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Technology Transfer: substituting universities with private organizations.

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Abstract

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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.

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Chapter 1

Introduction

Definitions, perspectives, issues

In layman's terms, Technology Transfer can be broadly defined as the process that takes research results to final 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 large literature is that even the technology transfer itself has no shared definition, and no unique notion can possibly comprehend every characteristic, angle and shade. Anyway, a simple and recognized definition can be taken from the Association of University Technology Managers: "the process of transferring scientific findings form one organization to another for the purpose of further development and commercialization" (Genshaft et al., 2016). Even Bozeman (2000), in his well-known review, recognize 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 better explain the aim of this process, is the one given by 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) observe 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) states that 65% of scientists have experienced 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 direction.

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) uses an historical perspective. He divides policies regarding generic technology development and exchange in three consequential paradigms. The first was the market failure paradigm, which identifies an historical moment with clear negative externalities, extremely high transaction costs, unavailable or distorted information, creating the opportunity for a government intervention. His 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 recognize 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 refer 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 sustain 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 state 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) use five stages to illustrate the shift in the University 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 acknowledgement 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 seek for a 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).

In fact, 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 form publicly funded research (Bercovitz and Feldmann, 2006).

Questions have been raised on 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) has been criticize also 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 will never be introduced without the university contribution (Bekkers and Bodas Freitas, 2008).

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

Moreover, if knowledge and technology remain key factors in firm competitiveness, and if a significant part of this innovation continues to be generated into 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, form both public and private entities; a growing importance of (technological and scientific) entrepreneurship and of intermediating entities.

This perspective match he one of O'Shea et al. (2004) who recognize the growing importance of knowledge creation and exploitation, especially the one linked to new technological-based entrepreneurship. These firms 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 researches 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 context, 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 researches focus mainly on mechanisms that can be easily codified, but have their limits in the weakness and limited information they provide in respect to the magnitude of the phenomena. In other words, the easier are to gather data and information about a phenomenon, the better understood it will be.

The same author observes 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 arise from the difficult in the typicization of the phenomena.

So, academics has a deep understanding of the technology transfer between university and, ultimately, the market. But the same literature has quite overlook 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 institution? 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 obsolete, when referring to private entities?

To answer this question, firstly will be constructed an organic review of the overall literature. Will be considered the main authors and publications in the last decade and a half, in an attempt to cover the most important contributions. There is no ambition in cover all the knowledge related to the process, given the extremely large corpus of scientific publications related; however, an attempt will be made to draw 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 of the topic.

Chapter 2

The University Side

And internal actors

2.1 University as institution

The first university has been founded in the 1088, but the “scientific” approach and role we usually acknowledge them for has come only in the 17th century. The “open science”, that has 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 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 form the appropriation of newly created value and the reward for commercial exploitation in exchange for the disclosure.

Clearly there is a conflict between these two models, enforced by the increasing focus of universities and public policies on commercialization activities, further challenging the culture of open science. In fact, academic scientists’ fundamental devotion to the open science paradigm created 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 open 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 could be the phenomenon of “patent-paper pairs”: starting from the same knowledge, a patent will be firstly applied for, then a paper will be publisher after the delay required by the patent process (Murray, 2005). In this model, the needs of both parties will be satisfied: the publication, for academic purpose, and the IP protection, for commercialization. In fact, even scientists themselves are interest in protect their ideas, as patents have become important bargain chip - a currency in the knowledge economy.

A different terminology is used by Stern (2004) who refer to a “science approach” quite similar to the open science approach. He defined it also (and most interesting) 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 each system: basic and applied research. Many organizations tried to mix these elements, but the tension among them lead to extensive differences in objectives and administration, including major difficulties in managing the conflicting goals of curiosity-driven research and commercialization activities, left alone the various shadows between these extreme points (Rasmussen et al., 2006).

A first argument could be the one of Geuna and Muscio (2009), in favor of the new commercialization model, who stated that the mission of creating and disseminating “knowledge for its own sake” can 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 were developed specifically to meet requirements of firms. Balconi and Laboranti (2006) noted that universities must be “intimately familiar” with industrial technology, in order to identify and perform useful research. Moreover, the technology transfer is a two way knowledge flow, where academics can benefit too.

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

Siegel et al. (2003a) instead defend the open science system. Firstly, he reports interviews where the commercialization mission was seen as inconsistent, with the traditional public domain philosophy that should be endorsed by public institutions. Then, he refers to a trade-off stated in Nelson (2001) where “the shift away from open science might slow down technological diffusion”. Also Stern (2004) states 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) report various changes in the government control and administration of universities, generally aiming towards a greater autonomy and competitiveness through a performance-based funding. However, even if the change itself has no positive or negative connotation, he seems to agree with others, arguing that academic freedom and basicness of university research may be treated by commercial activities. Others expose their concern about the shorter time horizon imposed by a more applied research, various tensions and conflict of interests.

Murray (2005) takes a case study as exemplification of the actual 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 limits in the acquisition and usage of oncomouses, the informal exchange of relative knowledge, and the appropriability of "reach-through" discoveries, leading to "a widespread infringement" from scientists.

Similarly, Stern (2004) empirically investigates this scientists' willingness to perform basic or applied research within these different systems, to get a better understanding of their true 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 employer organization's science approach and the premium wage they must pay.

Elsewhere, other authors criticize more directly the way universities are currently interpreting the phenomenon. Siegel et al. (2003a) consider the university management of IP rights too aggressive, and report a conflict between the overall willingness to commercialize and tenure and promotion policies, that promote scientific publications and grants. Murray (2005) instead observe that an extensive protection of intellectual property require 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 of 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 seen the emergence and consolidation of a "third mission", alongside the research and dissemination objectives. This additional aim requires universities to bring research results into the market, not only for fund raising purposes (even if it is usually pointed as the main reason) but also for economic development, technical advancement and wellbeing.

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

In this new economy setting, 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, evaluate 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 main purposes are to (1) conduct research and (2) train graduate students to perform research. In fact, these universities are considered more effective in the knowledge transfer, relatively to federal laboratories (Rogers et al., 2001), but they still miss the acknowledgement of the growing role of knowledge and technology advancement in this era, jeopardizing the 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, that are actively pushing universities to directly engage in technology transfer activities, i.e. contract and collaborative research. Contemporary, these can be seen as a recognition of the great endowment of knowledge-based assets owned by universities, that is seen as 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: his though is that the "ultimate sense" of these institutions is to set the foundations for new developments. It is implicit that the necessary condition for this is that universities must possess the necessary knowledge and a climate.

But what changed overtime in a more operative perspective? Early in the days, when the third mission was not so well established, the technology transfer heavily relied on personal relationships of academics, and there was only a few institutions that has 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)recognize now, instead, is the large trend to professionalize the technology transfer and the third mission of universities, whereas industrial R&D is getting more and more directed toward commercial ends (Fritsch and Slavtchev, 2007).

But what he acknowledges as source of this discontinuity is 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 governments; greater budget constraints and diminishing incomes from governments. Another perspective is that in the "scientificaton" of the industrial production process, 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 evidences 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) reinforce this view stating some non-obvious factors that has driven to a greater involvement of universities. First, innovative technologies reduced the need for concentrating research activities in large facilities that can afford certain costly machinery, allowing smaller centers to be competitive in performance and effectiveness. Secondly, the policy shift in allocation of intellectual property rights act as a motivation for researchers to get more involved. Third, he observes that these factors, unitedly to the declining amount of public funds, lead to an increasing competition for any source of funding. In this perspective, this process has become of "vital importance" for universities (Muscio, 2008); however, its use as funding source is a secondary objective (Jensen and Thursby, 1998).

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

In this setting, Wong and Singh (2010) investigates the impact of technological commercialization on publication activities: he 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 researches, gain insight and knowledge on practical problems, for teaching purpose, students internships and placement, to look for business opportunities.

Closing the stakeholder perspective, governments need universities to accomplish various tasks, especially referring to the regional innovation system (Fritsch and Slavtchev, 2007; Balderi et al., 2007): 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 firms. Azagra-Caro et al. (2010) directly 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 spinoff formation, a highly prioritized area for governments.

In fact, universities have a "special" attention for matter of national institutions: Rasmussen et al. (2006) observes that universities "seem quite eager to satisfy public expectations, which in turn generates goodwill from research councils and ministries", referring to the issue of decreasing funding. This expose 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 later.

These forces have led to a true change in the attitude of universities; Tijssen (2006) describe this shift toward 3 different phases of development. The first is the "application oriented - science driven" approach, that coincides with the rising awareness of possible link between universities and companies for the resolution of industry-related problems. Later comes the "product oriented - utility driven" approach, that consists in the emergence of activities such as prototyping, development services etc. specifically aimed to the discover 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 indicate "soft emphasis on commercialization".

What this historic perspective cannot illustrate are the challenges that universities are facing in this new system; Rasmussen et al. (2006) divide them in 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 the contribution to the economic development, both at a local and a national level, to justify the university's funding requirements with their 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, greatly different mission required by stakeholders with different purposes. What is needed, to overcome these challenges, is ambidexterity: universities nowadays should not draw a clear line between exploration and exploitation activities. They should manage their relative tension, integrate them and take advantage of every potential synergy.

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

In refer to this ambidexterity capability, many authors assume an historical perspective to identify and evaluate the most common constrains 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) refer to this problem as the "social-contractual commitment of universities to the intellectual commons", which constraint their ability to exploit economic opportunities. Muscio and Pozzali (2013) instead observes 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, and the modern commercial approach, filled with business values.

In this perspective, every university has its peculiar historical path. In fact, many authors found these as one of the most relevant factor in their comparative analysis of technology transfer performance. As an example, O'Shea et al. (2005) identify the "uniqueness of historical conditions" as the basis for a sustained competitive advantage, when evaluating spinoff performances.

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

However, has to be specific remembered that there are also empirical evidence to discredit this correlation, at least in particular perspectives, like the results showed by Thursby and Thursby (2002) who find evidences for a little effect of past (licensing) performance on the propensity of the university administration to further promote (patenting) activities.

2.1.1 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 can play a role in determining the technology transfer performance.

As a starting point, the most recognized factor that influence the university 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 its 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 technology transfer willingness and engagement, 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 commercial orientation, are a series of factors that can be referred as 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 member championing for entrepreneurial projects, on-campus incubators, investments in startup, earlier and easier access to venture capital (Baldini et al., 2007). Guerrero et al. (2014) uses 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 research by D'Este and Patel (2007), on whether the founding mission specifically includes the university support to regional development; in fact, he found a significant and positive relationship with commercial engagement.

The literature has considered other university-level factors that refer to the actual, processual ability 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 research aimed to uncover the influence of organizational structures and governance on the engagement, which have 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 its performance analysis that there is deviation from the best performance that cannot be completely 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 specific industry. Performance of academics involved in such divisions has been found to be superior, and the gap widens over time.

The latter configuration refer 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 new, dedicated units and the importance vested in them are found to be relevant; other internal and external units or agencies that can help are the Technology Licensing Offices, Industry Liaison Office, incubators, science parks, joint ventures, spinoffs (Tijssen, 2006). More information on the topic will be provided later, but it is essential to understand the role of the university administration.

A related topic that has gain an increasing attention refer to policies regarding the evaluation of academic research 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 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 universities live in plays 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 form top tier universities can reach discoveries faster, through an easier access to the personnel 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 spinoff.

However, scientists differ in their willingness to get involved into technology transfer. Many researches have 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 in three different categories, according their interests and orientations.

The first is what he called the Edison scientist: an academic who is interest only in purely applied research, oriented to the development of new product to meet people's needs. At the other end, there is the Bohr scientist that was intended to be a pure, basic scientist who most strictly adhere to the open science approach. Between these extremes, Strokes identified the Pasteur scientists as the most relevant for the technology transfer process, who presents as a main trait the desire to advance scientific knowledge, but only in fields or applications that can have real-world, useful applications. Ideally, this academic employee had 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 dual categorization, useful even if simpler, in which scientific occupations have been divided into two distinct types (Beath et al., 2003). On one hand university scientists perform fundamental and basic research, motivated by the desire and the reward of establishing their priority on the discover. On the other hand, private sector researchers which has 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 investigate the impact of the organizational orientation on scientists' wages, comparing public research organizations and private firms. He starts form two different assumptions: researchers may have an intrinsic preference toward the open science approach, while firms may have economic interests and benefit for 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 show that, once controlled for the relative ability of researchers, there is an actual premium wage payed by "closed" firms devoted to the protection of ideas, and that it is considerable in its extent, evaluated in around 27% of difference 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) recognize 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 find that both types of scientists express concerns for various constrains due to commercial exploitations, and they still may engage 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 his open science approach, still the most diffused today, shapes various factors that influence the academic willingness to engage in commercial activities. The main group of variables refer 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 form external influences that might carry unwanted constrains in time and effort. This is partially due to the "ambiguous relationship of researchers to money" (O'Shea et al., 2004), that refer to the disinterest nature of university research and thus the seek for public funding that enable academics and teams to work completely unrelated and free from industry-related constrains.

A recognized factor related to this perspective is the unwillingness to delay publication of many researchers (O'Shea et al., 2004; Thursby and Thursby, 2002; Baldini et al., 2007). The main driver is the "publish or perish" rule, that require academics to continuously publish in order to gain, and not lose, reputation. These delays may arise form: 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 advantages; 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 woks, 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) express 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. He 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 positive 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 on a first sight the average relative impact factor could be diminished; oppositely to Lee and Bozeman, however, he 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 constrains that commercial activities may impose, and the negative impact that could have on their career; these worries may arise from poor information and a low 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 stated, the open science culture may have a negative effect on scientists' engagement with industry; however, many factors have been found to influence on 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 (O'Shea et al., 2004): outgoing, extrovert personalities; a strong need for achievement; the desire for research independence; 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 to increase their reputation and to build more extensive and valuable social networks; later, reached a satisfying level, they try to building legitimacy for their invention Fini et al. (2009). However, empirical findings from D'Este and Patel (2007) suggests 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 spinoff 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 the individual 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, the primary motivation for the academic scientists seems to be the recognition among the community and the reputation gain: collaborating with industry can help publishing in top-tier journals, conferences, federal research grants.

As largely recognized, technology transfer positively influence the research performance through the bi-directionality of 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, to verifying the applicability of the research, to 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, but also alter through its actions what is perceived as socially desired. The cohort effect (Bercovitz and Feldmann, 2006) refer 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 author found relevant a previous experience, especially a formal academic training (i.e. the PhD itself) in an institution which present a good performance in technology transfer. Similarly, Murray (2004) and Link et al. (2007) demonstrate 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 founds 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 well managed, 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 author address this issue modelling 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; expectably, the preferred form is the sponsored research, which among other channels allow scientists to continue work as they prefer, i.e. in-house with their own teams, on selected topics. Another suggested compensation is the equity share, that Jensen and Thursby (1998) found to be of less distortion on firms' and academics' decisions. Further attention should be placed in the form choice, especially when it comes to the various, unwanted effect of each channels and the conflict between them: an example form O'Shea et al. (2004) is that higher royalties allocated to academics will decrease the spinoff 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) agrees on the point, stating that fund rising performance can act as a signaling mechanism, positively affecting the reputation. Rizzo (2015) adds two financial motives specifics to the spinoff 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 (Link et al., 2007; Baldini 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 champion, 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 the environment, which should balance emphasis 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 require a specialized intermediator that can comprehend and effectively relate with both sides. The generalized acknowledgement and recognition of this problem led to a recent and substantial increase of 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, in this stage, is whether or not the idea has enough appeal for the market.

Secondly, if the invention match 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 passage: to identify a potential, interested partner, and to establish a value for the transaction. Specific to the latter issue, there is the problem of estimating a new, unknown technology, which involve 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, let alone a failure 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 three 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 will allow a competitive performance on this topic, will be the same that allows the overcoming of all issues.

This 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, while firms about the market; however 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) observes 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 identifies the source of these constraint 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 industries while providing indications to scientists on which idea to develop (Debackere and Veugelers, 2005). Moreover, intermediaries can balance the low bargaining power of individual scientists (Bercovitz and Feldmann, 2006), and also overcome the opportunism problem.

To uncover this last, specific benefit, some researchers have modelled 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, therefore 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) comes at the same conclusion: in a repeated game, intermediaries have the incentive to "behave honeslty" 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 push toward the concentration of intermediaries: first, a critical mass of inventions, thus the related research activity, is required to achieve a relative 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 larger the intermediary, the greater the opportunity to attract valued human resources and to economize on this key element.

Third, even if specialization is common in markets with intermediaries, the same force could lead to inefficiencies: in this peculiar 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 incentive 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 be 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. when they are internal to or participated by public research organizations, they are also required to manage the patent portfolio, requiring again additional personnel like patent attorneys. Empirical findings have demonstrate the importance of these specific professionals (Siegel et al., 2003a), in order to protect and market inventions and securing 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 spinoff, 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 to 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 configuration 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.

As a general categorization, an ideal starting point is 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 identify as "emblematic types" university TTOs, community college TTOs, public research organizations and non-profit organizations.

In fact, 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 make an useful example of these differences, Landry et al. (2013) turns to the knowledge value chain construct: the development of an idea can be divided in three non-linearly consequential 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 phenomena. 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-fund 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 is for 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) propose 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), which 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 researches suggest that most universities employ only few employees 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 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. 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 academics through proximity and avoiding possible conflict of interests (Debackere and Veugelers, 2005). However, this organizational solution compromise the exploitation of synergies among activities and topics, other than 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 (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 spinoff 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) differentiate 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 particular useful solution in the case of smaller universities and fragmented environments (Debackere and Veugelers, 2005).

2.3.2 Organizational 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 have modelled 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 obvious impact of university-level regulation and incentives, TTOs have a peculiar, major factor at their disposal, to enhance the attitude of scientists to disclose: their reputation. By demonstrating a deep understanding of both academics and firms, and by building a history of successes, TTOs can make themselves perceived as professionalized and useful, thus acquire credibility and gaining the trust of academics (Owen-Smith and Powell, 2001). Specific to the importance of the ability to understand firms and markets, 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 in 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 have 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 itself on the goals set by the university administration. Two main model 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 faculty and academics involvement, thus a lower performance.

The second model, apart from being preferred by scientists, would be the natural path for technology transfer officers: a survey by Jensen and Thursby (1998), demonstrate 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 government. This may be the main factor explaining why the technology manager interviewee see themselves as "juggling" between different interests, trying to maximize a weighted average of the administration's utility and the inventor's utility.

Fitzgerald and Cunningham (2015) use a quite different approach to uncover drivers and models beneath TTOs activities: their mission statements, that are 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 for a strategic plan, thus influencing the personnel behavior and their performance.

He reported in his empirical research that even if almost all mission statements 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 constrain makes TTOs concentrate in the core activity, identified in the management of the IP portfolio.

More recent research reported a shift, or at least an enlargement, of the TTO main activity: Geuna and Muscio (2009) reported as main focuses (1) patent and licensing activities and (2) the creation of spinoff. Even if he mentioned also contract research and consultancy, it is important to note that in his view the focus has shifted 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 is reinforced by Balderi et al. (2010) who identified as main activities patenting and licensing, spinoff and other activities complementary to the first ones.

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

- Facilitate the management of activities and projects: 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 spinoffs;
- 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 controlling and managing 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 difficult in monitoring research activities and comprehend which results may be susceptible of commercialization, while on the other hand TTOs usually have resources and time constrains that impede the eliciting activity.

This scenario highlight the importance for TTOs of having highly skilled and trained professionals. Every activity requires specific knowledge and often interdisciplinary competences: 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 technologies 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 provider, both specialized in one activity, i.e. patent attorneys and technology consultant, 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) reinforce 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 (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 the its supportiveness to general policies and the administration.

A fundamental study on this topic is the one authored by Owen-Smith and Powell (2001). He found three significant factors for the institutional success of patenting, as one of the technology transfer channels: (1) the faculty perception on the potential benefit 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, thus influencing the individual behavior.

Firstly, promotion and tenure policies may be shaped by the university mission and orientation, but are enforced by faculties and departments. Moreover, they are also 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, Owen-Smith and Powell (2001) empirical findings suggests 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, per member, received from industry which is found to be correlated with future engagement in commercialization activities (D'Este and Patel, 2007). Also Blumenthal et al. (1996) in earlier days found evidences that industry-funded faculty members are commercially more productive, suggesting a Matthew effect. Similarly, Thursby and Thursby (2002) empirical findings 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 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) indicate that, apart from its effect on the volume of interaction, it influences also the preferred channel; specifically, he found that researchers in lower rated departments tend to prefer consulting, whereas departments with higher evaluations and income are more likely to engage in more frequent contract research.

The impact of the faculty's scientific field has been extensively studied. Firstly, there is no doubt that cultural norms across fields may be important (D'Este and Patel, 2007); secondly, the nature of the research – its applicability in industry matters – 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, because 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 publication delays 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, engineering, increase technology transfer. However, Owen-Smith and Powell (2001) observe 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 refer to the impact of research areas and the cognitive distance from the related industry: surprisingly, Muscio (2010) found that departments with greater cognitive distance from industrialists do collaborate more. This finding support the theoretical literature that suggested 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 university systems, can lead to this contradictory result.

Finally, faculty benefits from technology transfer usually refer to the individual benefits, and the impact that these could have on the research performance of the overall personnel. Baldini et al. (2007), for examples, indicate 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 of engaging in technology transfer.

Chapter 3

The Industry Side

Firms, spinoffs and others

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 observes 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 stated and demonstrated; more specifically, many authors highlighted how innovation activities are necessary for competitiveness. Beath et al. (2003), in example, states that firms do depend on continual improvement, either in processes and products, whose source is the applied research. Yusuf (2008) argues that firms need to sustain innovation processes, in order to sustain their competitiveness. Jimenez-Barrionuevo et al. (2011) refer to the knowledge base as the most strategic resource a firm can possess and deploy for obtaining a competitive advantage. Siegel et al. (2003a) observes 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) notes 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 makes 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; 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 represent a point in the continuum between these extremes; secondly, open innovation can be pecuniary or not, inbound or outbound.

This particular system, which has gain a considerable attention in 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 that this approach may 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 extend 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) report 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) reports 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 spinoffs (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 knowhow and new technologies: a concept named absorptive capacity.

3.1.1 Absorptive capacity

The absorptive capacity is a construct originated from the seminal paper of Cohen and Levinthal (1990). They initially state that is critical for firms to have the ability to recognize the value of, to assimilate and exploit external knowledge. More important, they hypothesized that this ability is mostly determined by the level of internal knowledge that the firm already possess. 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 increase 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 sense, learning is cumulative: it is easier and faster to absorb a knowledge that relates with 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, in an iterative cycle. However, if 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 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 refer to the exploitation of both internal and the new acquired knowledge, combined in a competitive configuration.

Later authors use 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 ad reconfigure it for a latter purpose. 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 study the absorptive capacity in 4 dimensions, as a process; notably, he argues 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 depend on a preliminary evaluation of the technology, which require an initial, even if simplified, assimilation. Similarly, the "transformation" process may depend on the results of the commercialization phase, which may require additional development of the technology, thus its transformation. Lastly, the "exploitation" stage create 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 refer 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 provide empirical evaluations on the importance of this concept. An example comes from Nieto and Quevedo (2005): in his 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 form 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 arise 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 is 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 allow 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 resource 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, gain flexibility through 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 is 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 investigate the impact of universities on localization choices of firms. The rationale behind his 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, he define 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, he 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, his 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 have in shaping a network and the firm position. Zeng et al. (2010) instead, provide an insight into the relation between the network activeness of actors and their overall economic performance: he found a significant positive relationship between the cooperativeness of the firm and its performance, especially for inter-firm cooperation and SME. However, he found weak support for the impact of cooperation with research institutions, universities and governments, opening a quest for further investigations.

3.2 Spinoffs

Spinoffs are one of the most important and effective channels for technology transfer, but they also represent an external entity. In its industrial definition, a spinoff is a new entrepreneurial activity born from knowledge, technology or other activities of a parent organization. In the case of university spinoffs, 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, spinoffs' 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, both in employment and financial terms (O'Shea et al., 2004), as well as their unique role in catalyzing knowledge and technology. They prove 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) suggests 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 spinoffs 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 spinoff performance, a starting point is the "astonishing survival rate" (Balderi et al., 2007). In its 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 spinoffs created the 77% of induced investment and 70% of the employment, in respect to the overall MIT activities.

However, even if spinoffs seem a particularly effective channel for university- industry technology transfer, it requires longer periods. As example, university spinoffs graduate later from their incubator, 2 years compared to 1 years 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 establishment and the actual generation of economic benefits (Leitch and Harrison, 2005). Similarly, Pérez and Sánchez (2003) states that a rapid growth is "both rare and often even unwanted among spinoff", due to the high uncertainties involved in the process.

At the base of the spinoff absorptive capacity, which allow them to gain a similar 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 spinoff sees them as standalone technology transfer channels, they are separate entities: this will require a transfer between the original institution to the spinoff, and later between the new venture and the market.

This means that every channel of technology transfer may be applied to the spinoff firm itself. In example, Pérez and Sánchez (2003) cite training activities in the initial stage, consulting and product development in latter phase between the spinoff 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 spinoffs are the size of the customer base and its great flexibility. For the former, spinoffs usually have only few customers in initial stages of technology development, which will serve as lead users and validators. For the latter, spinoff firms usually are smaller, flexible organizations which can adapt faster and efficaciously to new technologies and market needs.

Their peculiarities influences 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 licensing and development of infrastructures. Druilhe and Garnsey (2004) further categorize spinoff 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 among 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 sources for tenured academics.

3.2.1 Types

Spinoffs are only a small fraction 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 academic spinoff phenomenon, a comparative approach can be taken.

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

Widening the corporate spinoff concept, Colombo et al. (2010) consider the category of New-Technology Based Firms (henceforth NTBFs). The author uses 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 is that academic spinoffs, 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 spinoffs to perform better than other NTBFs, as suggested from their empirical results.

Mustar et al. (2006) use a similar category, Research-Based Spin-Offs (RBSOs) when investigating the different challenges that academic and industrial spinoffs may encounter. He 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) analyze the case of second-generation spinoffs (a spinoff generated by a spinoff) with mixed characteristics from both the industrial and the academic environment.

The same author distinguished among university spinoffs, 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 spinoff category, however, a difference has gained far more attention from the literature: academic entrepreneurs versus surrogate entrepreneurs.

Radosevich (1955), in particular, analyzed and compared these different approaches to the spinoff entrepreneurial leadership. The first kind, the academic entrepreneur, refer 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 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 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 spinoff 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 spinoff process, by modelling 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 spinoff.

3.2.2 Factors

Academic and industrial entrepreneurs may be driven by two generic kind of forces: the opportunity, which arise 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 a greater 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 spinoff founders (against non-spinoff company founders). Siegel et al. (2007) found determinant the involvement in local groups, especially the ones with a great entrepreneurial attitude, and suggests 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 his empirical research, a positive relationship between the university's stock of knowledge and the amount of spinoff generated, as well as for the availability and expenditure in the TTO and proper, professional advice. Other relevant variables are linkages with other universities and the faculty involvement in the spinoff management, which however has may delay, rather than facilitate, the spinoff 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 constrains, availability of venture capital founds, 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, technology related factors refer to its characteristics, 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 spinoff channel a suitable alternative (Rizzo, 2015).

3.3 Other external agents

3.3.1 External 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, consortial 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; he 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 researches show that over an 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 on 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 explore 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-participate 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 External 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 proof 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 observes how European's and national governments' approaches on 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 aims to promote cutting-edge research projects and help 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 spinoff process. The two main institutions that will be 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 spinoff in accessing financial resources.

Clarysse et al. (2005) analyzed incubators' activities to uncover any difference in their approach; he 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 spinoffs 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 spinoff, incubators provide access and integrate spinoff 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, in 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 promote 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.

Chapter 4

Channels

Mechanisms and processes

4.1 Channels and categories

A technology transfer mechanism can be defined as an instrument or a channel 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 exist 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. He 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, he 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 valuate 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 modelling 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 perspective come from Gilsing et al. (2011). In his 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 more applied, systemic and interdisciplinary knowledge specific to industrial applications; 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) separate 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 grouped 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: spinoffs, licensing, publications, meeting, cooperative R&D. Debackere and Veugelers (2005) further differentiates 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 differentiate between: transactional, i.e. patents, licenses, spinoffs, 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, spinoff and research contracts by modeling the choices that public institutions can take. The two main alternatives, in his view, are to diffuse the new technology through publications, congress, and other non-contractual mechanisms, or to protect and privatize the research results. In this 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 spinoff, exclusively or not. In the latter, should be preferred mechanisms such as training, consulting, collaborative research and alike.

Lastly, the literature mainly regard two main channels: patents and spinoffs. As previously stated, the concentration of researches 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 spinoffs, 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, spinoff 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 problematic 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 many empirical researches indicate that this may be unnecessary, and the institution unwilling or unable.

Jensen et al. (2003) investigate this issue by modelling 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 author suggests 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 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 appear interested, starts the phase in which the counterparts negotiate the license agreement. In the case of a negative result of the negotiation, and in the case of a successful one which comprehend a non-exclusive license, the process may continue by seeking another potential partner. In any case of a successful negotiation, the new born relationship among organization may require maintenance and, occasionally, the re-negotiation of the agreement (Siegel et al., 2003a).

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 success 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 author 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 researches (63%), industry (17%) or unsponsored (18%). Elsewhere, has been found a concentration of inventions in a few areas, specifically schools of science, engineering, medicine and nursing. However, this concentration around specific topics has been largely discuss later, but the most part of the literature agrees on the best performance of applied sciences.

Jensen et al. (2003) specifically studied the optimal license contract. Firstly, inventors cannot be effectively monitored and enforced during the further development; this moral hazard issue, unitedly to the asymmetric information issue, require the usage of a mixed payment, i.e. a mix of fixed fees, up-front fees, license-issued fees, royalties, milestone payments and alike which may induce efforts from the inventor; equity payments should be preferred. The financial value of these incentives should outweighs the inventor 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 do 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 perspective in fact allow a better understanding of how critical has become this issue in 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 receive 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 Duke's 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, this 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 the 1980, this law focused on the intellectual property arising from federal funded research: at the time, only few research products were being patented by universities, as an underutilization of federal funds, thus payed taxes. The new legislative approach assigns the university the ability to patent and possess research results, in order to use the potential financial outcome as an 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 author found a relative decline in effects since the 2000: 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 a 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 the patent 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 applicant tend 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 Spinoffs

As previously stated, spinoffs 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 spinoff 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 have 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). He divided the generic entrepreneurial process, with no direct reference to the spinoff 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 refer 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) propose a different three-stage model for the spinoff 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 put a little attention into the opportunity recognition.

Degroof (2002) instead suggested a six-stage model, which require 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. Selected spinoffs 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 from Ndonzuau et al. (2002), who modelled the spinoff 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 competences in opportunity recognition. The second stage refer 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 it, how to exploit it, and how to finance it. Thirdly, the spinoff 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, he found relevant the opportunity recognition, but he focused on two other topics previously overlooked: the decision to commercialize and the choice between channels. For the first, he 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 author 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 milestone the licensing and the spinoff channels, based on the estimated financial returns, academic willingness, 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 model has been described by Vohora et al. (2004), who uses 5 stages separated by 4 critical junctures. The process starts with the research stage, which end with the opportunity recognition: the author described this critical juncture as "the match between an unfulfilled market need and a solution that satisfies the need that most others have overlooked"; the overcome of this issue require 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 opportunity. At the end of these activities, the issue regards the entrepreneurial commitment of researchers; the author 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 regard the pre-organization, in which will be established how to exploit the opportunity and the involved researchers and TTO's officers starts 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 spinoff finally left the umbrella of the originating institution and enters a pure commercial environment.

4.3.1 Entrepreneurs and teams

The spinoff process involves a multitude of different individuals and institutions, from the inventor, the parent organization, external and surrogate entrepreneur, 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, he starts from the hypothesis that TTO officers, venture capitalists and other actors tend to support spinoff 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"; Shane empirically confirmed that this is actually the kind of inventor that TTO officers tend to favor.

Secondly, Der Foo et al. (2005) study 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 internal to the new venture, rather depending on the marginal ability of individual employees to bring new experiences and fields of knowledge. He differentiated between task-related and non-task diversities, i.e. education, work functions and company tenure versus personal and psychological attributes. He found a little empirical support for a positive correlation of task-related diversity and investors' evaluations, a negative one for non-task diversities, suggesting the relative 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 investigate 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 author 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 spinoffs, 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, acting as a compensation mechanism. It is important to note that the various forms of sponsored research are not exclusive, and can 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 provide only the financial means for the research activity or a previous protected intellectual property, while the research organization provide 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) refer 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; he focused on publication of outcomes, indemnity responsibility, ownership of outcomes and compensation forms. He found the optimal combination in a contract that (1) allow 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 seem 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, Aristei's empirical results indicate that the typical firm engaging in research cooperation is R&D intensive, makes a wider use of IP rights, takes benefit 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 depend on different forms of previous linkages other than the past experience, i.e. job mobility and other informal linkages. In fact, his results show 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 his 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 typical narrowed focus of TTOs on patents and spinoffs, only a part of university knowledge and research can be codified into patents, while spinoffs 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, spinoffs, 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 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) decompose a systemic source of innovation in three different repositories: people, tools and tasks; together, they form a network which embed 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 on the effect of inbound mobility on the firm performance: he found a positive, significant effect of 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 spinoffs, 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 knowhow are more likely to survive the competition and inevitably generate spinoffs and new startups.

Researchers' mobility takes a fundamental role also in the social capital framework: by employing an academic researcher, a firm do 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 refer 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 of channels

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. On the university perspective, TTOs are usually focused on patenting, licensing and spinoffs 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 spinoffs, in 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 spinoffs do not represent a stable sources 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 was already be "carried out in close co-operation with firms" who will lately 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) consider the 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 gained through the consideration of the various barriers which can obstacle, slow down or reduce the effectiveness of the process. These barriers can be categorized in 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 distance that actors perceives 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 distances 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 indicate the academic research is "too advanced", with little or no practical value. Similarly, Gilsing et al. (2011) describe 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) evaluate 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 conflict of interests, this misunderstanding represent 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 breakthrough 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 the 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) evaluate the delay in the knowledge value chain in 6 to 10 years. Link and Siegel (2005) suggests 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 new 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 stated previously, 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) suggests 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 is 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 include as 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 an underperformance 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) refer 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 is 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. Another area of possible intervention are formal and informal activities of information among researchers: outside the US, national and internal patent policies are still fairly unknow 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

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 is 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, spinoffs, 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. spinoffs 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. The age of 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 with a non-disclosure agreement and alike. A greater market segmentation can favor the establishment of new academic spinoffs, while universities can provide little financial and industrial support, limiting the success probability of internal spinoffs in fields with a higher need for complementary assets.

On a similar topic, the second contribution of Bekkers and Bodas Freitas (2008) aims 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 spinoff channel. He observed that while the ownership of broad patents on radical technology may positively affect the success of the spinoff, 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 is moderated by the size of the market.

Other relevant technology and industry variables are (Balderi et al., 2010): the rights of the licensee or contractor on the technology, the time to market, the presence of knowhow associated with the patent, regulations, residual life time of the innovation, the presence of an established industry standard, ability to defend from imitation. 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.

Chapter 5

Policies and evaluation

For universities and governments

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 in two different levels: efficiency and effectiveness. The former refers to the relation between the process costs and the general outcome, as in number of patents, spinoffs, 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 makes "the measurement of the knowledge transferred from a public research institution towards other actors represent 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 for formal technology transfer, but even these codified information may be incomplete: in example, data on patents usually refer 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 data at both the institutional and individual levels (Wong and Singh, 2010), including data on activities rather than the simple outcomes.

The second issue refer to the seek for viable indicators of research organization impact on their context. A first problem is to identify the true effects of the technology transfer on the society, including as example the level of innovativeness, employment, economic performance, as well as numerous other socio-economic indicators. The second problem is to isolate the single organization's impact 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 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 spinoffs 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, spinoffs) and the increase in the rate of employment.

It is to note, 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 entirely 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 efficacy, 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, in refer to the single institution and its internal mechanisms, and the macro-economic perspective, to include its effects on the district, local system innovation or other unit of measurement 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 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, using 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 perspective such as NIS, RIS and the triple helix frameworks.

5.2 SFE, DEA and qualitative approaches

Most analysis on the university efficiency in technology transfer activities uses the production-function approach, which relates the output of the process to its factor of production. Briefly, it prescribes the construction of a best practice frontier; the distance of the specific institution's combination and the frontier represent 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 non-parametric 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) use 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 licensing output and invention disclosures, while the number of employees influence the number of licenses but not the total income generated; the amount of legal expenditures 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 conclude 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 individual, TTOs, faculties and university level policies and practices.

In fact, Link and Siegel (2005) further develop 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 in fact the strongest impact on the relative performance: the higher the share, the higher the overall performance. They conclude suggesting a further development of the model to include non-pecuniary incentives, as promotion, tenure policies and alike.

The non-parametric approach instead does not require to specify the functional form of the production function, allowing researchers to identify best practices. However, if on one hand it avoids similar assumptions, on the other hand 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. Three 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, therefore at the change in performance at 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 for licenses, which they attributed to a bias in the analysis, specifically the time lag, or at universities 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 shown 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 all models, they found a substantial inefficiency: on average, universities were operating at a 18.7% of efficiency. However, contrary to previous results based on US universities, they found decreasing returns of scale to in licensing activities.

5.2.1 Other approaches

The production-function framework is the most widely used quantitative method, but other authors took different approaches. Lee (2000), in 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 is the collaboration with the federal government. He seek 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 filed 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 tried to develop a theoretical framework for assessing and guiding the technology transfer process, the “master plan for technology transfer”. The tool contains 271 rules and good practices, referring to 32 different facilitators in 7 groups. Eventually, they describe a tool called “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, presence of policies etc. However, these tools lack the ability to assess one of the most relevant factors that influences the technology transfer: the external linkages of the research organization, its context and the relative importance 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 the 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 be used also to assess the organization's efficiency, but its ability to compare the relative importance of actors among the network makes this 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, but 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 too be presented here.

To investigate the institutional and government level policies, instead, a different approach must be taken: this level of policies mainly refers to the efficacy, rather than the efficiency, of the technology transfer. Since the previously stated issues in its assessment, the literature focused instead on qualitative and comparative approaches to evaluate the performance on a systemic level, mainly referring to 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 last 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 researches seem to have been performed in this perspective, at the best of my knowledge. However, institutional policies regarding the organizational climate can provide a useful insight on this topic.

5.3.1 University-level policies

As noted by Geuna and Muscio (2009), some universities have made the strategic decision to institutionalize technology transfer activities, instead of letting them 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 of the low levels of European university-industry linkages, among issues on both sides, institutional 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 the single aspect of the transfer and can provide supporting measures. 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.

A first 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) observes 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) in 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.

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 policy for the IP management, engagement with industry partners etc.; the second refer to a set of human resource practices to intervein at a more individual level, like entrepreneurship education programs, mentoring and the enrolment 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 context, its acceptance and supportiveness for entrepreneurial activities, thus their willingness to engage such activities.

Hunter et al. (2011) investigate this perspective further differentiating among 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 the relation, 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. He 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 gatekeeper or boundary spanner. Among practical suggestion he 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 in the creation, management and monitoring of research contracts and knowledge policies.

Similarly, Guerrero et al. (2014) exposes the need for an entrepreneurial lead highly committed to transform 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 form 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 financial support from 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 have already formal policies for encourage 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 contribution on this topic is Genshaft et al. (2016), who made 5 recommendations on the topic that 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 characteristic 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) highlight 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, these policies 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 to higher commercialization activities.

Among pecuniary incentives, Beath et al. (2003) specifically investigate the two major alternatives that universities have to use technology transfer activities as a source of incomes. They consider two major alternatives, specific to the case of consulting, collaboration and contract researches: 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. After all, 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 use 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 strategic lever, thus an undervaluation of the entire phenomenon.

—Has been demonstrated that characteristics of individual researchers have a stronger impact than departments' or universities' ones. (Guena, 2007)

Patenting

Patents are considered fundamental as means of technology transfer, because of their influence in 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 in fact can be useful in determining organizational changes and supporting inventors: among possible improvement for technology transfer activities, it ranked 3rd thanks to the effectiveness due to its large scope.

Another important area for policy intervention is the modalities through which the TTO starts and manages the patenting and licensing process; as previously stated, an appropriate behavior of the TTO is a necessary condition for the researchers' attitude to disclose inventions internally instead of contacting firms directly. Specifically, Panagopoulos and Carayannis (2013) observes 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 expose a considerable loss of efficiency in the overall technology transfer process.

The author in fact proposed as 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 guaranty 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 benefit 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. In example, Phan et al. (2005) reported that the most attractive combination of technology development stage and licensing strategies for industry 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 author suggests that the motivation may be the disappearing of institutional incentives to patent, due to the changes in the evaluation and ranking procedures for universities.

Spinoffs

In respect to the patenting and licensing process, spinoff 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, spinoffs 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 entrepreneurships and start their own ventures.

More specific policies may regulate the spinoff process, i.e. steps to take, rules for decision making, financial contribution, surrogate entrepreneurs Franklin et al. (2001) and alike, 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 a venture funds. Siegel et al. (2007) specifically cited policies for supporting the building and maintenance of network of peer scientists, which may significantly influence the performance of the spinoff. Lastly, these policies should include also students as possible entrepreneurs.

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 an historical perspective. He linked the creation of the firsts TTOs to the Bayh-Dole act; they were not originally intended by the act: they rather arisen 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 with 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 advocates for a decentralized and more specialized organizational structure for TTOs, which should further the institutional entrepreneurial culture, increase the involvement of academics, and higher performance due to the rising specialization. Moreover, he 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 undertake 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).

5.4 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 institution is embedded in. As examples, the geographical proximity enable a more direct communication among organizations, which allow an informal flow of knowledge and further 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 have added its contribution on the phenomenon, considering different angles and perspectives, especially on the role of national government, local institution 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.

5.4.1 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 interorganizational 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 time and space-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 working class 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 shown 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 institution, 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, he analyzed the japan innovation system, along nine regional blocks of technology specialization in six different technology groups. Notably, he found that the spatial reach of R&D networks is different for each field, but over the 50% of them is limited at 100kms, regardless the domain. He 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 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. He 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 author suggested that maximizing university-industry interaction, along with technology transfer activities, might be in contrast with local development policies.

Relevant is also the regional organization, which has been found by Agrawal et al. (2014) to have a significant impact on innovative performance. He 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 author empirically evaluated this effect in a 17% increase of citation-weighted patent count per inventor, and a 28% increase of spinoff 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 spinoffs, 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 aim 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', meaning 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 might have strategies and tools in common.

5.4.2 Short-term policiy objectives

In fact, there are many narrow and selective policy interventions that institution 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 or 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 for 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, he found a strong correlation coefficient with the number of patents (0.73). Moreover, his 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 suggestion 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 spinoffs (Yusuf, 2008).

On the topic of business knowledge, Chapple et al. (2005) also suggests 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). He also pointed at Bayh-Dole type legislations and similar reforms as fundamental.

5.4.3 RIS, NIS and triple helix

For more long-term policies for innovation-based economic activities, the literature based its suggestion on the concepts of regional innovation systems and the triple helix. The first refer to a more static perspective of the phenomenon, while the triple helix focus 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 on 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) distinguish 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 met stronger policy intervention and institutional planning. Lastly, regionalized national innovation systems are driven by and integrated in the entire national innovation system, with the highest degree of policy intervention.

More dynamic is the triple helix framework, which expand the RIS concept to its evolution over time. The model is based on same three different 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 lead to institutional transformation (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).

Chapter 6

Theoretical differences

between UI and B2B technology transfer

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 topic of an otherwise very specific topic: a scenario in which the only knowledge producer, repository and distributor is the university, a scenario that is clearly and largely characterized by the various characteristic of this kind of institutions.

In the modern knowledge economy, however, universities are not anymore 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 some 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 be changed 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 are able to take greater 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.

6.1 Actors

6.1.1 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, NDAs and alike. While they may perform basic research and publication activities, these activities 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 PhD programs, trainings and apprenticeship. However, these are not a core element of the business model; 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 needed by the context or be included in the main business model. In the first case, related research grants and networking activities 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 contemporary manage 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 as a distinct activity from the 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 were profitable, but accessory to the research, pillar in which where autonomously and independently generated ideas and prototypes to bring into the market.

In a private environment, the relative importance is inverted: leading activities are commercial in nature, 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' researches, instead, are 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 push the private organization to focus mainly on applicable 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 they refer to: it might be useful to weights the market pull and the pushing force from the technology and knowledge field, therefore the research and the commercialization pillars.

This issue is strongly connected to the differences in the funding sources among types of organizations. Universities mainly relies on public funds, block grants and research grants, from local, regional governmental 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 instead invert the relative importance of their funding sources. They might also use public funds and grants, but their amount implicates the need to raise 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 a competitive business models, a flexible organization, 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, 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, partners. The issue arises from a divergence in interests: the growth of the context for public institutions, the survival for firms.

6.1.2 Researchers

Along with the type of research 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 should prefer instead researchers with a strong preference for applied research, its benefits and outcomes: possibly less recognized by the scientific community, but nevertheless ground-breaking and with a powerful impact on the society. At the same time, publications should not be 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, i.e. 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, imposed by the organization, but an endogenous driving force: as long as researchers have the best knowledge of their knowledge and technological fields, and decide on the prosecution of their research, they should exhibit the economic attitude to choose the most competitive alternatives, while comparing the choice of which technologies and knowledge fields 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 or departments are the best suited for the assessment of their personnel; significantly, researchers are evaluated by peer academics, with a similar area of expertise and specialization, i.e. the head of department. Other offices provide accessory services, for mobility and visiting professors, research funding and grants and alike.

The organizational structure of a firms, instead, might include a central office for the human resource management, which oversees their evaluation, reward and promotion. However, this office has no competencies on the research topics, 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 the latter case, in a private environment, the evaluation can be split: 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 contract 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 public-funded or public research institutions, while the decision on whether and how to promote can be made in concert between the administration, 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 policy might be fundamental in acquiring the best human resources: as previously stated on 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 organizations are subjected to. For public entities, available contractual forms usually provide a stronger protection for the human resource, depending on the country and its legislation. Firms instead have at their disposal a lager extent 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.

6.2 Channels

Differences in channels between private organizations and universities are mainly limited to the preference toward specific channels, and 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 topics of their own choices, produceing outcomes to place in the market. In this case, these 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 latter 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 market: highly specialized, with strongly customized services, limited in its dimension both for demand and supplies representatives.

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

6.2.1 Preference

The traditional economic literature suggests that private institutions do have a preference for easily controllable outcomes and less uncertain activities; in the case of research organizations, this risk aversion should influence the channel preference, thus its choices. Therefore, there might be the preference for contractual forms of transfer, short term and less risky projects.

The primary effect of this preference affect 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 the right company image for the market.

Informal channels might be fundamental also 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 for their development, technology validation and alike, that can easily outweigh the short-term loss in incomes and profits. The decision should also consider the potential effect on local and national governments, including the influence on their policies, legislative activities, funding strategies and decisions.

A very specific example, 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 in fact help other firms to get on board. While it might seem counter-intuitive, markets for new and immature technologies are usually small, and might 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, might be the basis for a successful long-term strategy, while sacrificing potential profits in the short-term.

Spinoff might also not be the preferred channel for private organizations. The creation of a new venture eventually requires for the spinning organization to left 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 might require the loss of valuable human resources in favor to the spinoff.

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

Moreover, spinoffs 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, spinoffs can be considered a safer 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 difficult, 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 attorney or firms specialized in their valorization or the protection from patent infringement. In fact, the ultimate value of a patent largely relies on how the application - and especially the inventor's claims - are written, which require 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 incrementality 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 spinoffs and informal mechanisms.

Consulting, contract and cooperative research instead are expected to be the preferred channels. Firstly, these process starts 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 outcomes and the resources to dedicate, while being compatible with other contemporary research activities. On the other hand, these channels might generate a sizeable amount of incomes, and under the proper management they could sustain the entire organization.

The downside of these contractual forms are the legal costs associated with the writing and management of contractual arrangement. 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.

6.2.2 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 acquire an institutional trait rather than being managed at the individual level. As previously stated, informal knowledge transfer might be essential for the creation and development of a network of exploitable relationships; thus, the organization might 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 other events, or the provision of mobility programs for employees. Depending on the institutional focus on local or larger 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 spinoff 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 spinoff-friendly organization might provide instruments as business plan competitions, business development services, access to their industry 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. On the other hand, non-supporting organizations might choose to not provide any assistance, or even to take legal precautions toward spinoff establishment.

Moreover, if the institution is willing to support spinoffs, a major effect can be foreseen. In respect to a university or a public institution, a private organization should achieve higher performance in supporting spinoffs, especially in network development activities. The roots of this effect reside in the connections that a private organization should have into its economic context, that are 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 resides in the relative importance of this channel in the business model of the private organization, especially if this last contemplates basic research along with the on-demand R&D. In fact, basic research may be performed in order to acquire the knowledge necessary to future research contracts, but also specifically patent applications and license incomes. If not, 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 and employees. In fact, if patents arise only as a by-product, the need for specific skills and competences might require 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 refer to 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. Private organizations instead might be preferred by firms because of 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. Moreover, contracting firms may exhibit a higher willingness to engage with private organizations, rather than public ones, because of their relative flexibility, accountability and other factors. The examination of legal differences is left to the competent literature.

6.3 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. This chain of events arises 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 and oriented contractual forms, hierarchy and many others. These tools are in fact 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 some 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 present 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 from the characteristics of research and development activities.

Firstly, the outcome of the research process is 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 researches, unreachable objectives, etc. If researchers are evaluated only on the fitting 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 work 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 have different 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 requirement 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 then a fashion 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 to use different approaches to evaluation, as in a mix of factors each one with a different weight.

At the same time, the evaluation of research personnel along task-related factors instead of the outcome is not safer. In this case the problem is more on the identification of indicators that can universally represent the participation of an employee to the project. These indicators should be applicable to every researcher in every project, in order to be perceived as fair, thus shared and trusted. Examples might be the number of hours spent on the project, financial income, number of partners involved, of patent generated, of 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 complete different set of problems arise in the establishment and usage of qualitative indicators: subjectivity, reliability, trustworthiness etc. If the organization makes use of both the types of indicators, an additional issue might be the understandability of the evaluation process: to be effective, it should be simple, understandable and perceived as righteous, and complete at the same time. In fact, the process-based evaluation does not resolve opportunism issues and the deviations of behaviors that may arise form 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 exhibit several issues regardless the type of institution. However, private organization might be better equipped for this task. On one hand, the activities researchers are involved in are narrower in scope, more focused and centered on the development: in respect to a university environment, private researchers have not 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 researches, avoiding the need to evaluate them over more teams, research groups and projects. 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 might 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. Agaiin, the different type of organization 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, mission and policies, should also push 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. In fact, if the input value is known and fixed, the relationship between research input and commercial output will be easier to evaluate, along 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 in a research environment, where uncertain results and knowledge asymmetries might represent additional issue.

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 example, the performance of the head of research and support units might 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 of the networking activities, i.e. through the number of signed framework agreement, variation in public funds etc.

6.4 Policies: examples

The easier process design and evaluation influence also on the identification and implementation of effective policies: methodological and structured processes make the evaluation clearer, enabling a faster and more precise discovering of ineffective or inefficient tasks along the process of transfer. Thus, these issues should be 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 a private organization should consider; general purpose policies at first, 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 researchers' job description. Thus, the need for the provisioning of structured services from the TTO and other supporting offices, and the structuring of the connection between these different organizational units.

Even more, 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. Surely, researchers might still be activated by the request of the TTO and vice versa, depending on who receive a request from external entities; again, scientists might still propose commercial activities based on unforeseen new technologies developed. However, the organization's economic survival should not rely on these spontaneous triggers, but on more institutional, structured and planned mechanisms.

In this perspective, a continuous communication and a structured relationship between research and transfer units is 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 might be misleading and jeopardize the profitability of the firm. The organization may still survive if processes are managed in complete isolation, but it will generate inefficiencies that in the long run could affect the competitivity of the research center. Apart from the suggestion 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 profitable. Examples are the diffused need for (ergonomic) design, the economic value of hybrid projects that includes both hardware and software, the competitivity of high-tech products based on traditional knowledge and new technologies. Similarly, a research center should focus on distinctive capabilities and knowledge, including fields which require two or more knowledge fields that the organization may master.

Another general policy worth considering is the writing or 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 and main 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 might 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 might consider to implemented HR policies, especially evaluation, reward and promotion practices tailored for a research organization. Other examples may be directed toward the internal structure of the TTO, its process flows and its human resources.

Other policies might regulate the single transfer channel or process, i.e. spinoff, 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 effectiveness. Again, policies should establish which internal actors are involved, their tasks, responsibilities, process flows, legal management etc.

Chapter 7

Case Study

Fondazione Bruno Kessler

In this chapter will be presented the case study of a research fundation, the Bruno Kessler Foundation (henceforth, FBK), to test the hypotesis made into the previous chapter. Specifically, FBK is a private research institute, largely financed by the local public institutions, a case particularly fit to present real world application of many of the consideration previously made. In fact, it includes the problems from which suffer both private and publicly-funded institution, while its history carried some issue of an entirely public institution.

at the same time, it represent a significant case in the european research landscape, with its importance tested with social network analysis tools. the entity of its revenue flows, about 28-30M in euro, together with the number of researchers and other personnel it employ, over 400, classify it 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 nation, a region in which local policies have a greater impact on the local context due to the special institution, makes it fitted also for the analysis and evaluation of tech transfer policies, which however will not be discussed here.

the chapter will begin with a short presentation of the institution, including an historical perspective, a brief examination of the local government's influence on mission and operativeness; after a fast presentation of its organizational structure, a specific picture will be presented for the structure and the organization of its TTO.

Secondly, will be described the channel used, taking an esternal perspective focused on services provided to firms, research organizations and spinoffs. the fourth perspective, services for the local government and society, will be left aside?? Later, under and internal perspective, will be analyzed the processes and mechanisms corresponding to those channels; this will be an effort of process modeling, in an organizational structure that otherwise have grown and evloved over time as a series of adjustements and modifications that almost completely covered the original design. in fact, the institution has adapt itself to the specific requirement progressively made by the market and the local institutions.

Lastly, will be dicussed the evaluation of this organization. on one hand, will be assessed the efficacy of its research through instruments of social network analysis, trying to provide a truly quantitative evaluaton of its relative performance. on the other hand, will be discussed two methodologies to evaluate the efficiency performance, investigating the issues involved. differently from the previous framework of analysis, policies will be threated marginally, being the rest of the chapter an explanation of what policies established and how them has been implemented.

7.1 The institution

7.1.1 Historical perspective

and context!

7.1.2 Public interference

7.1.3 Organizational structure

7.1.4 TTO structure

7.2 Processes

in this section, will be presented channels and processes related to the technology transfer activity of FBK. Firstly, an external perspective can be taken to describe the used channels as the kind of services and products that the organization provide. lately, the internal channels will be described through the analysis of internal processes that lead to the development and delivery of the product or service. this way it is possible to describe both the external apparence and the internal mechanisms of the activity.

7.2.1 External perspective

the external perspective on channels can consider each of those as single products or services that the organization provide. caution: this perspective is more market-pull than the process in the real world: considering only external, independent actors, we are considering the kind of requests that the firm can make to FBK, momentarely leaving aside a more proactive, technology push approach in which the commercial relation with external entities is led by the deliberate actions and intentions of the research organization, rather than the ones of external entities.

For firms

for firms, the main service that fbk can provide is the development of a technology or an investigation, i.e. a feasibility study, on a specific topic. the main contractual forms that allow the external to acquire such services are contract research, cooperative research, consulting, licensing.

As previously stated, the contract research is a contract in which the research organization "si impegna" to develop a technology, investigate an issue, study the feasibility of an idea or project, deliver some knowledge, to another organization in exchange for a "contribution", which usually assume a financial flow but could be also in nature, as the right to access and use a protected idea or technology. contracting firms can also provide resources in kind, i.e. employees, laboratories and other assets, but the core idea of a research contract is the commissioning of an activity, as in outsourcing, of something that cannot be or won't be performed internally.

in the specific case, FBK

cooperative research is similar to reseach contracts, but it starts from a different assumption: the idea is that neither the research and the industry firm have, single handed, the entire knowledge base and resources (in any kind) to succesfully complete the project. in this case, in fact, two or more organizations agree to cooperate on a specific activity, that can range - again - from technology development and knowledge generation and whatsoever. therefore, in this category fall every contract that has r&d as object and both organization as researchers or providers

FBK

consulting usually refer to the transfer of knowledge rather than technology. the primary example is for firms to request the "help" of the research organization in developing their technology, evaluatin something etc. the main corpus of knowledge and technology for the ultimate product already resides in the requesting firms, and any futher activity should take places in their locations and with their assets. a specific case is the provisioning of training activities for HRs, by far a minoritary activity

FBK

again, as previosuly stated, licensing is a contract in which the industry organization acquire the legal ability to make economic use of (slash exploit) a technology or knowledge already developed by the contracting research organization and patented or otherwise protected. other tools are expecially used in different knowledge sectors, i.e. software in italy cannot be patented, but the copyright can provide some protection and excludability. licence agreements can widely differ for the utilization, payment and other legal clauses, therefore providing a fair degree of personalizaiton without other specific contractual forms

FBK

For research organizations

Private research organization can establish contractual relationships between them, as in exchange or the provision of a service or licence. specifically, exchange contracts between research institutions can take any of the form previously desribed; however, some forms acquire a higher importance, especially research cooperation.

another contractual form more specific to this case is the framework agreement. this contract states the interest of organization to collaborate whith each other, and the contract states the forms and the topic in which these further researches and collaboration will be performed, possibly including resources, decision making rules, propriety of the results. in fact, this agreement constitute a ground for any further development of the relationship.

another specific contractual form is the grant agreement, which however do not take place directly between research orgnaizations. with these, organizations states an arrangement of resources, tasks, objectives relative to a research project financed by some public institution, especially the EU commission. the most important type of grant, for organizations like FBK, is constituted by the FP7 programme and grants. to make a request for these funds, the organization has to present a proposal for a research question/topic decided by the EU institutions. it will state mainly the modalities and resources (especially human resoures) through which the research organization means to achieve the prescribed resources. in latest years, fp7 grants are more and more competitive: given the increase in number of organizations that apply for these funds, and their being fixed to a relatively stable amount, these grants are becoming harder and harder to win. one specific movement is taking place: to assure the presence of the needed expertise, skills and capabilities, and generally increasing the probablity of a successful research, many grant applications are made by consortia of research organization, stating the collective willingness to achieve the result. in the case this proposal will be selected, the consortia has to present a grant agreement, a form of contract between the organization that describe the modalities through which the research will be performed: who will seek for which sub-results, resources, shares of appropriation of the grand funds, responsabilities, the selection of a central coordinator etc.

For spinoff

spinoff, considering the kind of services that a research organization can provide to, can be divided in "would be" and already spinned (already a separate legal entity).

for prospective spinoffs, a reseach organization can provide services centered on the provision of a favorable entrepreneurial organizational environment, scouting of spinoff opportunities, and supporting services in shaping the would be venture, its business model and its appetibility for external investors

in the first case, such activities mainly encompass entrepreneurial courses, the structuring of understandable and supporting policies, conferences with successful scientists entrepreneurs, meetings, the provision of usable relationships into the industry etc.

in the second, the scouting can be proactive, institutional-pushed, similar to the process of disclosure eliciting in an academic setting, and emergence, meaning the providing of a self selecting environment. example is the provision of business plan competitions: it is based on the emergent, individual willingness to start a new venture, while the selection activity is provided by the necessary evaluation included in this activity.

supporting activities instead reange from the supporting in business modeling, including specific training activities, suggestions and checks with competent human resources internal to the TTO or other offices, to business development activities, i.e. the help in establishing contacts among firms, the access to the parent organization network, help in hr practices. other supports are financial, as in grants and equity, favorable licences (under the parity, in example)

the supporting activities should last also for already spinned new ventures, especially networking activities. in the first period, i.e. 1-2 years, the parent organization can also be part of the equity, thus directly and legally influencing the choices

7.2.2 Internal perspective

emergence

Ignition

Evaluation

Development

Finalization

7.3 Evaluation

7.3.1 Effectiveness

7.3.2 Efficiency

To evaluate the efficiency of a process or an organization, the economic literature usually refer to two different methodologies. The first refer to the tracking over time of the changes in its inputs and outputs, that are the available resources and the resulting products. The second approach require the analyst to compare the organization's performance to the one of other, compatible, instutitons, assessing its efficiency through comparison. Both these methodologies however present some issues.

Performance comparison over time

In the first case, the first necessary condition for the usability of this method is the presence of an effective information system, especially for "contabilita analitica", which keeps track of the resources in input and the poducts or services in output. Secondly, to evaluate the very process, it is implicitly assumed that it will not change between periods of evaluation, at least not in an extensive way; otherwise, the analysis will not be able to distinguish between a difference in performance alone and the difference in the context and institutional framework. In the case of FBK, these issues represent clearly recognizable problems with a great impact.

First, it exist in fact an informative system that could keep track of the performances over time, but it is not able to for a set of reasons. the main issue is to evaluate the amount of resources that end in each process, at an istitutional level: in a tech transfer process, resources that end up in the product include, but are not limited to, the time and effort researchers put into the process; the time of supporting personnel, among which TTO, legal office, administration,and others; materials; machinery time; external services. specifically, the most relevant issue is to keep track of the time researchers and other employees dedicated to the project. -> contabilita dei costi

the most representative example is time of TTO's officers, if the entire office is divided into different units specialized per thematic sets of activities, i.e. marketing and communication, business development, legal counseling, contracts, etc. in this case, projects are concurrent in the time they take to the TTO's employees, being him involved in any project that share the particular activity. At the same time, while impossible to estimate the amount of work hours for the single, identified project, extensive differences among projects make also difficult to evaluate the mean time spent on each project: no average measure to apply to the cost calculation. This issue come up many times during interviews, with no employee being able to estimate the average time spent on each project, with lapses that range betwen hours and days.

moreover, if the evaluation is based on a time serie approach, the danger is to evaluate the impact of external factors that change the process instead of the incremantal endogenous improvement of the process. the point is that the performance itself depend on a serious of factors, both internal and external to the organization. the first case includes the process flows, the quality of involved human resources as in skills and capabilities, financial resources dedicated, a change in inputs, the overall institutional setting and policies. the second case includes governmental policies, changes in markets, industries, technologies, industrial context, national and sovranational policies.

The analysis should be based on a model complex enough to include the external factors, to not imputate wrongfully changes to the process or the organization. the model should also distinguish between the change for which the entire organization is responsible, i.e. the research input to the transfer process, the marketing devel program and office etc, from the resposabilities of the TTO and the researchers directly included in the development of the selected technology. with such approach, the administration or who is interested into the evaluation, can discover any enhancement due to the learning process that is supposed to take place.

However, in the specific case of FBK, the internal accountability seems to not include detailed informations on the amount of resources involved. while the overall costs and resources involved are known, due to the national accountability laws, the actual information system can not in fact connect the single cost to the project. "in the same way, as previously stated, the price estimation for each technology to transfer is assessed on the basis of the presumable costs for matierials, researchers' hours and a flat rate to cover the structure costs"

Performance comparison between competitor

the economic literature pointed at the comparison of competitors' performance as an effective method for evaluating the individual performance in absence of the necessary deep knowledge of the cost structure of the original organization. in fact, maybe the process is to complex or contains too many variables to get a relable evaluation, but if another, similar organization perform the same activity, the two can be compared to establish which is the most performant, eventually leading to the discover of potential best practices.

However, this methodology relies on a necessary condition: the availability of a similar organization. While the degree of similarity is somehow a personal evaluation, some condition should be matched nevertheless. the organizations should share the context, or at least be located in similar contexts, includind the degree of technology advancement, r&d expenditures, academic level/environment, local policies, emplyable workforce, neighbour firms and, to some extent, their level of specialization and economic performance, as well as the relative importance of knowledge for their business (even if it is a requirement needed in this specific case)

similarly, the organizations should share some trait: the scale of operations, that is needed for the level of economies of scale at play; the organizational mission; the main type of activity; the scale of incomes. otherwise, the analysis will highlight which local, institutional and organizational setting can achieve the best performance, rather than which process performs better, as in its structure, personnel, resources, activity etc.

the problem starts with the peculiarities of the italian context in general. the average size of firms is smaller, which impact their innovation capabilities and processes; italian universities perform worse than the EU average ("NOMEAUTORE); the limited number of private research organizations; the tendency of these research organization to be public, as in for local and national government funded and financed. a secondary problem is the trentino context itself, which represent quite an ecception in the italian landscape, for legislative and historical conditions.

thsu, the availability of a "paragonabile" competitor, in the case of FBK, is more of an issue. in its context, R&D is performed by the local university, which is not directly comparable due to its main mission imposed by the local governement; and the edmund mach foundation (henceforth, FEM). This last institution, in fact, is the "sister" foundation to FBK.

similarly to FBK, FEM is a publicly-funded research foundation. it conduct teaching and training activities, having an internal second grade school (istitutio secondario, approfondisci) and doctoral programs. it conduct r&d activities in high-tech fields characterized by a large rely on codified knowledge, especially in the field of biotechnologies. it performs production activities, through the connected wine "factory", and provides specialized services to the agricoltural industry, both local and not. lastly, it operates technology transfer activities and possess a TTO.

however, differences among these organizations are very extensive. firstly, the size: FEM employ twice the personnel, but only a small part of them are researchers (indicatively, around 150 scientists), while the total income is more the double (90M against 35M). activities are centered over the provision of formation activities and services to the local agricultural sector, as in environmental analysis, study of fito-deseases and their diffusion, genomics. moreover, the FEM organizational structure is far more heavier than the FBK's one: at its institution, the Trento province institution actually grouped a series of different public institutions, maintaining a separate administration for each new established organiational unit.

lastly, and even more important, the approach through which FEM interpret, concept, and perform technology transfer activities is significantly different. FEM perform some basic research which is hardly applicable to the local industry, thus the necessary shift away of TT activities from the basic research. the applied research, instead, is limited in its extent, thus the tt transfer of newly developed technologies. what's left is the provision of specific services, which might include some research from FEM. the TTO department is actually involved into this kind of service provision.

thus, the extensive differences between FEM and FBK make the former not a suitable organization for a comparative analysis of performances. however, comparable organizations could be found in different contexts. this research should start from the comparison of local innovation contexts and local government policies; if a similar context is individuated, the researcher could investigate the internal actor to this environment seeking a similar organization.

considering the focus, objective of this thesis, this procedure and other further developments are left for later research. what was significant was to give the reader a perspective on the evaluation of the organizational performance both in a qualitative and quantitative setting. at least, the quantitative evaluation seems useful.

7.4 Policies

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