective alternative to the challenging evaluation of traditional constructs such as NIS, RIS and the triple helix frameworks.

5.2 Common methodologies

Most analyses of the university efficiency in technology transfer activities uses the production-function approach, which relates the outputs of the process to its factors of production. Briefly, it prescribes the construction of a best practice frontier; the distance of the institution's combination from the frontier represents its level of inefficiency or inability to maximize its output. Two different methodologies can be used to build the production function: the parametric and the nonparametric approaches.

The parametric approach requires the researcher to specify the functional form of the production function; later, parameters will be estimated through a regression. Specifically, the manual specification of the functional form is at the same time an advantage and a disadvantage of this approach: it will enable the researcher to distinguish between the interesting variables and avoid the underlying noise in the dataset, but it assumes implicitly that the selected parameters will be effectively representative of the phenomenon and will be the same for every organization. A parametric methodology often used is the Stochastic frontier estimation (SFE); two key examples are the contribution of Siegel et al. (2003a) and Link and Siegel (2005).

Siegel et al. (2003a) used eight different variables to describe the phenomenon: the number of inventions disclosed annually, TTO employees, annual expenditures in external legal support, the presence of a medical school, the status of public or private institution, the age of the TTO, the average industrial expenditure in R&D and the average annual real output growth in the university's state. They found a positive correlation of the licensing output and invention disclosed, while the number of employees influences the number of licenses but not the total income generated; the amount of legal expenditure instead is positively related to the total incomes, while slightly reducing the number of licenses. Lastly, older TTOs tend to perform better and local R&D expenditures positively influence the university output.

Notably, they reached the conclusion that deviations from the production frontier cannot be explained only through institutional and environmental factors: relative differences may also arise from organizational practices. Their contribution constitutes the very basis for any successive analysis of organizational factors previously cited discussing policies and practices at the individual, TTO, faculty and university level.

In fact, Link and Siegel (2005) further developed the model found in Siegel et al. (2003a), including two organizational variables: the percentage of licensing royalties allocated to the academic inventor, and the type of structure for describing a centralized or decentralized licensing office. The first of the two new variables, used as a proxy for the various organizational practices that favor the technology transfer, has the strongest impact on the relative performance: the higher the share, the higher the overall performance. They concluded suggesting a further development of the model to include non-pecuniary incentives, i.e. promotion and tenure policies.

The non-parametric approach, instead, does not require to specify the functional form of the production function, allowing researchers to identify best practices.

However, while it avoids similar assumptions, this methodology cannot distinguish and avoid the noise embedded in the data. The most common non-parametric model is the Data envelopment analysis (DEA), originally developed by Fare et al. (1993), usually used to compare the relative inefficiencies of universities. Two relevant examples are Thursby and Thursby (2002) and Anderson et al. (2007).

Thursby and Thursby (2002) used the DEA framework to examine the growth in the Total Factor Productivity (TFP) between four different years. Specifically, they decomposed and calculated the movement toward or away from the frontier, later analyzing the change in performance at the individual level, and the frontier shift, as the difference on aggregate results. They found a substantial increase in the propensity to patent, while the propensity to disclose reported a modest increase. Notably, they found a negative growth in licenses, which they attributed to a bias in the analysis, specifically the time lag and other university's factors, i.e. more demanding and aggressive TTOs. They also found a generalized growth in the frontier, but significant and increasing inefficiencies among universities.

Similarly, Anderson et al. (2007) used the DEA as a tool for productivity evaluation, but they focused on the direct comparison of universities. The analysis revealed a positive correlation between performance and the status of private universities, as well as the presence of a medical school; however, the regression showed a surprisingly little explanation power and statistical significant. Anyway, the assessment of inefficiency scores reported considerable high results ranging from 112.5% to 619.3%.

Lastly, Chapple et al. (2005) combined the usage of the SFE and DEA in assessing the relative performance of UK universities. For the parametric analysis, they expanded the model from Siegel et al. (2003a) including the total research income of the university, and substitute the average annual real output growth with the regional GDP per capita, with the first resulting significantly and positive influencing both the number and incomes of licensing agreements; they also found a positive effect for the number of employees. In every model, they found a substantial inefficiency: on average, universities were operating at an 18.7% of efficiency. However, opposingly to previous results based on US universities, they found decreasing returns of scale to in licensing activities.

5.2.1 Different approaches

The production-function framework is the most widely used quantitative method, but other authors took different approaches. Lee (2000), for example, provided an extensive qualitative assessment of the technology transfer phenomenon, investigating 425 different US R&D projects. Notably, he reported that in 82% of the projects is mentioned the company support, but the most frequent are the ollaborations with the federal government. He sought the relative importance of benefits for both academics and firms: in the first case, 67% of the interviewees mentioned as significant the funds necessary to support graduates, 66% the insight that can be obtained in collaborating, 56% the possibility to conduct field tests. For firms, the main benefits are the access to new knowledge and research, the development of new products (76%) and the contribution to new patents.

Resende et al. (2013) instead undertook the development of a theoretical framework for assessing and guiding the technology transfer process, the "master plan for technology transfer". The instrument contains 271 rules and good practices, referring to 32 different facilitators in 7 groups. Eventually, they describD the "Best Transfer Practices", a qualitative tool that can be employed in assessing TTOs and institutions. At its root, the tool prescribes an initial documental analysis, to identify the key actors and the main operational issues; later, strategic objectives for the technology transfer should be formulated. In a second major phase, the goal is to map the various facilitators, to identify the most relevant ones, bottlenecks and critical facilitators, and measured their correlation. Lastly, facilitators should be remapped, then the reporting of both the analysis and recommendations.

Among quantitative methods, traditional approaches based on the production-frontier framework are able to assess the individual efficiency in the usage of input resources. A major strength of these tools it the capability to incorporate both financial measures, i.e. revenues, attorney expenses and alike, and dummy variables for other major traits of the universities, which cannot be expressed by an economic measure: structure, the presence of policies etc. However, these tools lack the ability to assess one of the most relevant factors that influence the technology transfer: the external linkages of the research organization, its context and the relative importance the institution has in it.

As previously stated while discussing absorptive capacity, brokerage, social capital and other constructs, networks and the networking activity are essential to the technology transfer. To assess this aspect of the process, in latest years the literature had largely employed a tool called social network analysis. This methodology uses both information about the individual actor and its relations, intended as presence and possibly intensity, to specifically assess the network position and performance of the institution and uncover the social structure in which it is embedded (Pinheiro and Lucas, 2015). This methodology can also be used to assess the organization's efficiency, but its ability to compare the relative importance of actors among the network makes the tool best suited to evaluate the effectiveness of the technology transfer process, providing one of the few quantitative measurements available for the performance at a systemic level.

5.3 Policies

One of the goals of the aforementioned econometric analyses is to use results as guidelines for policies suggestions and modifications: in fact, many of the previously cited authors concluded with the policy implications of their work. However, since they mainly treat the micro-level of the university itself, the largest part of quantitative-driven policies suggestions refers to the university-level policies, practices and alike. These will be the first to be presented here.

To investigate the government-level policies, instead, a different approach must be taken: this level mainly refers to the efficacy, rather than the efficiency, of the technology transfer. Since the issues in its assessment stated previously, the literature focused instead on qualitative and comparative approaches to evaluate the performance on a systemic level, mainly using frameworks as the triple helix and regional innovation systems instead of the pure technology transfer process. Few other authors used social network analysis tools and narrow quantitative analyses to uncover specific trait of the process. This second level of policies will be discussed later in this chapter.

A final level of analysis, proposed by Rasmussen et al. (2006) instead seems to be overlooked: the author differentiated between top-down policies, imposed by universities administrations and government, and bottom-up policies, emerging directly from individuals. This last type of policies mainly refers to informal expectations, procedures, and instruments arising spontaneously from the academic social environment: due to the difficulties in gathering data on this phenomenon, no research seems to have been performed in this perspective. However, institutional policies regarding the organizational climate can provide a useful insight on this topic.

5.4 University-level policies

As noted by Geuna and Muscio (2009), some universities made the strategic decision to institutionalize technology transfer activities, instead of letting them be driven by individual researchers and their network. However, this decision must also involve the writing and enforcement of internal policies, in order to promote and manage these activities. In fact, Debackere and Veugelers (2005) cited as responsible for the low levels of European university-industry linkages, among issues on both sides, specific factors and incentive structures on the "science side". In this perspective, universities must take an active role in fostering academics motivation and institutional supportiveness, and policies have been considered the most important tool.

Moreover, institution-wide policies are the most suited instruments for changing and shaping the university attitude toward technology transfer: as previously noted, the traditional open science approach can be a very restraining issue; procedures, mechanisms, and specific policies can regulate single aspects of the transfer and provide support. Among other instruments, a powerful, illuminated leadership, context, and networking activities can shape the attitude toward commercialization, but policies are in fact the most widely used, easier to manage and largely researched tools for this task.

An example of their relevance can be taken from Bercovitz and Feldmann (2006): policies can bridge the open science attitude and commercialization activities by seeking a "compromise that accommodates the public good nature of knowledge spillovers while providing the property rights that are required to guarantee returns for the additional private investment required to commercialize academic research". Considering the organizational mission as one of the many policy instruments available, Debackere and Veugelers (2005) observed that the implementation of industry relations as a central component of the institutional mission can be an "especially successful" tool for improving the technology transfer capabilities and performance.

A proper management of these policies, however, is fundamental: D'Este and Perkmann (2011) for example stated that undue policy emphasis on commercial activities, usually linked to the financial need of the university, may obscure other considerable benefits that industry engagement might have on research activities, especially non-pecuniary ones. Similarly, Debackere and Veugelers (2005) reported the need to balance the portfolio of activities and financing sources, between government funds for long-term, fundamental research and industry financing for applied, short-term research.

Another potential failure of these policies refers to tacit knowledge and informal transfer channels: according to Muscio (2010) in this case management policies "can achieve little" in fostering informal transfer, especially considered the higher difficulties in assessing and evaluating the commercial value of this kind of knowledge.

5.4.1 General policies

The first strand of policies has as its subject the entire organization, encompassing every office, faculty and researcher, through a range of mechanisms oriented toward two different objectives. The first is to foster the development of an entrepreneurial climate at the organizational level, i.e. through TTOs, procedures and policies for the IP management, engagement with industry partners etc.; the second refers to a set of human resource practices to intervein at a more individual level, like entrepreneurship education programs, mentoring and the enrollment of individuals with relevant expertise to act as role models (Guerrero et al., 2014).

To foster the entrepreneurial climate, Klofsten and Jones-Evans (2000) suggested the creation and maintenance of a proper organizational culture, along with the provision of separate courses for entrepreneurship and training programs. In fact, the main use for intervening at the organizational level is to modify the perception that researchers have of the environment, its acceptance and supportiveness for entrepreneurial activities, thus their willingness to engage such activities.

Hunter et al. (2011) investigated this perspective further differentiating among the commercialization-support climate and the boundary-spanning climate. The first case refers to the presence of a strong, oriented leadership, procedures on engaging in technology transfer and in managing relations, the creation of normative expectations of entrepreneurial activities arising from researchers. The second case instead includes practices, procedures and organizational structures aimed at fostering the exchange of information and collaboration among different teams, units and faculties. In fact, empirical results from Hunter et al. (2011) evaluated the importance of this climate. They found that an increase in the supportiveness perception lead to a 4.44 times increasing of invention disclosures, 30.57 for boundary-spanning climate.

Other critical organizational factors have been listed by Debackere and Veugelers (2005), i.e. the policy for royalty and equity distribution to researchers and the organizational role and position of the TTO, which specifically influence its ability to act as a gatekeeper or boundary spanner. Among practical suggestion they made, are the combination of basic and applied research within teams, to promote direct transfer and day-by-day proximity, the build of relationships with venture capitalists, the usage of external technology transfer organizations and consultants. Further attention should be placed on the creation, management, and monitoring of research contracts and knowledge policies.

Similarly, Guerrero et al. (2014) exposed the need for a university leadership highly committed to transforming the institution into entrepreneurial and innovative organizations. Other organizational tools may be: cross-functional research teams, the availability of positions for external and foreign researchers, alliances and networking activities with other organizations, the provision of financial capital to support the various transfer processes. Other themes from Owen-Smith and Powell (2001) are the publicity and widespread awareness of university successes in technology transfer and the status benefit ascribed to commercial accomplishment.

Building an entrepreneurial climate, however, does not influence only the individual attitudes, motives and incentives: it shapes also the organizational structure. Rasmussen et al. (2006) suggested to treat them not as separate entities, but to let culture and structure to mutually reinforce themselves, and to take advantages of the synergies. Also Guerrero et al. (2014) expressed the need for entrepreneurial organizational structures, specifically linking them to the university ability to transmit and communicate its willingness to engage in technology transfer and entrepreneurial activities to both internal researchers and officers, and to external entities.

Lastly, O'Shea et al. (2005) suggested a four-point policy roadmap for developing an organizational context that can positively influence the technology transfer: to build and maintain a commercially supportive culture; to engage active partnerships with the financial support from both industry and government; to recruit and develop academic stars; to develop a commercial infrastructure in support to commercial and valorization activities.

Elsewhere, the need for proper human resource practices arises from the fundamentality of the human capital in technology transfer processes. Many universities already have formal policies for encouraging researchers to seek industry collaborations and assignments (D'Este and Perkmann, 2011); basic examples are the preferential treatment for inventors, the provision of specific contractual arrangements and access to R&D laboratories and other university resources for any further research required by the transfer (Fini et al., 2009).

Among individual policies, a considerable part of the literature agrees on the primary importance of personal evaluation and tenure promotion policies, and their link to technology transfer activities (Debackere and Veugelers, 2005). One of the most important contributions on this topic is Genshaft et al. (2016), who made five recommendations on the topic which can be summarized as follow:

- Policy statements should acknowledge the importance of the technology transfer, but they should also regulate the relation between research, teaching activities and the third mission, including specific safeguards against conflicts of interests among activities.

- Technology transfer and commercialization activities should be included explicitly among the relevant criteria for the personal evaluation and tenure promotion; they should be assessed with enough flexibility to include many relevant characteristics of the transfer, i.e. the relative importance in various disciplines, innovativeness and effort required, using the intellectual contribution and the expected social benefit as guidelines.

- While it is important to acknowledge and evaluate such activities, it is fundamental to consider them as an optional component of the researcher performance, not among mandatory objective; Rasmussen et al. (2006) highlighted the importance of a voluntary contribution, including the freedom to publish results and the possibility to choose between commercialization and traditional research activities.

While organizational practices and policies may enable and support technology transfer, they should also sustain the individual motivation to engage these activities: the opportunity for additional incomes may be insufficient, apart from its need to be managed. Similar in spirit are pecuniary and non-pecuniary incentives for academics (Link et al., 2007), i.e. attractive individual remuneration packages (Debackere and Veugelers, 2005). However, non-pecuniary incentives as tenure and promotion policies should be preferred for policy intervention, since Friedman and Silberman (2003) found that greater pecuniary rewards are not significantly associated with higher commercialization activities.

Among pecuniary incentives, Beath et al. (2003) specifically investigated the two major alternatives that universities have for exploiting technology transfer activities as a source of income. They considered two major alternatives, specific to the channels of consulting, collaboration and contract research: overhead charges and to hold down academic pay. Four factors shape the optimal "taxation" level: relative productivity of researchers in fundamental and applied research; relative amount of time required by keeping up with the literature; the intrinsic preference for fundamental research. However, the authors individuated a rule-of-thumb for establishing the tax rate: the ratio between university wage and industry wage.

Alongside with researchers, some of these policies may be extended to students themselves: access to laboratories, financial incentives, positive impact on their academic evaluation and career and alike. Eventually, as stated by Rasmussen et al. (2006), one of the university's objectives is to "educate and support students in their commercialization efforts", by integrating commercialization into education activities and academic curricula.

Lastly, it is important to take a strategic approach in managing these different policies (Siegel et al., 2007). They must match the overall institutional goals and priorities, research fields of choices, effort in the regional development, resources allocation and similar institutional factors. However, Rasmussen et al. (2006) empirically found that university initiatives are "mainly set up to support individuals and projects already in process, while few measures are taken to motivate and stimulate the creation of new projects"; this lack may be linked to an insufficient usage of technology transfer and related policies as a strategic lever, thus an undervaluation of the entire phenomenon.

5.4.2 Patenting

Patents are considered a fundamental mean of technology transfer, because of their influence on the individuals' ability to appropriate the economic value of the newly generated knowledge and technologies (Bercovitz and Feldmann, 2006) thus their ability in bridging commercial and academics reward structures (Owen-Smith and Powell, 2001). Following the results from Tijssen (2006), university patenting output is determined by university endogenous factors, and unitedly to their relevance, these two factors eventually lead to the need for patent strategies (Siegel et al., 2007) and patent regulation.

According to Baldini et al. (2007) a university patent regulation describes: which steps the inventor have to take to patent their inventions; actors and mechanisms for relative decision making; duties and benefit for both the academic and the university; the royalty distribution scheme; which part bears the costs of patenting and control the licensing process. The presence of a similar policy significantly reduces the perceived obstacles, with an impact evaluated in a triplication of patent filled (Baldini et al., 2006; Baldini et al., 2007). Contrary to the previous forms of policies, centered on the royalty distribution formula, a more comprehensive regulation can be useful in determining organizational changes and supporting inventors: among possible improvement for technology transfer activities, it ranked third thanks to the effectiveness due to its large scope.

Another important area for policy intervention is the modality through which the TTO starts and manages the patenting and licensing process; as previously stated, an appropriate behavior of the office is a necessary condition for the researchers' attitude to disclose inventions internally instead of contacting firms directly. Specifically, Panagopoulos and Carayannis (2013) observed that in the worst case scenario, in which academics do not take advantage of the TTO's professionalized services, the difference in bargaining power between researchers and firms may lead to a considerable loss of efficiency in the overall technology transfer process.

The authors proposed indeed as a solution the institution of an "insurance" for proceeding through institutional channels, specifically the TTO: this insurance, that can be both pecuniary and not, should be granted on disclosure, and to guarantee the researcher some return in case the licensing fails to take place. To establish its amount, administrators and TTO officers should compare the expected payoff, for both the university and the researcher, to the probability of licensing, possibly adjusting it iteratively through learning by doing.

The obvious necessary condition for these two, as well as any similar policies, is the diffusion of information among researchers about their existence. In fact, the same can be stated for any of the potential benefits of technology transfer activities, given the previously cited empirical demonstration of the misinformation surrounding this phenomenon.

While there is a need for the establishment of relationships with industrial actors (Baldini et al., 2007), there seems to be a lack or misalignment of strategic choices in technology transfer policies. For example, Phan et al. (2005) reported that the most attractive combination of technology development stage and licensing strategies for industries is at the same time the least likely to be favored by universities.

Lastly, it must be reported that, according to Leydesdorff and Meyer (2010), patenting activities in the most advanced economies are decreasing since the 2000s; the authors suggested that the motivation may be the disappearing of institutional incentives to patent, due to the changes in the evaluation and ranking procedures for universities.

5.4.3 Spin-offs

In respect to the patenting and licensing process, spin-off activities require a larger involvement of researchers and inventors, which in fact are the ultimate responsible for the success of the process. Therefore, a different set of policies should be deployed, specifically focused on the training and supporting of these academic entrepreneurs.

A first area for policy intervention is the so-called "knowledge gap" for new ventures, defined by Lockett and Wright (2005) as "the difference between the knowledge endowment of the start-up and the knowledge it requires to succeed". In other words, spin-offs may lack certain knowledge resources, as in business and market knowledge, networks and relationships with industry partners and alike, that may jeopardize the probability of success. Therefore, the first objective for policies should be to bridge this gap, through the development of an appropriate culture and infrastructure, active partnerships with industry and government, the recruiting and development of star scientists.

These activities might be confused with those previously cited as general policies for shaping the attitude of researchers toward industry and commercialization activities; however, in this case the intensity and scope of the intervention must be greater, to urge academics to embrace entrepreneurship and start their own ventures.

More specific policies may regulate the spin-off process, i.e. steps to take, rules for decision making, financial contribution, surrogate entrepreneurs and alike (Franklin et al., 2001), and the relation between the new venture and the university, as in the access to university infrastructures and laboratories, and the licensing of university-owned technologies (Fini et al., 2009). Other policies may institute business plan competitions, university incubators, science parks and venture funds. Siegel et al. (2007) specifically cited policies for supporting the building and maintenance of a network of peer scientists, which may significantly influence the performance of the spin-off. Lastly, these policies should include also students as possible entrepreneurs.

5.4.4 TTOs

TTOs and their management are another major strand of policy intervention of universities. Their position in brokering relations and technologies make them essential to the technology transfer process, but they have to be managed properly in order to achieve a good performance both in efficiency and effectiveness. In fact, they can undertake their central position as facilitators, as originally intended, or as bottlenecks in the process (Siegel et al., 2003a; Geuna and Muscio, 2009).

Litan et al. (2008) studied this issue using a historical perspective. They linked the creation of the first TTOs to the Bayh-Dole act, in which they were not originally intended: they rather arose to cope with the increasing demand for specialized services in commercializing universities' technologies, thus acting as facilitators. Over time, however, two series of university policies encouraged their shifting to bottlenecks: the most relevant example is the type of policies that concentrated on maximizing revenue streams, rather than maximizing the volume of innovations transferred, giving them the direction toward bottlenecks. Secondly, the institution of TTOs as university monopolies on the commercialization activities gave them the ability to assume the role of gatekeeping, thus enabling them to become bottlenecks.

Nowadays, this issue can be found in the kind of incentives TTOs' officers are subjected to: their rewards are usually linked to the gross income of the office, implicitly suggesting to prefer patentable and patented technologies, with known potential licensees to which grant exclusive rights. While this kind of management might seems flawless in a competitive, open market, the profitability of the technology transfer is not the only objective and mission of both the office and the administration: these policy do not consider the impact extent of innovations and open science incentives, i.e. publication and diffusion objectives, failing in motivating academics to disclose and transfer.

Litan et al. (2008) in fact advocated for a decentralized and more specialized organizational structure for TTOs, which should further the institutional entrepreneurial culture, increase the involvement of academics, leading to a higher performance due to the rising specialization. Moreover, they suggested other management models as alternatives: the concurrent usage of external agencies, among which the researcher can choose; the externalization of TTOs' functions to regional alliances, if properly managed; to use internet-based matchmaking tools; to automatically assign any intellectual property right to the faculty, making them more responsible for commercial activities.

Another area for policy intervention is the role and participation of the TTO: its supportiveness is determined by the stock of financial and human resources at disposal (Siegel et al., 2007). The demand for skilled and competent resources can be undertaken by proper policies intended to attract and remunerate appropriate human resources and capital (Rasmussen et al., 2006).

Apart from skilled, TTO's staff must also be specialized in different areas (Guerrero et al., 2014): lawyers and managers with previous experience in both industry and academy, preferably former researchers (Debackere and Veugelers, 2005), with satisfactory marketing and negotiation skills (Siegel et al., 2003a) and generally wide commercial skills (Siegel et al., 2007), who are also able to significantly contribute to the university networks with their own social capital (Geuna and Muscio, 2009).

5.5 Institutional-level policies

As previously stated, the technology transfer phenomenon has a deep geographical connotation, both as proximity to other actors as well as the institutional and economic context the organization is embedded in. As examples, the geographical proximity enables a more direct communication among organizations, which allows an informal flow of knowledge and foster the performance of any channel; location choices also largely influence the pool of potential partners and the probability of establishing a successful relationship, let alone incentives from the local government, taxation, etc.

In a general perspective, the existence and the effect of a functional relation between organizations and their context have been studied since the Marshall's cluster theory, published within Principles of Economics (Marshall, 1890). Every school of economic thought has added its contribution on the phenomenon, considering different angles and perspectives, especially on the role of national government, local institutions and their legislative activities.

However, it is not the aim of this work to present and discuss a literature review on this specific but wide theme. In what follows, will be presented some of the most important concepts on the topic, in the perspective of understanding what matters the most for the technology transfer processes.

5.5.1 Geography does matter

Apart from its value for the technology transfer, geography is fundamental to the very innovation process itself (Asheim and Gertler, 2009). Proximal partners, which belong to the same context, should share a common language, code of communication, conventions and norms, possibly intra- and inter-organizational routines. Similar factors facilitate the exchange of knowledge, especially if tacit, and socially organized learning processes, which constitute the most important basis for innovation-based value creation. This is the source for the importance of innovative clusters: only a firm embedded in this context can take advantage from the region's unique endowment.

Moreover, clusters tend to specialize by industrial sectors, therefore by the knowledge base, which should be similar among embedded actors, further enhancing their mutual absorptive capacity. Agglomeration of actors and knowledge is even more important in the case of tacit knowledge, which require mechanisms as the learning by interacting, exposing the relevance of a common context. In fact, characteristics required for an effective technology transfer are highly space and time-specific (Asheim and Gertler, 2009).

Florida (2002) made a relevant example of how the context and its attributes deeply influence the kind and the performance of knowledge-related activities. He started from the concept of the creative class: a workforce of creative professionals and knowledge workers, which demonstrated themselves as increasingly fundamental for both corporate profits, economic growth and social development. In his book, the author showed that while firms' location choices are influenced by the presence and extent of this working class in the local context, the creative class's location choices are determined primarily by the openness, the diversity and other social factors of the region. Thus, the significant impact of the context on economic and knowledge activities, plus the need for local and national institutions, as well as the individual firm, to actively and effectively manage the cultural trait of the context.

Yokura et al. (2013) instead used the social network analysis as a different approach to uncover the relevance of the geographic specialization; specifically, they analyzed the japan innovation system, along nine regional blocks of technology specialization in six different technology groups. Notably, they found that the spatial reach of R&D networks is different for each field, but over the 50% of them are limited at 100kms, regardless the domain. They also suggested that intraregional and interregional R&D relationships are both important, but for new and smaller firms shorter distances are crucial, thus the location choice of establishment. In this perspective, also peripheral universities may have a prime role in technology transfer, not as producers but as a provider of skilled labor and as a knowledge provider, an antenna for new technologies developed elsewhere.

Similarly, Azagra-Caro et al. (2010) focused on intra- and extra-regional university-industry cooperation, by investigating the relation between firms' absorptive capacity and universities' R&D activities. They found that an increase in the first will increase firms' participation in the regional university-industry interaction, while an increment of universities activities will strength the extra-regional collaboration. The authors suggested that the maximization of university-industry interactions, along with technology transfer activities, might be in contrast with local development policies.

Relevant is also the regional economic structure and organization, which has been found by Agrawal et al. (2014) to have a significant impact on innovative performance. They suggested that the contemporary presence of at least one large research laboratory and a "sizeable" population of smaller laboratories and satellite firms may, in fact, increase the regional innovation productivity. In fact, the authors empirically evaluated this effect in a 17% increase of citation-weighted patent count per inventor, and a 28% increase of spin-off formation. Specifically, a larger research center should expose a greater number of "misfit ideas" in respect to the main activities, thus producing more spillover and spin-offs, competitively fitted for a context constituted by a large population of small firms.

Lastly, policy attempts to artificially establish a cluster, a district or a high-tech region require a significant effort, both in financial resources and in time. As an example, the North Carolina's Research Triangle Park required 50 years to realize valuable economic benefits (Bercovitz and Feldmann, 2006). However, there are different policy objectives that institutions can achieve to in shorter spans, to improve the performance and competitiveness of regions: human capital, organizations and institutions, investments in R&D, industrial structure, and 'sequences' (a chain of events ignited by a unique public investment) (Niosi and Bellon, 2002). Moreover, Heher (2006) observed that similarities in performance among different countries and cultures suggest that the innovation process might be similar whatever the environment; this should imply that also governmental policies among countries may share strategies and tools.

5.5.2 Short-term policy objectives

There are many narrow and selective policy interventions that institutions can make to improve local systems in the short term, actions that are considered essential nevertheless. Tijssen (2006) found in fact that the patent intensity of universities, the ratio between patents and publication productivity, representative of the overall commercial performance, are indeed determined by exogenous factors: domestic policies, regulatory frameworks, support systems. A relevant example is the case of SMEs in university-industry cooperation.

SMEs mostly present a passive attitude toward technology transfer, especially the acquisition of external technologies (Yusuf, 2008). However, Zeng et al. (2010) noted that government policies "can be effective only when they focus on the need to promote cooperation between SMEs and innovative partners": it is necessary, anyway, for policies to create and promote a favorable context for cooperative projects and technology transfer in general. An alternative is to establish or enforce different forms of intermediaries, i.e. consortia and technology transfer centers.

Similar in spirit are policies aiming to increase the amount of R&D expenditure of local firms. As previously stated, internal R&D activities are fundamental in fostering the firm's absorptive capacity, as well as generating spillovers in favor of the local economy and community. Fritsch and Slavtchev (2007) investigated the extent of the impact of local R&D activities on the innovative performance of the region; using the number of employees, they found a strong correlation coefficient with the number of patents (0.73). Moreover, their empirical results strongly suggest that the geographical proximity to the university significantly influence the R&D employment, with an elasticity between 0.22 and 0.17 in a radius of 50kms, falling to 0.07 between 50 and 75kms, a distribution that has a "remarkable degree of correspondence" with the university's external funding. Policies suggestions in this cases include the fostering of private R&D, urging universities to seek for external funds, to favor the spatial concentration of firms.

Another issue frequently reported by universities is the funding of university's commercial endeavor. The financial support from national governments is important, but there is a widespread believe in the economic literature that a more competitive and diversified funding might in fact further the university's willingness to engage in technology transfer and commercial activities (Rasmussen et al., 2006). On the other hand, policies should also consider the relative importance of financing intermediaries, i.e. venture capital funds, which have proven themselves as "particularly helpful" for both funding and business knowledge they can provide to spin-offs (Yusuf, 2008).

On the topic of business knowledge, Chapple et al. (2005) also suggested that policymakers should also intervein in guarantying the availability of appropriate human resources. This purpose that can be partially fulfilled also by public policies fostering the employee mobility (Franco and Filson, 2006), which eventually lead to a greater technological diffusion and knowledge exchange, both regarding scientific discoveries and business experiences and methods.

Fini et al. (2009) summarized the different mechanisms that local and national institutions have to support the innovative context: financial development (VCs, institutional funds etc.); specific entrepreneurial support services (training, loans, physical infrastructures and direct services); and the local industrial composition (providing networks and related services). They also pointed at Bayh-Dole type legislations and similar reforms as fundamental.

5.5.3 RIS, NIS and triple helix

For more long-term policies for innovation-based economic activities, the literature based its suggestions on the concepts of regional innovation systems and the triple helix. The first refers to a more static perspective of the phenomenon, while the triple helix focuses more on a dynamic view.

The regional innovation system can be defined as the "institutional infrastructure supporting innovation within the production structure of a region" (Asheim and Gertler, 2009). Starting point is the previously stated tendency of regions to specialize their economic activities in a relatively narrowed knowledge base, exhibiting a path dependency that bonds local organizations and institutions. Therefore, the regional competitiveness could be enhanced by promoting stronger relationships at a systemic level, both between organizations and between them and the region's knowledge and institutional infrastructure.

The literature proposed different definitions for the RIS; the simplest incorporates universities, public and private research institutions, private organizations and firms, local government. A broader definition instead includes "all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring" (Etzkowitz and Leydesdorff, 2000). Moreover, Asheim and Gertler (2009) distinguished between three different types of RIS: the first is the territorially embedded regional innovation systems, in which innovation activities take place mainly in firms with low cooperation with knowledge producer. Secondly, the regionally networked innovation systems, where the emergence of the system meet stronger policy intervention and institutional planning. Lastly, regionalized national innovation systems are driven by and integrated into the entire national innovation system, with the highest degree of policy intervention.

More dynamic is the triple helix framework, which expands the RIS concept to its evolution over time. The model is based on same three institutional spheres: university and research organizations, industry and government. Again, actors are characterized by their function, as in their set of competencies and roles in the system, and are connected by various kind of relationships: technology transfer, collaboration, networking activities. However, the triple helix suggests that the equilibrium and the connections among actors are dynamic: in the evolutionary perspective, institutions are a "co-evolving sub-sets of social systems that interact through an overlay of recursive networks and organizations, that reshape their institutional arrangements through reflexive sub-dynamics" (Ranga and Etzkowitz, 2013). In other words, the social dynamics underlying the innovation systems autonomously adapt to the circumstances, constituting an evolutionary mechanism that leads to institutional transformations (Etzkowitz and Leydesdorff, 2000).

The RIS and the triple helix frameworks can be used to picture the objective that governmental and local policies should aim to: a system in which the driving force for collaborative activities is indeed the expectation of profits, but moderated by utility functions and proper opportunity structures (Etzkowitz and Leydesdorff, 2000). Building blocks should be the technology innovation, which provides the variation necessary for the evolution, as its engine; markets, which should be the prevailing selector for survival; and institutional structures to provide the control system, as guidance. The resulting system should favor the collaboration and conflict moderation, especially through collaborative leadership and substitution between institutional spheres, and leave room for uncertainties and the change process, without necessarily seeking to resolve the tension among different roles (Ranga and Etzkowitz, 2013).

5.6 Recap

Chapter 6

Different approaches

U-I versus B2B

To describe the university-industry technology transfer, the previous chapters reviewed selected topics from the literature, including: the academic environment (Chapter 2), the industrial counterparts and other receivers (Chapter 3), the various channels that bridge the two realities (Chapter 4), the evaluation and policies (Chapter 5). Following the same outline, this chapter will decline the university-industry framework in a business-to-business approach, pointing out the differences in perspectives. This analysis will be later used in Chapter 8, as a baseline for the discussion of the case study and to draw the conclusions.

6.1 Introduction

As previously stated, the largest part of the aforementioned authors focused on the technology transfer between university and industry. In example, many of them longer discuss the university open science approach, the scientists' willingness to engage transfer activities, the best management practices for the transfer performance of a university. Thus, the literature covers almost any issue of an otherwise very specific topic: a scenario in which the only knowledge producer, repository and distributor is the university, a scenario clearly and fundamentally characterized by the various characteristic of this kind of institutions.

In the modern knowledge economy, however, universities are not the only sources of knowledge and technologies: other research organizations have emerged as relevant and competitive alternatives, i.e. public and national research centers, publicly-funded and non-profit research organizations, private development firms, etc. These are only examples of the large ensemble of organizations that the complex economic landscape has generated, but helpful in exemplifying how restrictive can be to consider only universities.

Therefore, the question is whether this narrow focus of the literature jeopardizes its effectiveness when analyzing and modelling other types of private entities. More specifically, the issue does not refer to the applicability itself of the technology transfer literature to private agents; it relies instead on the identification of factors and constructs that should change and what instead can be held constant, to successfully use the previous literature in a different environment.

Has to be noted, in fact, that universities and private research organizations do share a major behavioral trait: even if with different extent and modalities, they both perform research and development activities, and both try to valorize their results through commercial activities. By and large, academic and private scientists are driven by similar motivations and objectives; exploitation activities follow similar paths; their management may encounter the same issues and make use of similar tools. However, private organizations do have very different and narrower priorities, and can take advantage of various instruments not available to public organizations.

In this chapter the topic will be analyzed by focusing on the differences between paradigms. Following the same structure of the literature review, in each section will be drawn a comparison of actors, channels, evaluation and policies. For practical purpose, except where explicitly mentioned otherwise, the basis for comparison in the private environment will be a completely private organization, mainly involved in applied research. At the same time, the university side of the comparison will be expected to show at least a minimum entrepreneurial activity among all channels.

6.2 Actors

6.2.1 The institution

Private organizations and universities do share some traits: both are structured institutions, which make use of units or teams of researchers to generate new knowledge. However, the activities they perform might be very different: universities, especially the public ones, mainly focus on basic research with an open-science approach; private firms instead may need to focus on more practical research, centering their business models on requested, on-demand R&D services.

In fact, private research organizations are characterized by a different organizational culture. They may borrow a few traits from the open-science approach, but they also rely on the excludability of their research results, through instruments as patents, copyrights, NDAs and alike. While they may perform basic research and publication activities, these will not overcome the relative importance of knowledge exchanges for a financial reward. Private organizations have not the historical baggage of universities, thus the acceptance of an economic model for knowledge production and share comes with less difficulties in respect to the academic environment.

Research firms also lack one of the three academic missions: teaching. Specifically, teaching and training activities are still present, i.e. the offer of collaborative Ph.D. programs, trainings and apprenticeship. However, these are not a core element of the business model; instead, students might be seen as a human resource, with significant specialization but no experience. Moreover, these activities might be a requirement to access to local or European research grants, i.e. through policies that aim to improve the skill and competencies set of the local workforce.

The research activity, as in the basic science approach, may also be required by the context or be included in the main business model. In the first case, related research grants and networking activities based on the open science system may be necessary to sustain the organization, through funding and relationships in various kind. In the second case, the firm might recognize the basic research as a distinctive and advantageous activity, to perform in order to build a stronger knowledge base, thus a greater competitivity in the research market. In this case, the objective is to manage at the same time short- and long-term objectives; potential ground-breaking patents might also be an incentive.

However, the largest part of research activities should be expected to be tightly linked to the commercial endeavour, represented by the third mission in an academic environment. In this latter case, the economic literature has pictured it more as development and a distinct activity from research, but in the case of a private organization that survive by selling its research outcomes, the boundaries are less clear. In the traditional academic approach in fact, the commercial activities are profitables, but accessory to the research, pillar in which autonomously and independently generated ideas and prototypes are brought to the market.

In a private environment, the relative importance is inverted: leading activities are commercial in nature, especially development, while research is more of an internal service, functional to the ability of realizing and delivery a product or service. This difference can be seen in the driving force for the research activity: academics choose to investigate a topic according to their interests, personal agenda and funding opportunity. Firms' research, instead, is driven by the needs that the organization spotted from the market. These institutions usually work on commission, or sell discoveries to the highest bidder.

This different perspective pushes the private organization to focus mainly on appliable knowledge fields, transferring the choice from the individual to the institutional level. However, the duality of basic and applied research, and their relative approaches, has to be manage also in the private environment. Eventually, researchers have the strongest expertise, thus the ability to successfully predict the next shift in the industry their work refers to: it might be useful to weights the market pull and the force from the technology and knowledge field, bringing together the research and the commercialization pillars.

This issue is strongly connected to the differences in the funding sources among the types of organizations. Universities mainly relies on public funds, block and research grants, from private, local, national and European institutions; the usage of industry funds instead is limited in its extent. These funds are mainly directed toward research and teaching activities.

Private organizations once again invert the relative importance of their funding sources. They might also use public funds and grants, but their size implicates the need to raise other, substantial funds elsewhere: the market. Private research firms are required to gain funds through research and development services, as in research contracts, cooperative research, consulting. Therefore, the need for competitive business models, a flexible organization, and the responsiveness to the market needs.

Also the organizational structure and the internal processes should be properly configured. Firstly, commercial exploitation of research outcomes is no longer an emergent activity, relying on the individual attitude and willingness: it should be institutionalized, mandatory for research positions. The organizational structure instead should include a commercial structure, among which a TTO, legal and financing office, a marketing function, etc.

The degree of complexity increases in the case of a public-funded research organization. Along with the financial support, public institutions can improve in various forms the local relationships and generally cooperation and networking activities of the private firm. In example, greater and easier participation to the local context, driven by public institutions, may bring the organization new technologies, development partners, customers, suppliers.

However, the public interference in private matters can influence the mission and the modalities in which a private organization act. In example, it may push the organization toward low competitive choices, in matters of technologies, products, and partners. The issue arises from a divergence in interests: the growth of the context for public institutions, competitiveness and the economic survival for firms.

6.2.2 Researchers

Along with the type of activities performed, also researchers and their characteristics should change. In the collective imagination, universities should seek for scientists with a preference for theoretical research and hypothesis testing, with little interest in individual financial gain. Private organizations instead should prefer researchers with a strong preference for applied research and development, its benefits and outcomes: possibly less recognized by the scientific community, but nevertheless ground-breaking and with a powerful, tangible impact on the society. At the same time, publications should not be as important for private as academic researchers, especially when it comes to the need to postpone publications for patent applications.

In fact, research firms should need human resources for short-term developing projects, for example stage-gate commissioned projects with an outcome designed by the customer: the focus of the activity shift from the objective of the research, the "what", to the process itself, the method and approach to achieve the required objective, the "how". Private researchers might lose the control over their short-term tasks, while eventually maintaining the control over the long-term choices.

More specifically, they should understand and value the economic protection of their ideas, not only in the form of patents, but also as secrecy and excludability of economic outcomes, for competitive purposes. These reasons should not be an exogenous factor, enforced by the organization, but an endogenous driving force:

as long as researchers have the best knowledge of their technological fields, therefore deciding on the prosecution of their research, they should exhibit the economic attitude to choose the most competitive alternatives, while comparing projects to further develop.

Another significant change between environments involve mechanisms and processes for the evaluation and management of these researchers. In the organizational structure of universities, faculties and departments are the best suited for the assessment of their personnel; researchers are evaluated by peer academics, with a similar area of expertise and specialization, i.e. the head of their department. Other offices provide accessory services, for mobility and visiting professors, research funding, grants and alike.

The organizational structure of a firms, instead, might include a central office for the human resource management, which oversees evaluations, rewards and promotions. However, this office has no competencies on the research fields, thus it lacks the necessary resources to properly evaluate the scientists. To overcome this issue, the HR office might base its assessment on the evaluation that the heads of units make on their subordinates, as a reference for the individual activity.

Therefore, in the case of a university setting, the evaluation is mostly direct and research-related. In a private environment, instead, the evaluation can be splitted: each scientist can be evaluated along multiple dimensions of its work, i.e. quality and complexity of his research, the effort required, the income he was able to generate, the number of contracts he was involved in, further projects that derives from his work. The evaluation can also take advantage from classic firms' instruments as the 360-degree feedback, therefore including the concurrent assessment of other offices, i.e. TTOs and legal offices, for the same human resource. Eventually, private research organizations have the tools for a more precise and effective evaluation.

The same argument holds for promotion decisions and reward policies. In the first case, career development patterns can be borrowed from other publicly-funded or public research institutions, while the decision on whether and how to promote can be made in concert between the administration, the HR office and the head of unit or research center. For the reward policies, private organizations should provide both pecuniary and non-pecuniary incentives, i.e. preferences for mobility programs. In fact, the reward policies might be fundamentals in acquiring the best human resources: as previously stated citing the work of Stern (2004), scientists do prefer universities and public research institutions, while private organizations must provide a premium to compete in the labor market.

Related is the topic of the legal framework that the different organizations are subjected to. For public entities, available contractual forms usually provide a stronger protection for the employees, depending on the country and its legislation. Firms instead have at their disposal a larger number of employment contracts and any configuration of legal protection, reward and promotion clauses, length of the contract etc. Again, contract forms can be used as a competitive element in the labor market.

6.3 Channels

Differences in channels between private organizations and universities are mainly limited to the preference toward specific channels, with minor adjustments in their usage. In fact, has to be notices that choices and management on this topic are not entirely up to the transferring organization.

On one hand, knowledge producers might follow a technology-push approach, autonomously deciding to perform R&D activities in fields of their own choices, producing outcomes to place in the market. In this case, organizations might choose themselves channels and terms for the transfer.

The market-pull approach instead requires these organization to act on the basis of the market needs, being them unexpressed desires or specific requests from the industry. In this case, the industry representative has a significant influence on the characteristics of the requested transfer: the specific technology to develop or the issue to investigate, channels, prices, legal agreements, etc. Moreover, firms tend to have a higher bargaining power on the research organization, mainly due to the characteristics of the research products market: highly specialized, with strongly customized services, limited in its dimension both for demand and supply.

On the other hand, also researchers concur in determining the characteristics of the transfer: their competencies and interests in the selected knowledge field, their willingness to participate in future developments, the time they would devote to the project. They also shape the technology trajectory of the research institution, influencing the field of expertise, objectives for future developments and their applicability.

6.3.1 Preference

The traditional economic literature suggests that private institutions have a preference for easily controllable outcomes and less uncertain activities; in the case of research organizations, this risk aversion should be one of the most influencing factors in shaping the channel preference, thus their choices. Therefore, different effects may lead to a significantly higher utilization of contractual forms of transfer, short-term oriented and less risky projects.

The primary effect affects the usage of informal channels, especially direct transfer between researchers and firms, and more indirect ones, as publications, conference and alike. Considering the process perspective alone, the impact of the organizational private status might be negative; however, strategic issues come into play. Participation to the scientific community, mainly made through publication activities and the contribution to the literature, strongly influences the reputation of the research center, thus the ability to absorb new scientific advancement, hire skilled researchers, collaborate with prestigious institutions. Moreover, this participation might be necessary to build a competitive company image.

Informal channels might also be fundamental for research organization embedded in favoring local contexts, especially high-tech clusters. In fact, the informal participation in the local community might bring to the organization various advantages, among which customers, suppliers, new technologies, new ideas to develop, technology validation and alike, that can easily outweigh the short-term loss in incomes and profits. The decision should also consider the potential effect from and on local and national governments, including the influence of their policies, legislative activities, funding strategies and decisions.

A very specific case, but not uncommon in these high-tech contexts and industries, is the usage of informal channels as market development tools. In example, scientific publications surrounding a newly developed technology, as well as the open-sourcing of a patented technology, may help other firms to get on board. While it might seems counter-intuitive, markets for new and immature technologies are usually small, and may encounter difficulties in reaching the momentum needed for an autonomous expansion. In similar markets, producers do not compete over each other's market share, but in expanding the market frontier: as the cumulative investment in marketing and communication arise, the total market size increases, thus the economies of scale, let alone opportunities for product testing and technology validation. Disclosing information, the core of informal transfer mechanisms, may be the basis for a successful long-term strategy, while sacrificing potential profits in the short-term.

In this perspective, spin-off might also not be the preferred channel for private organizations. The creation of a new venture eventually requires the spinning organization to leave a significant part of its management and control to the entrepreneur and other equity partners, resulting in the mere ability to influence the project, rather than drive it. Moreover, this activity may require the loss of valuable human resources in favor to the spin-off.

At the same time, the financial profile of the originating firm mau negatively influence the extent of spin-off activities: they require considerable investments, prolonged in time. With the increase in the number of spin-offs, the issue growth exponentially, but extended activities might justify the institution and usage of specific instruments. Examples are the creation of, or the establishment of relationships with external venture funds and incubators, business development consortia, even specific agreement with the local government. On the other hand, these instruments might lower the financial need of the channel, but will require a substantial effort in networking activities and contractual management.

Moreover, spin-offs might be the one of the less risky channels: as previously stated, these ventures have a significantly low ratio of failures in respect to common firms. In respect to other channels, especially informal transfer and licensing of patents, spin-offs can be considered a safer but profitable choice, but their effectiveness largely rely on the availability of skilled and trained human resources in supporting the project, i.e. the incubator personnel. Eventually, other processes as licensing can be modelled to include similarly specialized employees, bridging the gap in the relative risk perceived.

Licensing requires similarly high costs and time: apart from the development requirements, the granting process itself might easily need years. The licensing process can be challenging, especially in the case of immature technologies hard to evaluate. Specific institutional-level strategies and policies might be required to make this process successful and profitable. In example, focusing the research activity on a narrow knowledge field, or even on a single technology, may result in an ensemble of results that can generate a thematic stack of patents, significantly more effective and valuable than a the single one.

For specific choices and tasks among the process, it is also strongly advice the usage of external, specialized firms: patent attorneys or consultants specialized in the valorization of patents or the protection from their infringement. In fact, the ultimate value of a patent largely relies on how the application - and especially the inventor's claims - are written, which requires professionalized and specialized skills. These external agents might also reinforce the bargaining power of the research organization and make use of their networks in seeking potential licensees.

Eventually, patenting and licensing activities might be considered safer, while their cost structure, mostly variable costs, allow a greater control over resources and costs involved. Their profitability instead is reported to be limited (Balderi et al., 2010): only a small number of patents will become "blockbusters", but their incomes might be able to sustain the entire organization, alone. Thus, this channel may in fact be preferred over spin-offs and informal mechanisms.

Consulting, contract and cooperative research instead can be expected to be the preferred channels. Firstly, these processes start from a formal contract with other firms, therefore their profitability is known from the beginning, while institutional effort and investments required are relatively smaller. The contractual form also allows the transferring organization a larger control over the process, its resources and outcomes to dedicate, while being compatible with other research activities. On the other hand, these channels might generate a sizeable amount of incomes and, if properly managed they could sustain the entire organization.

The downside of these contractual forms are the legal costs associated with the writing and negotiation of contractual arrangements. In example, an internal legal office or specialized attorneys might be required. At the same time, the bargain power of the research organization might be lower than the firm's, limiting the profitability of these projects.

6.3.2 Mechanisms

Another relevant question is whether, and how, the private status of an organization influence the modalities through which each channel is managed or used.

Informal transfers, if performed, should be managed and controlled at the institutional level rather than the individual. As previously stated, informal knowledge transfer might be essential for the creation and development of a network of exploitable relationships; thus, the organization may establish different institutional moments for informal exchanges, in order to take advantage from these mechanisms while retaining some level of control over them.

Examples are the hosting of conferences and contests, the participation to fairs and similar events, or the provision of mobility programs for employees. Depending on the institutional focus on local, national or international contexts, scientific publications might still be discouraged, while preferring more personal forms of exchange for tacit knowledge, i.e. co-development activities that not include public disclosures.

The spin-off channel and its characteristics largely depend on the specific policy chosen by the parent organization: at the two extremes, the question is whether or not to support these activities. On one hand, a spin-off-friendly organization might provide instruments as business plan competitions, business development services, access to their industrial networks, seed funds, favoring licenses and alike. In respect to a university, in a private environment should be expected a stronger pressure and larger responsibilities and accountability over new entrepreneurs, at least in an informal way. Elsewhere, non-supporting organizations may choose to not provide any assistance, or take legal precautions from the establishment of spin-offs.

Moreover, if the institution is willing to support spin-offs, a major effect can be foreseen. In respect to a university or a public institution, a private organization should achieve higher performances in supporting spin-offs, especially in network development activities. The roots of this effect reside in the connections that private organizations should have into their economic context, expected to be larger in number and stronger. Thus, business and network development activities should be facilitated.

Similarly, differences in the patenting and licensing process mainly reside in the relative importance of these channel in the business model of the private organization, especially if it contemplates basic research along with the on-demand R&D. Basic research may be performed in order to acquire the knowledge necessary to future research contracts, but also patent applications and license incomes. Elsewhere, patents might be required by research contracts, as a clause, or arise as by-product of the required development activities.

These approaches differ in the extent of resources dedicated to the patenting process, as in financial terms and employees. In fact, if patents arise only as a by-product, the need for specific skills and competencies may lead the organization to continuously outsource the process, increasing the costs and progressively lowering the institutional attitude toward licensing. In the case of institutional basic research activities, internal professionalized services may be provided.

A relevant issue on this topic is the ability to grant exclusive licenses. Public institutions are usually advised against this practice: according to the larges part of the economic literature, public funds should lead to public-domain knowledge and technologies. In this perspective, private organizations may be preferred by firms for their ability to exclude other parties from the appropriation of economic and financial results of research outcomes.

For consulting, contractual and cooperative research, the main difference among institutions should reside in the larger contractual freedom of private organizations. Examples are funding options, accountability, NDAs, exclusivity and the generic assignment of research outcomes. Therefore, contracting firms may exhibit a higher willingness to engage with private organizations, rather than public ones. The examination of legal differences is left to the competent literature.

6.4 Evaluation

The evaluation of technology transfer activities in a completely private environment should be more straightforward, once compared with the university case. Among other differences, one of the most outstanding is that private research organization have a clear primary mission: sell technologies and knowledge, thus generate incomes and profits. These objectives arise from a unique purpose: to survive in a competitive environment. Eventually, the evaluation of the entire organization along a unique objective, instead of the university's triple mission, simplify the process.

Moreover, private organizations can make use of all the standard economic tools for evaluation and management; these include HR practices, project management tools, specific contractual forms and clauses, hierarchy and many others. These tools are available also for public institutions, but they are designed and best suited for a private environment, enabling a selective but greater relative performance. However, these newly available instruments have to face various of the same issues that may be experienced by public institution, arising from the kind of activities performed rather than the type of organization.

The first, major issue still presents in a private organization surround the personnel, including its motivations, orientation and evaluation. While the private contractual forms of employment give the organization more control over the personnel, their effectiveness will be useless if they push toward misleading objectives incompatibles with the organizational mission. The issue of identifying the right objectives and evaluate their achievement arise indeed from the characteristics of the common activities of research and development activities.

Firstly, the outcomes of the research process are not certain: evaluate and incentive the personnel on the basis of the process results may be counter-productive. The outcome, in fact, may or may not be the one expected, or even available to be assessed: inconclusive research, unreachable objectives, etc. If researchers are evaluated only on the fit of their achievement to the original project's objectives aims, their willingness to embrace technology transfer activities, especially the riskiest projects, may be fundamentally diminished, as well as the relative performance and the choices on the allocation of time among concurrent researches. They may even refuse to engage fundamental, ground-breaking proposal because of their relative risks, the kind of projects from which the firm can profit the most.

This issue refers to the larger concept of risk-aversion, and it affects researchers as well as other employees, especially TTOs' officers. More specifically, the problem has its roots in the individual evaluation along concurrent projects, projects that all differ for their risk factors. Therefore, the individual will choose considering the value of the outcome, moderated by the probability of achieving it.

Secondly, research projects may require different degrees of effort, capabilities and skills. Evaluating researchers only according to the presence of an outcome or its fit to the project requirements may discourage the most competent and valuable human resources, by jeopardizing their ability to distinguish themselves from other scientists. In an era in which the competency-based human resource management is more of a necessity than an accessory, it is necessary the use of another, different approach. To balance the choices of scientists, the organization might consider to offer an insurance, as seen in Panagopoulos and Carayannis (2013), or use different approaches for the evaluation, as in a mix of weighted factors.

At the same time, the evaluation of research personnel along task-related factors instead of the outcomes is not safer. In this case the issue is more on the identification of indicators that can universally represent the participation of an employee to the project. These indicators should be appliable to every researcher in every project, in order to be perceived as fair, thus shared and trusted. Examples may be the number of hours spent on the project, financial income, number of partners involved, patent generated, subsequent child projects.

However, a set of quantitative indicators cannot represent the research process in its entirety: qualitative indicators should also be considered. On the other hand, a completely different set of issues arise in the establishment and usage of qualitative indicators: subjectivity, reliability, trustworthiness, etc. If the organization makes use of both these types of indicators, an additional issue might be the understandability of the evaluation process: to be effective, it should be simple, clear, complete and perceived as righteous at the same time. In fact, the process-based evaluation does not resolve opportunism issues and the deviations of behaviors that may arise from an incomplete set of factors or non-fundamental variables: allocate more working time than needed, generate useless patents, grant agreements with low-contributing partners etc.

Eventually, the evaluation of the daily R&D operations exhibits several issues regardless the type of institution. However, private organization might be better equipped for the task. On one hand, the activities researchers are involved in are narrower in scope, more focused and centered on development: in respect to a university environment, private researchers do not have to deal with the teaching activity, simplifying the evaluation. Secondly, applied research which characterize private institutions is easier to evaluate than the basic research of universities. Thirdly, private researchers might also be involved in a smaller number of projects, avoiding the need to evaluate them over more teams, research groups or tasks. It is also easier to manage the individual responsibility and accountability, once considered the impact of private organizational structures, hierarchy and clearer assignments. Lastly, contractual forms of employment may contain specific objectives and metrics, easing the evaluation process and reinforcing the institutional ability to drive the individual efforts.

Apart from the evaluation of researchers, significant differences arise also in the performance evaluation of administrative and supporting personnel, i.e. TTO's employees, marketing and communication, lawyers and patent attorneys. Again, the different characteristics of private organizations should easier the evaluation, control and management these human resources.

Among the supporting structure of the organization, the most significant differences arise in the management of TTO's employees. In a university environment, many authors reported the activity of this office as contingent, on a case basis; officers try their best on an ensemble of projects that are uneven, hardly structured and disorganized (Jensen et al., 2003). In a private organization, instead, specialization may dictate the activities and processes of the office: skilled and trained personnel, larger in number, competent in different functions. The institution, its structure, missionss and policies, should also drive officers toward a unique methodology, i.e. preferred channels or mechanisms, further the structuring of the TTO's activities.

On the other hand, if the input is planned, structured and expected, TTO's activities can be further standardized, easing the management of transfer activities, thus the evaluation the office performance. If the input value is known and fixed, the relationship between research inputs and commercial outputs will be easier to evaluate, along with its efficiency, efficacy and added value. For activities that have no direct relation with the research results, i.e. marketing and business development, more standard approaches can be taken from the traditional management literature, except for the need to decline these tools to a research environment, where uncertain results and knowledge asymmetries may represent additional issues.

Similarly, employees belonging to other support functions, as HR, legal office, administration, etc. may be evaluated with traditional methodologies. In example, HR officers can be assimilated to their colleagues in other knowledge producing industries dominated by creative employees: designer, writer, advertiser, and alike. Best practices can be borrowed from successful organizations involved in those industries.

The evaluation of management positions should be similarly influenced, and simplified, by the type of organizational structure. Specifically, the relative strength of institutional policies and the hierarchy structure, in addition to methodic internal processes, should clarify the impact of these roles, and ease their assessment. As an example, the performance of heads of research units and support offices may be evaluated through the comparison of the ongoing and previous achievements, weighted for the known variation in office's inputs.

A particularly useful insight on the performance of the top-level management might arise from the analysis of inter-unit indicators, as in number of collaborative projects, shared patents and alike, and networking activities, i.e. through the number of signed framework agreement, variation in public funds, etc.

6.5 Policies: examples

The easier process design and evaluation influence also the identification and implementation of effective policies: methodic and structured processes make the evaluation clearer, enabling a faster and more precise discovering of ineffective or inefficient tasks along the process of transfer. Later, these issues constitute the direct objectives of policies, improving their speed and efficacy. In other words, a better representation of the process lead to a better analysis, thus discovering failures to address and the best method to correct them. What follow are examples of policies that private organization should consider: firstly policies of general purpose, then specific for process or office involved.

Firstly, in a private organization technology transfer activities should not rely on the individual attitude, propensity or willingness. In a similar environment, the relation between researchers' activities and results and the TTO's activity should be structured and organized, substituting the spontaneous trait of universities with institutionalization. These activities are no longer additional and voluntary: they are a fundamental task in the researcher's job description. Thus, the need for the provisioning of structured services from the TTO and other supporting offices, and the development and structure of the connection between these different organizational units.

Moreover, in private research organizations transfer activities should emerge from institutional activities, as in marketing and business development activities: planned, as part of the normal daily operations. Researchers may still be activated by the request of the TTO and vice versa, depending on who receive a request from external entities; again, scientists may propose commercial activities based on previously unforeseen new technologies developed. However, the organization's economic survival should not rely on these spontaneous triggers, but on more institutional mechanisms.

In this perspective, a continuous communication and an instructed relationship between researchers and transfer units are necessary for the success of a development-based organization. There is the need for policies that describe which actions should be taken, and by whom, when a request comes from a potential customer, the consequent line of actions, responsibilities, channel choices, mechanisms for market development, and alike. Even in the case of an "emergent" transfer, it is essential to picture it immediately into the landscape of the entire organization's activities and external relations, in order to take full advantage from the synergies that may arise.

In fact, the management of different units and offices as relatively independent may be misleading and eventually jeopardize the profitability of the firm. The organization could still survive if processes are managed in complete isolation, but it will generate inefficiencies that in the long-term run could affect the competitiveness. Apart from the suggestions the management literature make toward the complete exploitation of internal resources, another important reason resides in the type of industrial knowledge that is mostly profitable nowadays: in an era in which single knowledge fields have grown exponentially, the cross-contamination of ideas has become more and more important.

Markets that relies on the convergence of multiple fields have become more and more actractive. Examples are the diffused need for (ergonomic) design, the economic value of hybrid projects that include both hardware and software, the competitivity of high-tech products based on the combination of traditional knowledge and new technologies. Similarly, a research center should focus on distinctive capabilities and knowledge, including projects that involve two or more knowledge fields that the organization may master.

Another general policy worth considering is the writing and improvement of the mission statement; as found by Fitzgerald and Cunningham (2015), they are often underestimated. In the case of a private environment, a clear and useful mission statement should include the description of the orientation toward the market, fields of interests, vision, overall strategy, and alike. Private research organizations, still an economic movement limited in its extent, should never be confused with a public or academic environment, but the public understanding of the difference should not be taken for granted.

Lastly, specific policies may aim to single teams and office (research units, TTO, HR, administration, legal office etc.) or a process, which encompass more units along the same channel or transfer mechanism. In the first case, useful policies may consider the implementation of HR policies, especially evaluation, reward and promotion practices tailored for a research organization. Other examples may involve the internal structure of the TTO, its process flows and its human resources.

Other policies may regulate the single transfer channel or process, i.e. spin-offs, patents and licensing, contract research. In this perspective, the private organization and the university do not differ: they both need clear, understandable policies to manage each channel; any misunderstanding from researchers may decrease their motivation and performance. Again, policies should establish which internal actors are involved, their tasks, responsibilities, process flows, legal management etc.

6.6 Recap

Chapter 7

Case Study

Fondazione Bruno Kessler

In this chapter, will be presented the case study of the Bruno Kessler Foundation (henceforth, FBK); the case will be later discussed in Chapter 8 to test the hypothesis made in the previous Chapter 6, to provide the conclusions. Specifically, FBK is a non-profit research institute, largely financed by the local public government, a case particularly fitted to present real world applications of many of the previous considerations. In fact, it includes problems from both a private and publicly-funded organization, while its historical luggage offers the space for some consideration on an entirely public institution.

At the same time, FBK represents a significant case in the European research landscape, where its importance will be tested with the aid of social network analysis tools. At the same time, its relevance can also be assessed by the proxy of its dimension, both in revenue flows (about 30M euros) and the number of researchers and other personnel it employs (over 450), which both classify this institution as one of the largest private research institutes in Italy. Its localization in the Trento province, one of the most technological advanced areas of the country, and a region in which peculiar institutional settings positively influence the power and impact of local policies, makes it fitted also for the analysis and evaluation of government technology transfer policies, which however will be demanded to a more proper literature.

Due to the specific objectives of this thesis, the case study will point toward the organizational structure and the process perspective. The chapter will begin with a short presentation of the organization, including a historical perspective and a brief description of the local government's influence on mission and operativeness. After a short presentation of the organizational structure, a specific section will provide specific information about the structure and the organization of its TTO.

Later, the chapter will describe channels and processes: firstly, an external perspective will be taken to focus on the various products and services provided to firms, research organizations, and spin-offs, through a generic perspective on channels. These will be later decomposed and analyzed, following an internal perspective on the corresponding processes and mechanisms. This analysis will be an effort of process modeling, in an organizational structure, that actually has grown and evolved over time as an emergent auto-adaptation that shaped the structure concurrently with the organization designs provided by policies. Eventually, the institution has indeed adapted itself to the specific requirement progressively made by the market and the local institutions.

Lastly, will be discussed the evaluation perspective. On one hand, will be assessed the efficacy of its research activities, through instruments of social network analysis, with the objective of providing a quantitative evaluation of a typically qualitative topic. On the other hand, will be discussed two methodologies to evaluate the efficiency performance, investigating the involved issues. Will follow a brief examination of the main organizational policies on technology transfer activities.

A LAST FUNDAMENTAL NOTE

7.1 The institution

Nowadays, the Bruno Kessler Foundation is a nonprofit research institute of "public interest", funded in 2007 by a law of the local government but autonomous and regulated by the private legislation.[1] It has two major objectives: the scientific excellence and the local economic development.

The history of the institute begins in 1962. In this year, Bruno Kessler, the president of the Autonomous Province of Trento, founded the predecessor of FBK: the Trento Institute of Culture (ITC).[2] At the time, Trento had not a local public university, and the ITC was instituted with the long-term objective of providing a favorable, scientific and innovative context for the later creation of a university.

In 1972, the Free University of Trento was finally founded, thus requiring a change in the objective and future of the ITC. With a functional university, the institution finally could invest its energy in the knowledge- and research-based kind of activities and services that the context still needed, but the university could not provide. Therefore, the focus shifted to a more applied research, utilizable by the context and characterized by a long-term development perspective, capable also of maintaining and develop of the local culture.

A remarkable milestone, in fact, was the institution of a research center dedicated to more technical research and applied science: the Institute for Technological and Scientific Research (IRST). Along with other institutes, i.e. the Italian-German Historical Institute (ISIG), the Center for Religious Studies, and later centers, the ITC could cope with both the need for a technological development of the region and the need for preserving the local culture.

A more recent, major change in the strategic trajectory of the institution started in 2005 when the local government decided to reorganize the local system of research and innovation. This action ended with the dissolution of the ITC in the form of a public institution, with its transformation into the Bruno Kessler Foundation,

[1] For "public interest" is intended an organization that is subjected to the legislation dedicated to private entities, while one or more conditions (in this case the presence of a public institution among the founders) entails the respect of secondarly obbligations for public institutions, i.e. higher requirements for trasparency.

[2] Provincial law n.11, 29 August 1962 [accessed: February 2, 2017]

officially funded in 2007.[3] The foundation has, in fact, the local government (in the form of the Trento Autonomous Province) among its founders, but the institution is mainly regulated by the private legislation, the same that regulate the activities of foundations and other non-profit organizations.

While FBK may have lost its public status, the strong interference of the local government deeply influenced and still influence both the mission and the methodologies of the foundation. First, the financial impact: the local government accounts for two-thirds of the total income of the foundation, with about of 30M in a 45M euro total income. By all means, without the public sustain and support, the foundation would not be able to cope with the financial requirements needed to perform both applied and basic research, necessary to the accomplishment of its organizational missions.

A second major influence is on the mission and business model. Differently from other private research organizations, FBK explicitly stated among its main objectives the positive influence for the local society, equal for importance to the scientific excellence and the economic survival. This set of objectives, in fact, reflect the pure identity of a non-profit organization, but it is not clear if the actual interests and activities of FBK do descend from the influence of the public institutions or its history and legacy.

Eventually, the two primary objectives of FBK are the scientific excellence and the local development, suggesting the first as a necessary condition, a tool in achieving the second. The underlining idea is to hire star scientists, include them in a favoring structure, and employ them in (1) producing excellent basic research and (2) perform industry-led, research-based activities, i.e. contract development. Implicitly, by furthering the knowledge and technology bases of the local industry, FBK should be able to help the local economic growth by improving the competitiveness of local firms, attracting high-tech finances and other star scientists.

7.1.1 Organizational structure

A brief description of the organizational structure should help to understand this continuous duality, between technological progress and historical luggage, basic science and development services, local development and economic survival. Moreover, a blended framework of the organization will be useful in understanding the internal processes.

Main entities in the administration are the President, the Board of Directors, and the Secretary General. Notably, the Autonomous Province of Trento, as a founding member, nominate both the President and 6 of the 8 members of the Board, therefore the extent of the influence of the local government. In staff to the Board of Directors, the Scientific Committee, tasked with the ex-ante evaluation of annual and long-term plans, i.e. the long-term Program for Research Activities and Investments (PPARI), and the Budget and Annual Plan of Activities (B&PAA).

Under the administration, the structure includes the research structure and various support offices in staff. The research body is firstly divided in two different

[3] Provincial law n.14, 1 March 2005 [accessed: February 2, 2017]

hubs: the (1) scientific and technological, and the (2) human and social science hub. Each hub is further divided into research centers, specialized for knowledge and technology topics, led by different directors:

- Scientific and technological hub:
  - Information Technology Center (ITC)
  - Center for Materials and Microsystems (CMM)
  - International Center for Mathematic Research (CIRM)
  - European center of Theoretical Physics (ETC*)
- Human and social science hub:
  - Research Institute for the Evaluation of Public Policies (IRVAPP)
  - Italian-German Historical Institute (ISIG)
  - Religious Sciences Center (ISR)

Main centers are ICT and CMM, which account for the largest part of researchers. Given their size, these centers are further divided into different research units: 6 for CMM and 23 for ICT. While they employ in fact a similar number of researchers, CMM's projects tend to be larger, structured and demanding, requesting substantially larger teams; an example is the management and maintenance of the internal clean room. The structure also comprehends independent research units, that arise from special projects; i.e. the framework agreement with the Italian National Research Council (CNR) which led to the creation of a dedicated micro-center, with 3 internal units.

Other offices are in staff to the Secretary General and the research subsystem; the most important are Human Resources, ICT support, Infrastructure and Corporate Assets, AIRT (the organizational name for the TTO), Legal Office, Communication office. These are autonomous and independent from the research structure; they can activate or be activated by the research centers or units while performing activities on the request of the administration and other operations of maintenance.

The entire organization employs more than 450 human resources, clearly inclined toward the research structure rather than administration and support offices. According to the 2011 Integrated Report[4] the organization counts 462 employees, 347 researchers and 115 resources among administration and support personnel. This ratio describes the organizational effort to maintain its flexibility in an otherwise massive structure: a lightweight support structure, with a network of relatively independent and agile research units.

7.1.2 TTO structure

In this organizational setting, the office in charge for technology transfer activities is called "Innovation and Territorial Relationships Area" (AIRT), an institutional name for the Technology Transfer Office. It is tasked with two main objectives: to

[4] Integrated Report 2011 [accessed: July 31, 2016]

maintain and manage the relationships with external entities and seek for external financial support to the research. In the widest perspective, the office employs more than 12 peoples, both with specific tasks or more generic supporting functions.

The head of the Area is directly involved in building, developing and maintaining relationships with relevant external actors, i.e. spin-offs and relevant entities in the local context; on the other hand, the resource manages the internal connection with other prominent positions, as the President, the Secretary General, and the Centers' Directors. Along with these networking activities, the employee administrates the office and his subordinate, yet mostly on matter of strategic importance. In fact, his employees might have a greater knowledge on the specific topics and issues, while they may also lack the larger, strategic perspective to manage individual key relationships.

The organizational role and position are also greatly shaped by the individual characteristics of the resource: prior to his engagement in FBK, the employee had acquired a relevant experience both as a Ph.D. researcher and in various, major companies. His double background is believed to be fundamental in understanding and cope with the needs and requirements of both the research and the industry side of his activity. Moreover, significant personal relationships in the local context should ease and foster the local institutional networking activities.

Next to him, a second organizational position is specialized in the management of industrial contacts. More specifically, the employee performs any activity related to: (1) developing an initial relation of mutual interest and trust, instrumental for the later development of the relationship; (2) manage the relationship and maintaining contact for already established and active exchanges, especially bridging the communication between researchers and firms. Examples of day-by-day activities are the participation to acquaintance and technical meetings, economic and contractual arrangements and alike.

Again, the resources gained a background in both the scientific research, mainly internally to FBK as a former Head of a research unit, and in the management of industrial relationships, mainly through his previous transfer projects. In this case, the availability of technical know-how is essential to participate and support researchers in the most technical exchanges, while his personal network of industry contacts and the understanding of industry needs help in increasing the probability of a successful transfer.

A third specific position is dedicated to business development activities, including the scouting of potential industry partners and customer, and the support to researchers in delineating technology-push commercial actions. Daily activities include the elaboration of value propositions wrapping research products, individuate potentially interested industry segments, contact firms, gain their initial interest. Other activities include the strategic management of the patent portfolio, counseling to potential spin-offs, marketing operations. The related employee, differently from the previous examples, do not have a deep understanding of the technical content and the research processes, but he possesses a relevant experience in firms, business development and technology transfer activities.

Two distinct offices follow, each one operating in a more traditional fashion in support to research: a legal support office, for contractual matters, and the Research Funding office, which offers support for research grants.

The legal support offers internal services as the analysis and evaluation of prior contracts, as well as the literal writing and the negotiation of any research-based contract, including research contracts, cooperative research, licenses, grants and framework agreements. The office employs two human resources, combining both the experience and the knowledge needed, in economic and legal issues: the negotiation process, part of their daily operations, surely require a legal knowledge and training, but also the skills and competencies needed to evaluate the economic value of any project and contract.

The Research Funding office has instead the objective of providing a specialized support for the application and management of research grants. The employees actively seek for research grants from local, national and European institutions, screening the calls for projects that match the internal competencies and knowledge. Later, the project will be forwarded to the best-suited research Unit, while providing support in contacting potential partners, writing the grant application and the eventual consortia agreement. These activities clearly require the awareness of the research topic of every internal unit, deeper than the simple field of research, while personal contacts and relationships with researhers can offer a distinctive advantage in the successfulness of their activities. For this purpose, both the involved human resources have a long-term, decennial experience in these activities, in this very organization.

The last core office of AIRT, the Territorial Relationship Office, has the main purpose of managing the relations that FBK established with other institutions in the local context. In fact, one of the channels available and chosen, for a positive impact on the Trento province, is the active involvement of academic institutions and schools, i.e. in the form of curricular and formative internships; similar are the hosting and organization of conferences, meetings and alike. While this office might have not a direct impact on the foundation's incomes, it is necessary for accomplishing the second of the two main missions and purpose of FBK.

A separate mention should be made for an independent employee in staff to the Director of the CMM, due to the continuous and structured collaboration among him and AIRT. More specifically, the peculiar organizational role of this employee places him in the best-suited position to support researchers in a more informal setting. His daily activities comprehend the evaluation of patent proposals, the management of technical and informal aspects of industry relationships, and technology scouting. Peculiar to his position is the required experience and credibility that is required among researchers, in order to be spontaneously involved in their work, developed in over 20 years of experience in FBK.

7.2 Channels

In this section will be presented channels and processes related to the technology transfer activity of FBK. Firstly, an external perspective will be taken to describe the various channels as in the kind of services and products that the organization provides. Secondly, the channels will be described through the analysis of internal processes that constitute the development and delivery of the product or service. This methodology will also expose both the external appearence and the internal mechanisms of the activity.

7.2.1 External perspective

The external perspective considers each channel as a single product or service that the organization provides. While this perspective might be useful in exemplifying the entire offer, it may picture the process as more market-pull than the reality. In fact, considering external, independent actors alone, the analysis will proceed through the various products that a firm can request to FBK, momentarily leaving aside a more proactive, technology-push approach in which the commercial activity is led by the emergent, deliberate actions of the research organization, rather than the interests of external entities.

For firms

The main service that FBK can provide to firms is the development of a technology or investigations and feasibility studies, on rather specific topics. The main contractual forms for this kind of service, that allow external entities to acquire technologies and knowledge, are contract research, cooperative research, consulting and licensing.

The contract research is a legal contract in which the research organization undertakes the development of a technology, the investigation of an issue, the feasibility study of an idea or project, the delivery of a specific knowledge to another organization in exchange for a "contribution". While the compensation usually assumes the form of a financial flow, it could also contain contributions in nature, as in the right to access and use a protected idea or technology and alike; contracting firms can also provide resources in kind, i.e. employees, laboratories and other assets. Despite the form of the compensation, the core idea of a research contract is the commissioning of an activity, not unlike the outsourcing, of something that cannot or will not be performed internally.

Cooperative research shares most of its legal traits with research contracts, but it starts with a different assumption: neither the research organization and the firm have, individually, the entire knowledge base and resources (in any kind) to successfully complete the project. In this case, the organizations agree to cooperate on a specific activity, that can range - similarly to the research contract - from technology development, knowledge generation and others previously cited. Therefore, in this category falls every contract that has the R&D as object and both the organizations as active researchers.

Consulting usually refers to the transfer of knowledge rather than the technology. The primary example is for firms to request a support in ending or further the developing of their technology, product etc. The main corpus of knowledge and technology for the ultimate successful development already resides in the requesting firms, but its exploitation requires an external intervention; exemplary is the routine of performing any further activity at the firm location and with their assets. A specific case is the provisioning of training activities for human resources, but these are clearly minor activities among the services provided by FBK.

As previously stated, licensing is a contract in which an organization acquires the legal ability to exploit or make economic use of a technology or knowledge already developed by the licensing organization, an ability otherwise forbidden by the patent or other forms of protection. Tools tend to be relatively specific to the knowledge sector: in example, in many countries, a software cannot be patented, while the copyright can provide a similar degree of protection and excludability. License agreements can widely differ, according to the type of utilization, contribution and other legal clauses, thus providing a degree of personalization for the exchange without other specific contractual forms.

For research organizations

FBK also establishes contractual relationships with other research organizations. Specifically, exchange contracts between research institutions can assume any of the form previously described, i.e. the provision of a service or a license; however, some forms acquire a greater importance, especially research cooperation, with the two organizations collaborating on a shared topic.

Another example of a contractual form more specific to the case is the framework agreement. This contract describes the mutual interest of the organizations to collaborate with each other, framing forms and topics in which the further collaborative research will be performed. The contract may include resources, rules for decision-making processes, propriety of the results and similar clauses. Eventually, this contractual agreement constitutes the basis for any further development of the relationship.

A separate mention should be made for a very specific contractual form: the grant agreement. Similarly to the previous forms, while it may involve both research organization and production companies, it is usually signed between research organizations, both public or private in nature, as a necessary step in applying for a public call for research grants. The funding source may be a generic public institution, but the most relevant case involve the EU Commission and the FP7 or H2020 grants. Briefly, to apply for these funds, the organization must deliver a proposal for the call's research question or topic, assigned by the Commission. The proposal will state the modalities and resources (including material, immaterial, financial and human capital) through which the research organizations mean to achieve the prescribed objectives.

Since the begin of the H2020 program, applications for these grants have become more and more competitive: given the rising number of organizations that apply for these funds, the increasing specialization of calls and applications, and the relatively fixed amount of funds, these grants are becoming harder and harder to win. To overcome this issue, and increasing the probability of a successful application, the usual solution is to secure the presence of the needed expertise, skills and capabilities, and resources through a collective application, made by consortia of research organizations. If the proposal will be selected, the organizations will deliver a consortium agreement, a contract between the participants that describe the modalities through which the research will be performed: individual tasks, results, resources, share of the grant funds, responsibilities, the central coordinator and alike.

For spin-off

For spin-offs, FBK differentiates its support services among potential, in development projects and already founded new ventures. In the first case, the organization provides a set of services centered on the provision of (1) a favorable entrepreneurial organizational environment, (2) scouting for spin-off opportunities, and (3) supporting services in shaping potential projects, their business models and their appetibility for external investors. The first two cases share extensive similarities with the generic foster of a commercial-friendly organizational culture, as common, basic and multipurpose policies.

In the first case, activities mainly encompass the structuring of comprehensible and supportive policies, entrepreneurial courses, training, conferences with successful scientists entrepreneurs, meetings, and the provision of useful and exploitable relationships into the industry. In respect to the standard activities for the organizational climate, these activities are more focused on the main spin-off-related topics: business modeling, seed and venture capital, legal aspects of the creation of a new venture, and alike.

As any other commercialization activity, the opportunity scouting can be intended and performed as proactive, institutional, not dissimilar to the disclosure eliciting in an academic setting; in the simplest case, the technologies available are known, and the question is on the modalities through which exploit it. In the most complex case, AIRT officers must ask researchers for their current activities, then individuate and suggest a commercialization path. The phenomenon can be also emergent, provided by a self-selecting environment. The most significative example is the provision of business plan competitions: the spin-off process will begin with the emergent, individual willingness to start a new venture, while the evaluation and selection activity will be provided by the contest itself.

Support activities, instead, range from the aid in business modeling to business development activities. Examples include specific training activities, suggestions, and validation of the business model and business plan, the introduction of the new entrepreneurs in the network of the parent organization, aid in developing new personal contacts, support in human resources practices. Other forms of support are financial, both in grants or equity, favorable licenses, access to machinery and workspaces. FBK offers its support also to already founded spin-offs, especially networking activities. If the process involved the acquisition of an equity share, in the first 1-2 years the parent organization can directly influence the choices of the spin-off.

7.2.2 Internal perspective

The inner processes behind these channels have been initially structured by the statue and other policies, but the actual design has also bene refined by the experience of the involved human resources, who helped in further shaping the processes' flows in an emergent fashion. Eventually, the processes appear as unique and unified, where different offices and employees will be activated on the basis of the ongoing needs.

From a comprehensive perspective, the most part of technology transfer activities are performed by the Innovation and Territorial Relationship Area (AIRT). Apart from the advisory role for the various economic aspects of the research, AIRT holds five main processes: patenting and licensing, support for spin-offs, grants, and contracts, relationships management.

Patenting process

The sole Research Centers responsible for the origination of patentable technologies are the Center for Materials and Microsystems (CMM) and the Center for Information and Communication Technologies (ICT). The process of patenting, in its beginning, differ among the Center of origin, due to the presence of a specific organizational position in staff to the CMM Director, which act as facilitator through informal preparatory activities

Within the CMM, the process usually begins with researchers delivering a patentable technology, or a commercial idea, to the facilitator employee, through informal meetings or presentations. Specifically, researchers may directly suggest the patent channel; however, the decision is usually postponed to the examination and assessment of the commercial potential value of the technology, while comparing concurrent exploitation alternatives. The researcher is expected to expose key facts of the new technology, how it differs from the previous state-of-the-art, and how to extract economic and social value from it.

After a first evaluation from the facilitator employee, especially for the anteriority research, a basic template will be written to clarify the most common and important contractual aspects. It contains information and clauses about the proprietary structure, financial incentives for the inventor, the legal process, and alike. Lately, the patent attorney will be contacted to better assess the feasibility and potential value of the endeavor.

Otherwise, if the invention originates within the ICT, researchers should directly contact AIRT, to ask for an initial evaluation of the project, replacing the support of the CMM facilitator. In both cases, after different initial phases, the process flows will converge in a more formal procedure that begins with the so-called "invention notice".

It consists in a notice, similar in spirit to a dossier, which notifies AIRT and the Center Director of the reaching of a potentially patentable research product; it should include information about the discovery, its applicability to industry, identified market segment, novelty, and alike. The invention notice will be therefore evaluated, to be eventually accepted or refused. A necessary condition for a positive evaluation is the recognition of a clear potential customer or customer segment, already identified.

If the notice is positively evaluated, the patent attorney will be involved to support researchers in converting the invention notice into an inventor declaration, which will be deposited initially as an Italian patent. After twelve months, the application will be converted in a PCT or EU patent, in order to gain additional time to invest in commercialization activities before the nationalization process and its relative costs.

Valorization activities will begin immediately after the first deposit. Since the characteristic early stage of the patenting technology, AIRT and the CMM facilitator will start seeking for a potential investor, specifically interested in further developing the technology (1), apart from the usual organizations interested in licensing (2) or acquire (3) the pending patent. In the nearest future, a specific partner will be engaged in this phase: a firm specialized in patent valorization, who will perform activities like market analysis, partner scouting and customer seeking.

While the described process matches a typical academic case, it represents only a fraction of the potential patents: the largest part of patent proposals seems arises from EU-granted projects and direct assignments. In the former case, EU funds (especially H2020 funds) are reported to be assigned preferentially to consortia of organizations which include at lease one firm; according to the interviewee, the industrial partners usually participates EU projects because interested in any child patent that can be originated. Therefore, apart from the possible direct request of patenting of participant firms, even their sole presence will influence FBK and participant research organizations to patent the results, simplifying the decision process and the seek for a licensee.

For the latter case, instead, the direct research contract can anticipate the need for the patenting of research results: FBK already establishes and agrees, at the signing, to patent the research output. However, the property of the patent may be shared or entirely of the firm, therefore influencing the licensing process.

In both these last cases, the patenting process eventually differs for the absence of the invention disclosure and the initial evaluation of feasibility and profitability, resulting in a simplified seek for a licensee.

Relationships development and management

One of the most important tasks for AIRT is to manage the relationships with firms: the source for contract and cooperative research, the main technology transfer channel for FBK. The inner activities behind the task can be decomposed in three different processes, due to the involvement of different employees with different objectives, which eventually constitute different points of contact between the organization and the market.

In a chronological perspective, the first is the business developer employed by AIRT. Along with marketing activities, he actively elicits information from researchers on their research projects, to later seek for a match between these and potential markets and customers. Differently from other employees involved in this process, his approach usually points at new, unexplored markets, in a disruptive rather than incremental perspective.

More specifically, once gained information about a project, the employee will model any business opportunity that may originate from internal research, seeking any market niche or segment in which the technology may be deployed. After the identification of the best competitors in these markets, the employee will contact them and try to gain an initial interest, in order to establish a relationship. After this first contact, the potential customer will be redirected to other specialized AIRT's employees.

The main process of relationship development, in fact, is held by a different resource, whose sets of activities includes: the identification and contact of potential customers, focusing on territorial promotion based on FBK competencies; the reception of interested firms; the maintenance of relationships.

The identification and contact of potential customers and partners begin with the seek for technological issues in entire industrial sectors related to FBK internal research areas. A necessary condition, which will be discussed later, is the knowledge of internal strengths and the applicability fields of any internal research activity. Technological issues mainly refer to a limitation in current processes, being qualitative, quantitative or in terms of efficiency, which can be overcome by a technological leap. Once spotted a similar issue, if an FBK's technology can achieve, or help to achieve this leap, will be compiled a list of potential customers or partners, along with a brief documental analysis for every actor.

Then, a first contact will be made. Even in initial stages, the approach is relational, direct and informal: usually, a meeting which involves a presentation on the entire organization and its projects. The main objective of this stage is the understanding of the firm, its activities and industrial context, to better adapt the technological offer to the firm's peculiarities: the approach shift from a resource-based view to a market-based approach.

In this phase, the tendency is to rely on personal, local and previous networks of collaboration, rather than different contexts and industries, which can be seen as an effect of the local development mission of the organization. In example, the first contact will be made through a common acquaintance, if available. However, this approach may have a negative impact, such as a self-limitation in the market scope and auto-financing opportunities.

Direct firms' requests, instead, can be made directly to the office, to a researcher, or to external partner organization, i.e. Hub Innovazione Trentino and Trentino Sviluppo; in any case, the request will be forwarded to the office, for its analysis and development. The necessary condition for the acceptance is the innovativeness of the project and the final objective of an advanced demonstration of the newly developed technologies. Otherwise, the interviewee suggests that extended projects could compromise the FBK's role of research institute, shifting from a knowledge generator to a "supervisor", distracting resources from core activities of research.

In this scenario, the relationship evolves as follow:

1. A preparatory phase dedicated to the assessment of the counterpart;
2. The exchange of specific technical information about the potential project, under a non-disclosure agreement;
3. Contract drafting and negotiation;
4. Additional bureaucratic procedures;[5]
5. Sign of the definitive contract and its technical annexes;
6. The actual research phase, based on stages defined by contract;
7. Continuous follow-up;
8. Final demonstration;

A secondary share of this process is held directly by the CMM Director's staff. In this case, external requests usually involve the development and production of specific hardware, which constitutes the main competency of the CMM and its researchers. Secondly, the seek for customers is performed as a secondary and residual activity, mainly through the participation in various exhibitions and fairs.

Spin-off process

In respect to the patenting and licensing process, the spin-off process is less structured and standardized. Even if a specific policy does exist, and it anticipate differently, the process usually begins in an informal fashion. In fact, the standard exploitation channels for FBK are the research contracts and licenses: the opportunity to found a new venture is more of an exception, with the chance being usually considered during informal meetings and alike.

The initial proposal may come directly from researchers, or driven by AIRT; which explicitly suggest the opportunity to the scientist. The proposal may take the form of a communication of intent or more informal, in a simple inter-office meeting; after a first analysis and discussion between researchers and the TTO, the proposal will be articulated in a business plan, which will be officially submitted to the Entrepreneurship Evaluation Committee.

The committee consists of 6 members, aiming at gaining a complete evaluation by including perspectives from different professional backgrounds and areas of expertise. Half of the committee is composed by FBK members, representing the mission and scientific knowledge of FBK; the other three members are representatives of institutional partners, involved in different industries: startups and spin-offs, venture capitalists, patent attorneys. Together, they should be able to provide a complete assessment, including the mere market value and the strategic value the proposal may yield to FBK and the local context.

[5]The most significant example is for local firms: the "Legge 6", a law promulged by the Autonomous Province of Trento, act as a financial aid for research collaborations; if the contract is eligible, the process will include an additional precontractual agreement and the submission of the proposal.

After this preparatory phase, a more complete report will be redacted by the proponent, including a business plan and the draft of the new venture's statue. Eventually, the report will be presented to the Board of Directors for a more formal and complete assessment. The main objective of the entire process is clearly to extensively assess the robustness of the proposal and to ensure its alignment with the FBK mission. If the proposal receives a positive evaluation, an investment can be made, both in equity, grant or loan.

A final note on this process must be made: the process is currently being redesigned at its root. No startup has been spun off in the last years, to describe the recent form of the process flow, and no final design of the process has been implemented yet. This analysis is based on previous projects and different spin-off opportunities arisen in previous years.

Grant support

The Research Funding Office can provide a separate support for EU grants, especially in the form of H2020 calls, and local, less known and participated calls.

In the first case, the support for H2020 projects is mostly limited to the administrative and bureaucratic assistance for the application. This restriction is due to the scientific specificity embedded in each project: the researcher himself, over years of experience and activity in a specific field and its relative network, has a deeper knowledge regarding available calls, their financial entity, and feasibility, as well as other external individuals or firms to involve. The single office can not outperform the researcher in such activities. The focus of its activity, in fact, is sharper: to relieve researchers from any bureaucratic, organizational and legal affair, while exploiting their personal networks and scientific capabilities, enabling them to focus on the scientific aspects of the application.

The office performs activities such as budgeting, documental management, control and package of the proposal, submitting the application. If many actors are involved, the office will coordinate them, at least on the overall administrative affairs instead of scientific matters. Later, if the application is granted, the office will manage the later negotiation phase, especially the contractual phase for any Consortium agreement and the introduction of amendments. Lastly, no scouting activity will be performed.

In the second case, for local, smaller and less known calls, the office will provide a more extensive support. As a preparatory activity, the scouting for potentially interesting calls will be made through institutional communications, alerts, and channel such as official EU publications. After an initial evaluation on the eligibility of FBK researchers, these last will be contacted for any call related to their research area.

More specifically, the documentation will be sent to any scientist possibly interested: the assumption here, as for many other activities in the Area, is to know the actual interests of every researcher. In this specific case, the main tool is the experience of the employee involved, gathered through direct interviews and the development of personal contacts in almost any research unit. An example of the importance of these relationships is the continuous and spontaneous follow-up that researchers send to the office: in this scenario, no eliciting is needed.

Later, the willing researcher will be supported in every aspect of the proposal procedure. As usual, the office may also be activated by a direct request from scientists.

An interesting insight gained from interviewees is about the characteristics of researchers this support activity is aimed to, both on the organizational and individual level. Specifically, smaller units tend to be less competitive, negatively influencing their probability to successfully apply for major grants, i.e. H2020 calls. At the individual level instead, apart from the personal ability and talent, great emphasis has been placed on the personal network of the researcher.

Contractual support

The legal support office performs activities of contract drafting and negotiation; it can be activated by the individual researcher, for single collaboration with firms and grants, and by other FBK positions, i.e. Center Directors and the Secretary General, for institutional agreements with a variety of actors. Types of contracts include:

- Collaboration Agreements;
- R&D Agreements;
- Patent, know-how and software licenses;
- Services, for the prototypation and production of hardware;
- Feasibility Studies;
- Program Agreement, frameworks for the development of relationships with public institutions;
- Grant agreements for European projects.
- Non-Disclosure Agreements;

The contractual support typically begins with a formal internal request. The initial phase requires the employees to discuss with the researchers the basis and the evolutionary pattern of the contractual relationships. Later, a basic contractual model will be customized to the specific circumstance, which will be sent to the counterpart to begin the negotiation of inner clauses.

This process can easily require several weeks and requires a continuous strategic evaluation of the economic, financial and strategic means of every change. Eventually, the process ends with the reaching of a satisfactory combination of FBK's and the counterpart's interests, as the compromise the contract represent. This process is performed alongside with researchers, to ensure the desirability of the technical contents of the contract.

Among common clauses, a standard contractual model includes three significant elements: intellectual property, publication, and the clauses of licence-back and best-effort.

The intellectual property describes the property structure of knowledge and technologies involved in the process. It differentiates between: the background, known at the beginning of the process: the sideground, generated during the project, but not directly linked to the research objective; and the foreground, the actual results. The first two are usually property of the organization which developed it, while the third can be conjoint or individually assigned to one organization.

The publication is another important element for any research contract. The typical clause states that any potential publication will be sent to the counterpart for a formal control prior to the public release; the organization may deny the publication, presenting a report that clearly defines the motivation. In any case, publications must not jeopardize patenting activities, i.e. by postponing every external communication to the patent application, as well as no confidential information disclosed.

Two minor but relevant clauses are the licence-back and the best-effort clauses. Firstly, FBK usually requires a clause of license-back for the non-exclusive, unlimited use of the foreground generated, in the case in which the property is entirely assigned to the counterpart. The best-effort clause instead protects the Foundation from the potential absence or incompleteness of research results, due to the intrinsic uncertainty and risks of these activities.

In any case, researchers have the control over, and responsibility for the resulting contract: they lead the negotiation process and decide which form will be the accepted for final; the office act only as a support, providing skills and competencies and having little control over the economic and scientific content of the contract.

Additional insights

Interviewees involved in this process highlight several interesting topic.

Firstly, the need for a correct identification of internal competencies and research areas. In similar, highly-structured organizations with clear boundaries between research teams, inter-unit and inter-area communications become harder: the TTO may encounter difficulties in gathering this knowledge, especially considering the esteem and trust needed for a continuous and spontaneous communication. In such scenario, it might be fundamental to have a relevant experience in research, in order to gain a reputation before researchers, to be seen as a peer, therefore improving the communication performance. Formal and institutional moments of exchange may be useful but also potentially insufficient.

Moreover, disclosure eliciting is harder in the case of a research unit led by a researcher whose vision for its group is a "strongly independent, autonomous isle". These units have usually a low auto-financing ratio, due to few cooperation contracts and little cooperation with the TTO and external firms. On the other hand, more proactive and propositional units show a positive attitude in collaborating with other entities, leading to a higher auto-financing ratio. This difference can be due both to the leadership, in a top-down approach, but also the individual behavior, as in a bottom-up approach.

Secondly, interviews highlighted the importance of the perceived credibility, both for FBK as institution, its representatives, the researchers, and the patent attorney (if the contract anticipate the patent application). Specifically, the interviewees consider helpful to appears, as FBK, more application oriented, lean and flexible than a fully public institution; the representative credibility instead seems to be directly linked to the experience in industrial contexts and previous relationships with other firms.

Another topic is the researchers' perspective in the technology transfer activities. According to the interviewees, one of the main reasons for researchers to participate in these activities is actually the pecuniary incentive, both as potential royalties and generic rewards. However, these incentives may be for the individual benefit, but also financial resources for consecutive research projects.

Elsewhere, interviews have highlighted the need for researchers to participate in every phase of the relationship development, in an active and propositive fashion. Specifically, the initial stages can be used to build a direct channel of communication between the researcher and the firm's technical office, improving the flexibility and efficiency of exchanges in the prototypation phase.

Regarding the contract objectives, instead, has been highlighted the strong preference of firms for incremental R&D instead of a more disruptive innovation, which influences the innovativeness of projects. In fact, interviewees reported that at the initial request, during the very same meeting, the researcher is usually capable of immediately assess the feasibility of the project, indicating that the scientific complexity of the proposal might be less challenging than expected.

Lastly, a perspective on the origin and localization of FBK relationships. According to the interviewees, about 70% of the external relationships arise from the personal network of employees, reflecting the importance of the involved social capital. Moreover, external direct requests seem to origin prevalently from firms in the Trento local context. Apart from the local development mission of FBK, the phenomenon can be directly linked to the Autonomous Province of Trento and its legislation, especially for financial incentives, i.e. the previously cited "Legge 6".

7.3 Evaluation

As previously stated, the performance of an organization can be evaluated for its effectiveness or its efficiency. Especially in the case of research organization, which processes are not as clear, known, and standardizable as the ones of a production firm, these evaluations require different perspectives and approaches. In the first section, an attempt will be made to evaluate the efficacy of the research activities; later, will be discussed two different methodologies to evaluate the process efficiency.

7.3.1 Effectiveness

Partially following the example from Giuliani and Bell (2005) and Cantner and Graf (2006), this section will provide an attempt to evaluate the effectiveness of the FBK performance through the usage of Social Network Analysis instruments.

The Social Network Analysis (SNA) aims to study an ensemble of actors, or nodes, characterized by simultaneously operating in a certain context, economy, supply chain, or simply the same system. These actors may be or not connected each other with a relationship, a tie, that can be evaluated for its presence (in a boolean fashion) or its strength, whenever this information is available. The social network analysis uses this nodes-edges representation, called graph, as the object for a quantitative, statistical analysis; the analysis can aim to describe it, as in descriptive statistic, or to provide some information about its dynamics and evolutionary patterns, similarly to a predictive approach.

In the specific case of a research organization as FBK, the social network analysis is particularly fitted to evaluate the effectiveness of its performance. Assuming that the most fundamental of its two main missions is the scientific excellence, and assuming that the organization operates in an open science approach, it derives that the performance can be evaluated through the comparative analysis of its relative status in the scientific community.

This approach will require a suitable data source, which can be easily found among the publications of the European Commission, namely the data relative to the EU Framework for Research and Technological Development, a phenomenon that is similarly based on the same open science principles. Briefly, it is a funding program aimed to support and foster the extent and quality of the research activities of the European Research Area, by the provision of grants for research-based and innovative projects through open and competitive calls for proposal; the FP7 cover the 2007-2013 period, while the H2020 span between the 2014 and the 2020

The general tendency for the selection process of these calls is to favor projects presented by ensembles of research organizations and private firms, usually organized as consortia. The "aggregativeness" of these applications suggests that the participation in these consortia is directly linked to the scientific reputation. It will influence the willingness of other entities to contact, relate and cooperate with it for the purpose of these research grants: the higher the reputation of an organization, the more and more valuable the projects an institution is involved in.

Assuming that the co-participation to a common project is a favorable condition for the establishment of a continuous and proficient relation between organizations, it can be used as a proxy for the presence of a relationship, leading to a method for building a social network. The graph will be composed of the individual institutions, tied by the co-participation to a common project. In this analysis, the graph will reflect the FP7 network, because of its closeness and the larger dataset with respect to the H2020. The dataset will also be purged of useless data, especially grants entitled to a single organization.

Following this procedure, the network has been generated on the basis of 12.126 projects, about half of the FP7 grants, resulting in 851.655 relationships among 29.717 organizations.

Once represented the European research network, the graph can be used to evaluate the relative position and importance of FBK. The literature regarding SNA tools for the descriptive analysis refer to a wide landscape of standard metrics, all differently useful in evaluating the individual position. Among them, the most important are the centrality measures; the most common and simple are the degree centrality, closeness centrality, and the betweenness centrality, which will be used in this case.

The degree centrality is by far the widest used and simplest measure. It represents the connectedness of a node as its total amount of relationships; in fact, it is calculated as the number of ties that connect the node to the graph. Specifically, FBK scored 909 ties, filling the 257th position in the entire FP7. In other words, FBK is among the top 1st percentile of actors by degree centrality. It can be considered a remarkable result, given the presence and competition of significantly larger institutions, among which top-tier academic institutions and massive public research organizations.

Closeness centrality represents instead the average distance of a node from every other actor in the graph. Basically, this index assumes that the higher the centrality of a node, the more directed will be its linkages, instead of being mediated by other nodes. It is calculated as the reciprocal of the total distance, or length d of the shortest path, between the actor v in analysis and every other node t in the graph; it is usually normalized for the total number of nodes not in analysis.

$$C_C(v) = \frac{n-1}{\sum_t d(v,t)}$$

The closeness centrality of FBK has been measured in 0.41493, ranking 1448th in the top 5th percentile. The difference between the degree and the closeness centrality indexes is attributable to the presence in the network of a sizeable number of independent sub-graphs, isolated from the network, which members present a relatively higher score in a smaller environment, thus affecting the evaluation. Nevertheless, it can be considered a positive result.

Betweenness centrality instead evaluates the position of the node as an intermediary, a broker in the graph: the higher the number of shortest paths that cross the node, the higher its index. Its determination require, for the node v in analysis, to compute every shortest path j, k between every possible pair of nodes σ ; for each of them, will be calculated the fraction of shortest paths $\sigma_{j,k}(v)$ which pass through the node in analysis; finally, the results will be aggregated.

$$C_B(v) = \sum_{v \neq j \neq k} \frac{\sigma_{j,k}(v)}{\sigma_{j,k}}$$

The betweenness centrality of FBK has been evaluated in 1644274, 168th in the graph, in the 1st percentile. Again, a remarkable result, which places the organization in a truly central position in the graph, where it assume the role of bridging different sub-graph, realities, or local contexts.

Eventually, this analysis suggests that FBK has gained a position of primary importance in the European network of research and innovation, a result that would be hard to achieve without the performance of an "excellent" research, as prescribed by the organizational mission. Thus, relatively to the period 2007-2013, during the FP7 project which refer the data, it can be stated that the organization has in fact performed in according to, and reached, its objectives.

7.3.2 Efficiency

To evaluate the efficiency of an organization or its processes, the economic literature usually refers to two different methodologies. The first contemplates the tracking over time of the changes in its inputs and outputs, as in the available resources and the resulting products. The second approach requires the comparison of the organization's performance to other similar institutions, assessing its efficiency through the comparison. Both these methodologies, however, present some issues.

Performance comparison over time

In the first case, the basic necessary condition for the applicability of this method is the presence of an effective information system, especially for the analytical accounting, which should keep track of the input resources and the products or services in output. Secondly, to evaluate the very process, it is implicitly assumed the absence of major, uncontrollable change between periods of evaluation; otherwise, the analysis may not be able to distinguish between a difference in performance and the change in context or institutional framework. In the specific case of FBK, these issues do represent a clearly recognizable limitation.

In regard to the first issue, it does exist an informative system, but its effectiveness is limited by a set of issues. The main reason is the need for this evaluation to track the current amount of resources involved in each process, at an institutional level. However, in a technology transfer process, relevant resources include, but are not limited to: the time and effort of researchers and supporting personnel, among which TTO, legal office, administrative, and alike; materials, acquisition or use of machinery; external services unavailable internally. More specifically, the most relevant issue is the ability to keep track of the working time dedicated to each project.

The most representative example regards TTO's officers, especially when the entire office is divided into different units specialized per thematic sets of activities, i.e. marketing and communication, business development, legal counseling, etc. In this case, projects compete for the time of TTO's employees, being them involved in any project that requires their specific competencies. Therefore, the impossibility of estimating the cost in human resources for each single project. Moreover, extensive differences among projects preclude the alternative evaluation through the mean time devoted to each project: the average measure will not be a reliable proxy. In fact, the issue at hand has been cited many times during the interviews of FBK TTO's officers: no employee, from any office, has been able to estimate the average time spent on each project, with lapses that ranged between hours and days.

In the second case, relative to the time series approach, the issue is to distinguish between the impact of external factors and the incremental, endogenous improvement of the process. The first set of factors includes local policies, changes in markets, industries, technologies, industrial context, national and supranational policies. The latter refer instead to the process flows, skills and capabilities of human resources, dedicated financial resources, different inputs, the overall institutional setting, and policies.

The temporal analysis should be based on an economic model complex enough to account for the impact of external factors, in order to not wrongfully ascribe positive or negative trends that can not be controlled by the organization. More specifically, assuming that this kind of organizations has a manageable impact on its context, the model should also distinguish between controllable factors, i.e. the impact on the local workforce training and the market development due to collaborative, government level policies, from truly exogenous factors.

The problem that FBK faces in this specific case, instead, is an ever-changing environment. The continuous refinement, but still a change, in the local government's policy, as well as in the organizational leadership by the Autonomous Province of Trento as founder, blur the distinction between exogenous and endogenous factors. Unitedly to the limited accountability - and process standardization - possibilities, these issues make the evaluation the FBK efficiency over time clearly complex and unreliable. Any further discussion is left to a more competent literature.

Performance comparison between competitors

In the absence of the necessary deep knowledge of the organizational cost structure, the economic literature usually points at the comparison between competitors' performance as an effective, alternative method for evaluating the individual performance. The rationale is that while the process itself may be too complex or unstable, similar organizations that perform the same activity should encounter the same issues, opening the possibility for a comparison and the potential discovering of best practices.

Again, this methodology relies on an obvious, necessary condition: the availability of a similar organization. While the degree of similarity is somehow questionable, some condition should be respected nevertheless. In a general perspective, the organizations should share the context, or at least its major traits; examples are: the degree of technology advancement, R&D intensity and expenditures, the academic environment, local policies, level and competencies of the workforce, neighbour firms and, to some extent, the organization's level of specialization and economic performance, as well as the knowledge and research fields.

At a more operative level, other traits that the organizations should share are: the scale of operations, as in the level of economies of scale at play; the institutional mission; the main type of activity; the income structure. Otherwise, the analysis may highlight the various institutional and economic differences among context or unmanageable organizational factors, rather than discovery the difference in performance that arises from structure, personnel, resources, activity and alike.

This comparative evaluation, however, presents some issues arising the peculiarities of the Italian context in general and the Trentino context more specifically. For the first issue, examples are: the smaller average size of firms, which impact their innovation capabilities and processes; the performance of Italian universities in technology transfer activities, on average lower than the EU mean (Balderi et al., 2007); the limited number of private research organizations to use for a comparison; the related tendency of research organizations to be public, entirely founded and financed by the local or national government. Moreover, the Trentino context itself represent quite an exception to the Italian landscape, for legislative and historical conditions.

Thus, the issue in identifying a suitable organization for the comparison. In the local context of FBK, R&D is performed by the local university, which is not directly comparable due to its public mission and structure; and the Edmund Mach Foundation (FEM), which is, in fact, is the “sister” foundation of FBK. Other technology transfer entities, i.e. the Trentino School of Management and the Trentino Innovation Hub, do not perform internal research activities.

Similarly to FBK, FEM is a publicly-funded research foundation. It performs teaching and training activities, through its internal high school and cooperative doctoral programs. Secondarily, FEM conducts R&D in technological fields, especially biotechnologies and genomics. At the same time, the foundation performs production activities, through the connected winery, and provides specialized services to the local agricultural industry. Lastly, it formally operates technology transfer activities and its organizational structures include a TTO.

However, the differences between these organizations outweigh their similarities. Firstly, the size: FEM employ twice the personnel, of which researchers represent only a secondary component: about 150 scientists. Similarly, the total income is also doubled, while activities focus on the provision of teaching and training activities, and services to the local agricultural industry. Moreover, its organizational structure is significantly heavier and less flexible than FBK: at its foundation, the Autonomous Province of Trento gathered different public institutions, merging them together while maintaining internal separate administrative units for each of them; the result can be seen in the high number of administration personnel, which account for almost half of the employees.

Lastly, and more importantly, the approach through which FEM conceive, design, and perform technology transfer activities is significantly different. FEM perform basic research on topics that are less appliable to the local industry, thus the necessary change in the object of transfer activities. The applied research instead is limited in its extent, as well as its relative impact on the TTO input resources. Last is the provision of specific services, which is actually the focus of the FEM’s TTO. This mix, in fact, inverts the FBK primary attitude toward basic and applied research.

The extensive differences between FEM and FBK indicate that the former is not a suitable alternative for a comparative analysis of performances; yet, comparable organizations could be fund in different contexts. The seek should start from the comparison of local innovation contexts and government policies; whenever a similar context is individuated, the researcher could investigate the internal actor to this environment seeking a similar organization. However, considering the focus and the objectives of this thesis, this procedure, as well as other further developments are left to a more competent literature.

7.4 Policies

FBK addresses its commercial activities through five main policies. While the results of these policies have already been described by analyzing the various internal processes, this section will describe the letter of the individual policies. Firstly will be described the major, central policy, which describes the organizational attitude toward commercial activities; later, will be described other 4 minor policies related.

Policy for the valorization of FBK research

This is the most generic policy, which describes the attitude and orientation of the research organization. It delineates the general policies for the commercial exploitation, spin-offs, and patents while leaving the description of the inner processes and bureaucratic affairs to successive, specific policies. The same policy instituted the internal TTO and declares its functions and objectives.

- **The Innovation and Territorial Relations Area** is a TTO invested with two main tasks: to promote the sensibilization of internal human resources for the direct commercial exploitation, especially spin-offs; and to manage the intellectual property, spin-offs and other commercial activities, including negotiation and contractual activities.

- **The policy for the creation of spin-offs and subsidiaries.** This policy grants FBK the ability to participate in the foundation of spin-offs, by investments in equity, and to sustain the new venture through other means of economic and financial support. FBK may also provide supporting activities as tutoring, networking activities and alike. The main requirement for the potential spin-off is to have as main objective the valorization of research and know-how internally generated; in later stages, at least one member of the Board of Directors must be nominated by FBK.

  The initial proposal must contain a business plan, a draft of the statue, business partners and the composition of institutional bodies. The project will be firstly evaluated by the Entrepreneurship Evaluation Committee (CVI), composed by members with significant experience and knowledge; later, the Board of Directors will deliberate on the endorsement and financial aid to the project. Equity shares will be released after 5 years, other financial investment instead will be withdrawn after 2 years.

- **Exploitation through patenting.** This short policy describes the decision to outsource a significant share of the activities surrounding patents to external entities (i.e. patent attorneys and patent valorization firms). The policy, however, requires the first application to the Italian Patent office, as the first step for the patenting process; at the same time, researchers and AIRT will start seeking for potential licensees. In the successive twelve months, patent fees and legal costs will be sustained by the TTO, but if the patent has gained no interest in this lapse, it will be abandoned, sold back to the inventor, or maintained directly by the research unit.

- **Commercial exploitation of research results.** This last short policy states the limit of commercial activities, which do not comprehend research projects funded through research grants or direct research contracts from private firms. Therefore, the origination of commercial activities is left to the internal, independent research, and collateral discoveries in the excluded activities. If a financial income is gained, the amount will be shared with the researcher and its research unit.

Child policies

- **Policy for the management of the intellectual property.**[6] The policy describes the willingness to protect and valorize the intellectual property, mainly as an instrument for the local economic development. To achieve this objective, researchers are required to disclose the results of their research to the TTO and other dedicated employees; it also anticipates the requirement for researchers to transfer the entire intellectual property relative to the project.

  To foster the individual willingness to participate in commercial activities, the clause for the "fair compensation and protection" of the inventor states that for economic results outside the normal contractual research, results will be aknowledged and fairly compensated. The policy also describes the decisional process: the Center Directors, Unit heads, AIRT and the CVI are in charge of the evaluation of the project and the decision to pursue it, including the requirement for a preparatory a market analysis. AIRT can also act proactively, by discovering the market needs and contacting the researchers.

- **Procedure for patent exploitation.** This policy describes the general process flow for patenting and licensing FBK research. The policy firstly describes a preliminary phase, in which AIRT will provide training activities surrounding the major topics related to patents, and explicitly mentions institutional moments for the internal scouting of commercializable research, through periodical meetings between research representatives and TTO's officers.

  On the procedure itself, the policy divides the process into three stages. The process begins with the proposal, through a formal communication that includes: the description of the technology, its competitive advantages, an estimation of the potential market value and impact. Successively, the CVI will the assessment of the proposal. Lastly, an external organization will be appointed for the legal procedure. Again, contemporary to the first, national application, the valorization activity should start. On the licensing process, is explicitly described the preference for non-exclusive licenses, then the exclusive ones, then the sell of the entire patent.

- **Procedure for the creation of startup - spin-offs.** The policy describes the internal procedure for the creation of spin-offs; this activity is, in fact, more of an institutional objective, with its roots in the original statue and mission which describe the willingness to further and support new entrepreneurship

[6] FBK Policy for the management of Intellectual Property [accessed: Jenuary 31, 2017]

projects based on internal research. Similarly to patenting and licensing, the policy anticipate a preliminary phase and the actual process.

The preliminary phase includes the evergreen training activities, the internal scouting for ideas and projects suited for this channel, the external scouting, i.e. matchmaking tools and events, and the organizational support in the basic concept, as in design, of the project. The procedure itself is structured in seven different stages: the formal communication of intention (1) and the first, generic evaluation by the CVI (2) on its potential. Later, the preparatory stage (3) includes the structuring of the business plan, the statute, and other documents; then, the formal evaluation stage, firstly by a delegate (4) then by the Board of Directors itself (5). Eventually, the NewCo is activated (6) and the formal contractual arrangement between the spin-off and FBK can be made (7).

- **Procedure for the monitoring of subsidiaries.** The statute of FBK, along with granting the ability to spin off new ventures and participate other economic realities, requires the continuous monitoring of these relations. Specifically, external organizations are required to periodically report their financial and economic situation and position to the parent organization. The policy describes two different types of reports: a qualitative one, bimestrial, which should include an analysis of the ongoing performance, and its comparison with the forecasted values presented with the business plan; and a quantitative, semestral communication that should include patrimonial, economic and financial information.

7.5 Recap

Chapter 8

Discussion and conclusion

After the literature review, Chapter 6 presented the major differences between the Univerity-Industry and the Business-to-Business approaches to the technology transfer. The previous Chapter 7, instead, reported the significant case of a private research organization. Bearing in mind the theoretical differences and the real-world phenomenon, this chapter will initially discuss the case study, by highlighting three major positive and negative arguments. Lastly, the chapter will draw the final conclusions, extending the case discussion to a fully private environment.

8.1 Case study discussion

The previous chapter exposed the case study of the Bruno Kessler Foundation, highlighting the main organizational structure, the Technology Transfer Office, research products, and the transfer processes. This section will provide a qualitative evaluation of the FBK overall administration, management, and performances, focussing in the areas in which the Foundation excels (the pros), and the weakness of their business model (the cons).

8.1.1 Pros

By all means, the most evident and positive result of FBK is the research performance. As seen in Chapter 6, the social network analysis of the European network of innovation shown a significant and positive performance, easily framing the institution as one of the top 200 research organizations participating in FP7 projects, even considering the competition from research centers of national and European levels. According to Chapter 2 and following the Chapter 6, the source of the positive performance can be traced back to two main factors.

The first, and most obvious, is the quality of the human resources employed. The performance level heavily relies on the competencies and skills of the researchers, their personal networks, and reputation. Eventually, the organizational success can be seen in the efficacy of the scouting and selection process, among which stands out the ability to attract new researchers. This may constitute one of the most significant and defendable competitive advantages of the organization.

The second factor refers instead to the ability of the Foundation, in its entirety, to constitute an organizational environment and culture that actively support researchers in achieving their best performance. Therefore, the overall evaluation of the organizational structure, hierarchy, reward and promotion policies and alike is, in fact, positive. However, should be noted immediately that the organizational factors that foster the research performance may influence negatively transfer and commercial activities, as later discuss.

Another positive result that should be highlighted is the impact of the institution on its local context, through various modalities. The first and most evident is the impact of a highly skilled workforce, the creative class of Florida (2002). Effects range between informal and involuntary knowledge spillovers, attractiveness for other valuable human resources, higher payroll and their impact on the local economy.

A second element of local impact is the number of spin-offs generated over time. Specifically, FBK spinned 17 new ventures in the last decade, each of them exploiting internal research.[1] Again, the spin-off impact can be evaluated in a number of mechanisms: the diffusion of technologies in the industry first and the market later, the knowledge impact on the local context, the number of employees, financial flows brought to the Trentino economy, the ability to attract external companies or furthering the economic performance of pre-existent local firms.

As for the research, also the spin-off performance should be considered positive, since the Foundation outperforms many Italian public universities and research centers. However, the quantitative economic assessment of their impact is not currently available, nor a comprehensive evaluation model has been developed, and further studies should be performed on the topic.

A third area in which the Foundation excels is in balancing three levels of networking activities: local, national and international. Firstly, an example can be extracted directly from the data on the various contracts (including grant consortia) that FBK signed with companies and research organizations.footnoteExamples can be found at techtransfer.fbk.eu/story Among the first 44 partners, selected by monetary value of the relationships are:

- In the local context: OptoElettronica Italia, Informatica Trentina, Spaziodati, PerVoice, AdvanSiD, Edmund Mach Foundation, Muse Science Museum, CaRiTRo Foundation, Create-Net, EIT ICT, Trentino Innovation Hub (former TrentoRISE), University of Trento, Marconi Institute and the local Health Board;
- In the Italian context: SunEdison, Engineering Ingegneria Informatica, Environment Park, RF MicroTech, Thales Group, LFoundry, Telecom, Cariplo Foundation, National Institute of Nuclear Physics, National Research Council, University of Padova, Verona, Milano, Milano-Bicocca, Pisa, Rome "Tor Vergata", Politecnico di Milano, di Torino;
- In the European context: ST Microelectronics, University of Leuven, RWTH Aachen University, Delft University of Technology, German Research Center for Artificial Intelligence, SAP, Fraunhofer Society for the Advancement of Applied Research, European Space Agency, French Alternative Energies and

[1] The list can be found at techtransfer.fbk.eu/startup

Atomic Energy Commission, CERN, French National Center for Scientific Research, University of Catalunya, University of Valencia.

While this balance may be seen as trivial, it acquires relevance once considering the main modality through which FBK aims to achieve its mission of local development: by connecting the main local innovators to the national and European research network. The nature of research activities greatly influence the business model of research organization, especially for the key partners, and the scale of operations; thus, the largest part of the relationships maintained by these institutions may be expected to be on an international level.

FBK istead demonstrated to possess the necessary ambidexterity to handle the research side of its activities at the national and international levels, while managing the national and local relations with firms and other institutions. More interestingly, this balance seems to have emerged autonomously from the daily operations, without the intervention a specific and structured policy. Thus, the natural conclusion is that, given the original mission, the organizational climate and culture, autonomously and without the influence of internal and external policy-makers, precisely fit the objectives of the organization, and successfully shaping the daily processes.

8.1.2 Cons

While the research performance can be evaluated as positive, the first issue that arises from the study of the FBK's business model is financial in nature, recognizable as a threat in a SWOT analysis. This issue can be recognized in the latest income statement, which reports a total income of 44.5M euro: 30M are provided by the Autonomous Province of Trento (70%), the research grants account for 9.4M (21%), while industry funds represent the 5%, with 2.3M.[2]

While the statement reports a positive balance, it also expresses a major concern: the financial dependency on the funding from the local government. In neutral perspective, the dependency arises from the historical luggage of the organization, previously a public institution; the actual situation can be also considered an advancement from the initial starting point, as well as considering the dependency as a normal condition for a non-profit foundation. However, regardless its internal strengths, FBK truly depends on a financial flow granted from an external entity: without the public funds, the institution will face a considerable resize of its structure, both in term of activities and workforce, including a fundamental change in its business model.

The nature and extent of the financial risks embedded in the external dependency could be evaluated through the assessment of the local policies and government. While this evaluation is left to the proper literature, a major observation can be made. In Chapter 2 has been described the government approach to the universities' administration, mostly pointing toward a greater responsibilization for their

[2]The report can be found in the institutional website

incomes, the self-financing and the economic valorization of public-financed research. Since this shift, the same approach may be expected to take place in the relationship between the Foundation and the Autonomous Province of Trento.

In fact, the change has already begun: the public funds exhibit a slight decrease from 31.5M (2011) and 30.5M (2012-2013) to 29.5M (2014), and the perspective is of further and generalized decrease. Therefore, the safest choice may be to foster internally the research commercialization and the self-financing to anticipate the decrease in external funds. In other words, to reshape autonomously the research orientation toward a more commercial approach, according to the internal culture and environment, rather than being forcibly driven by the lack of funds and struggling in the path. Eventually, a suitable role for FBK in the most long-term perspective on the local innovation system, may be the one of a non-profit organization that primarily perform research for the market, with a positive influence on its context arising as a positive externality of its activities.

This last perspective exposes the next issue: the influence of the local government on the mission and activities of the Foundation. Actually, the two main missions are the scientific excellence and a positive impact on the local context, the result of both its history combined with the newest local policy. This public mission may be a perfect fit for a truly public institution, but it should be re-interpreted for the specific case of an institution that, regardless its legacy and the non-profit form, has clear financial and economic requirements for its survival in the open market.

The original mission required FBK to perform both basic research and applied research. The first, fundamental to the business model, dedicated to gain a reputation in the European research network; the last, as a secondary or residuary activity. This perspective has been further shaped from several interviews inside FBK, which highlighted the perception of employees of the Foundation as a research organization that works within a pure open science system - as in a truly public institution.

While the predecessor ITC was, in fact, a public institution that can afford this model, FBK is a private organization, that must bear with the economic requirements for its survival, needs that acquire a stronger relevance in the perspective of reducing public funds. Therefore, may be advisable an organizational shift, additional and incremental in its evolution, toward a greater orientation to the market; the main objective should be the increase of industry funds, while decreasing the dependency on public funds, eventually fostering the probability of economic survival of the foundation.

The modalities through which implement this shift lead us to the last argument. The question is on what, and how, needs to be modified in order to gain a better commercial performance. In the previous section, has been highlighted how the organization is capable of handling both the research and the industry side of its external relationships; however, the ability does not ensure a greater performance, nor the lack of space for improvements. Specifically, a positive outcome of this ability is the need for a development and evolution that is incremental in nature, rather than disruptive, possibly easier.

The first area for possible interventions arises from interviews among TTO officers, who exposed various difficulties in the disclosure eliciting and, more generally, in gathering information on the actual research interests and topics of internal scientists. These activities actually rely on the pre-existent network of relationships that officers have already developed in the organization, an alternative which exhibits a degree of inefficiency and unreliability. Three levels of solutions may be suggested: the improvement of the organizational culture, the enforcement of internal policies for disclosure eliciting, and the restructure of the TTO.

On the organizational culture, the main objective of any change should be to clarify, communicate and foster, both internally and externally, the organizational attitude and orientation toward commercial activities rather than the open science system. Specifically, the nature of private foundation should be clearly communicated, including the need and willingness to perform research for the market, while the basic research should be seen mainly as a competitive advantage, a tool for building new knowledge to later transfer to customer firms; the positive impact on the local context, indeed, will be the strong but still an externality rather than the main focus.

Intervention on policies may start from the mission itself, to give institutional relevance to the message stated above. Additional and more specific policies may involve the obligatoriness of disclosure, the structuring of a system to codify and share information about current research projects, the establishment of more formal moments of exchange between researchers, and between them and TTO officers.

Thirdly, policy interventions may consider a major change in the organization and structure of the TTO, especially toward a decentralized model. This shift should entail the establishment of bridging position in every research unit, which act as a TTO representative: being this officer already embedded into the research unit, the disclosure should be ensured, while main tasks should include the structuring of commercial ideas, the management of the technical content of ongoing relationships, and alike. The decentralized structure implies the ability to take advantage of the central TTO's specialization for legal activities, marketing operations, and similar processes that entail scale economies.

In fact, the second issue highlighted by interviewees is the need for a more extensive and effective commercial structure, especially for marketing activities and any process related to the seek for customers and the relationship management. Examples are market analyses, the contact of potential customers, commercial communications and advertisement, and alike.

The obvious solution is to hire specialized employees, but this solution is incomplete: the inclusion of new personnel will entail the need for reconfiguring the organizational structure and the process flows, especially to support the efficacy of the new activities and a suitable connection between them and the original organizational structure. The enlargement of the commercial structure may be coupled with the shift toward a decentralized model, by operating on both levels, fostering the effectiveness of the policy intervention.

8.2 Conclusions

The discussion of the case study leads to conclusions in three main areas: the organizational mission, culture, and structure. The original question was on whether, and how, the technology transfer between private organizations differ from an university-industry setting. From Chapter 2 to Chapter 5 has been reviewed the literature concerning the university-industry transfer, and in Chapter 6 an attempt has been made to draw some differences between systems, which however constitute only a preparatory work for the latter conclusions. Finally, in Chapter 7 has been presented the case of a private research organization, publicly-funded but still a private organization closer to the market than a public institution as the university. At the beginning of this chapter, has been discussed the case study, highlighting different positive and negative factors, laying the ground for some conclusion on a larger scale, here presented.

8.2.1 Organizational mission

The first conclusion regards the centrality of the organizational mission and its perception. Discussing the case study, the mission emerged as the factor that influences the most the approach to the technology transfer and its relative performance, the largest differences between public and private research organizations. While it may seem trivial, this idea can be further decomposed into more interesting elements.

The starting point is the consideration that the various kind of research organizations can be represented on a continuum, between a public university with a complete adhesion to the open science approach, and a research organization that performs exclusively commissioned research. In different ways, both extremes deliver only few technologies to the market: while this university focus only on non-commercial research, an organization that performs applied research exclusively on contract does not have the ability to build through basic research a sustainable and competitive knowledge base. In other words, if a private research organization do not perform at least a minimum basic research, in the mid- and long-term it will not have the knowledge necessary to perform the commissioned research.[3]

In the continuum between these two extremes, lie a discrete number of alternatives in the modalities through which an organization can perform and deliver research to the market. Two specific factors should distinguish them the most: the original mission and the organizational structure. Therefore, the most influencing individual factor should be expected to be the mission, as in the overall objective that guides direction and activities, while the structure represents the "supporting environment" that will allow the organization to reach these objectives.

[3] A solution may be the continuous hiring of researchers with new, cutting-edge knowledge; however, this practice will lead to a turnover that suggests to consider this organization as an intermediary between the researcher and the market, rather than a research organization. While these organizations should be studied, they are not the subject of this thesis.

The case study enforces this perspective. Similarly to a public university, FBK does have a public mission: the development of the local economy to further the local society. Similarly to a private research organization, the mission concerns also the delivery of new technologies to the market. The original statue seems to put more emphasis in the first group of objectives, therefore the organizational effort is greater in accomplishing them. On the other hand, following a historical perspective, the balance of these activities has changed over time, toward a more market-oriented mission.

Bringing this set of objectives in continuum previously stated, the Foundation exhibit a distance both from the "public mission" and a "private mission", therefore indicating the discrete number of shades between the two extremes. In a historical perspective, can also be observed how the position of FBK in this line has changed over time, following the need for different approaches for different times and level of local development. The direct consequence is that among alternatives, the mission or group of objectives may seamlessly float to fit the market needs and the local context and society, while balancing short-term applied with long-term basic research for a sustainable advantage.

Mapping to the same space the picture that the economic literature made of public universities, they seem less flexible in changing and adapting to the newest needs, both in time and scope. The public mission of a university, mostly aimed at the historical objectives of basic research and teaching, obstacles the implementation of the third mission, the commercialization of research products, resulting in a limited capability in adapting to the ever-changing economic context, especially in a timely fashion.

Therefore, the factor that differentiates the most universities and private research organizations is the organizational mission. Beyond the obvious differences in their relative objectives, private research institutions exhibit a greater flexibility and adaptability to the economic contest. Eventually, this difference influence also the approach to and the performance in technology transfer. Faster and lighter private organizations perform the best in rapidly changing contexts, as in the role of applied researcher in the knowledge economy, while massive and slower institutions like universities perform the best in research that requires more time, effort, and a more stable environment.

Different kind of organizations are best suited for different tasks: the suggestion is that the contents of the mission, the historical condition that led to it, the ability to change and adapt it, should be a fundamental element in discriminating the activities and the research that should be performed by a private or a public institution, thus the available technology to transfer and the commercial performance. The outcome is the need to further investigate how the differences in content, importance, and adaptability of missions influence the performance in technology transfer among types of research activities.

8.2.2 Organizational culture

The case study highlighted how the ensemble of researchers and officers inside FBK, as in an organic view of the organization, seamlessly and emergently adapted to the change in the organizational mission. As previously stated, despite the presence of organizational policies, i.e. for the patent and spin-off process, they are usually completed by the emergence of organizational practices tacit in nature, surrounded by a network of informal relationships and sustained by flows of knowledge, information, suggestions, opinions.

In this perspective, the organizational culture of private research firms seems to differ greatly from the university culture and environment. Chapter 2 reported how universities may struggle in shaping and spreading an entrepreneurial culture toward a more positive attitude for commercial activities. Private research organizations, instead, do not suffer from this issue: given a commercial-friendly mission, the FBK's case demonstrated how in private organization the culture autonomously embrace, to some extent, commercial activities and technology transfer.

Clearly, the cultural difference entails distinct management practices: whereas universities may need to undertake prolonged and widespread activities for changing the university culture, the private organization will need more subtle and narrow actions. However, while the culture may be already commercial-friendly, firms are still required to govern its development, in order to employ it as a positive driving force. Universities, instead, may be more involved in initiatives suitable to start the culture shift. Therefore, different backgrounds and cultures entail a change in focus for initiatives and management practices, including objectives, mechanisms, and tools.

The main implication of this perspective is the need for the top management of private entities to (1) establish a clear and proper mission, compatible with the market conditions and the local context, and (2) establish and lead activities for shaping and orienting the evolution of the organizational culture. Specifically, the mission sets the foundations, policies sketch out processes and mechanisms, while the fine tuning, which eventually strongly contributes in determining the final performance in both effectiveness and efficiency, may be the organizational culture.

The consequence is a greater importance of the human resource management, especially in the selection process for new hires. Specifically, they must be selected not only for their academic achievements, the crude knowledge, but also and foremost for other basic competencies: the attitude toward the market, the ability to recombine previous knowledge, the willingness to work with and for external firms, the ability and attitude to work with colleagues in different fields, and eventually to promote an informal, continuous flow of information, opinions, ideas, projects. Later, these competencies must be fostered, through training, exchange and alike, through the provision of organizational tools suitable for promoting the further development of the entrepreneurial culture.

By and large, the management of a private organizational culture may borrow some practices from the fostering of an entrepreneurial culture in universities, once adapted for a starting point that greatly differ. Similarly, a research organization may adopt several instruments from the literature of innovation management in private (production) firms, once reconfigured for the difference in activites and processes. Further research is needed to precisely identify the tools that these different realities may share.

8.2.3 Organizational structure

After the differences in organizational missions and cultures, the next step is the organizational structure, which is required to follow this new pattern. The "force" brought in the process by the culture need to be reined and oriented toward the objectives stated in the mission. The most suited tool is the organizational structure: it must be compatible with the culture and objectives, efficient and effective, able to drive and foster the organizational momentum.

Needless to say, the first difference between the university and private organization structures is the presence of a structure for teaching activities, and a different size and hierarchy of the basic and long-term research structure. Instead, a research firm will need a larger and structured department for applied research and the various commercial support offices. In fact, in a private environment, an obvious suggestion is to expand the commercial component of the structure over the single TTO, including marketing and communication, market and business developer, patent attorneys and lawyers.

Another significant change may be the decentralization of the TTO. This model requires the presence of an officer in every research team or unit, in charge for: keeping up with researchers' projects; provide them consulting services; maintain the communication with the central TTO; seek for potential customers; manage the ongoing relations for technical contents. At the same time, the central office should retain only the tasks that entail scale economies or specific competencies and knowledge, i.e. contractual and patent support, marketing and alike.

Significant differences arise also from the hierarchy and the leadership positions in the research structure. The leadership should be stronger, advocating for commercial activities, with a comprehensive perspective both on the internal competencies and the external technology trend and market needs. Leaders should also foster the usage of institutional moments of exchange and cross-contamination of ideas, as well as endorse researchers in the development of their own projects of technology transfer.

A specific topic is the evaluation of private researchers, which should be performed through other means with respect to the university environment. Indicators may include the number of active and successfully achieved projects, weighted for their challenges and the relative difficulty, the number of projects proposed to the TTO, and alike. The quality of the produced research should also be included, but it should be considered secondary, in order to urge researchers to commercial activities. Private organizations should also be easier to take advantage of a 360-degree evaluation, including team leaders, colleagues, customers, and especially the TTO.

8.3 Concluding remarks

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