From Universities to Start-ups and Firms: Knowledge Transfer, Proximity and Their Effects

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in order to obtain the
Joint Master Degree in General Economics

ACADEMIC YEAR 2010-2011

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If I have seen further it is only by standing on the shoulders of giants.

Sir Isaac Newton

Above all, I would like to thank my Parents and DiDi, who were always there for me during these years, for believing in me and for being so patient.

I am heartily thankful to my supervisor, Prof. Florian Mayneris, and to my readers, Dr. Ignace Adant and prof. Pedro Oliveira for their kind support, for their advices and suggestions.

I would also like to thank to Manuela Berjano and Alexandra Pinto (INRB/ L-INIA), Eric Giraud-Héraud (École polytechnique & INRA - France), Teresa Alves (GenIbet), Pedro Cruz (ECBio) and Marcelino Santos (Silicon Gate), without whom this thesis would not have been possible.

I wish to thank my good friends for caring so much and for all the laughs that made everything much easier.

Last but definitely not the least, I would like to thank the "giant" for the long hours spent talking and exchanging ideas, for all the support, guidance and kind encouragement.
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Introduction

The aim of this thesis is to study the geographical and spatial dimension of Markets for Technology in the commercialization of university research, and try to give an answer of a recurrent question found in literature (see, among others, by Mowery and Ziedonis, 2007): why and when are university research effects localized?

In order to do so, we opt for an exploratory research that allows us to understand in which situations proximity matters in the "market for ideas" and why can it be seen as an important variable, focusing on the university - SME interactions. This research aims at providing a better understanding of the functioning of markets for technology and was developed during the first phase (2010-2011) of a broader Federal Research Project conducted jointly by Université Catholique de Louvain, the Belgian Science Policy Office and the Belgian Patent Office analyzing the functioning of the Markets for Technology.

With the intention of identifying empirical facts that could be regularities in economies and industries founded on Science, we rely on a methodology that articulates literature surveys and case studies. This "back and forth" strategy - from field to literature and from literature to field - will give us insights from the interviews with the start-ups that can be used to select key variables explaining why and when proximity will be observed.

The first and second parts of the thesis are made of two surveys. We focus on the two strands of literature (Industrial Organization and Geographical Economics) that provide different points of view and place different emphasis on factors on the location decisions of start-ups.

The first strand of literature focuses on Markets for Technology (see for example, Arora et al., 2001, or Arora and Fosfuri, 2003) and on the commercialization of technology after R&D, without considering the possible existence of spillovers at the R&D level and their importance in players' decisions. In other words, R&D is considered as a previous and completed sequence that is no longer relevant for the players. Through this survey, we are looking for variables that could explain why proximity is needed mainly at the commercialization stage of an invention. Hence, some of the potential effects mentioned by Mowery and Ziedonis (2007), such as knowledge spillovers, are not considered.

The second strand of literature, geographical economics, offers complementary analysis of the importance of the diffusion of spillovers and knowledge, on the channels through which knowledge flows and on their reach. From this perspective, the choice of location relies upon knowledge diffusion and on its impact on R&D. The learning process, as well as the existence of spillovers, are included in order to explain location decision of firms. We believe that in combining these two different but complementary strands of literature we will have a broader perspective, and understanding, of the location decision of start-ups.
within a knowledge economy. Therefore, from our viewpoint, there are useful complementarities for our exploratory research and our specific methodology.

In the third part of the thesis we present the main questions used during the interviews conducted in start-ups located in ITQB and INESC-ID, which are situated respectively in Oeiras and Lisbon (Portugal). We considered that the main factors that could impact the start-up’s location choice were their own characteristics and their relation with universities, science parks and, finally, with intermediaries. The three start-ups selected belong to three different industries (pharmaceutical, cell biotechnology and electrical engineering), thus providing different points of view about the factors taken into account in the location choice. Lastly, the results of the interviews are then presented and put into perspective with the literature.
Part I
Markets for Technology

In this first part of the thesis we explore the Markets for Technology perspective. Despite the fact that it is assumed that R&D is done, and, therefore, is "black-boxed", it is nevertheless interesting to analyse the literature in order to isolate factors that could influence and determine the location of firms. The main elements considered are patent licensing (in and out); the relation between Markets for Technology and Markets for Products and their structures; sources of uncertainties and causes of market failures and the role of intermediaries.

1 The Territory

Arm’s length trades in technology disembodied from physical goods (patents, other IP rights but also knowledge not patentable) occur between independent entities on the so called "markets for technology" (Arora, Fosfuri and Gambardella, 2001). The interactions between universities and firms in these markets are gaining a renewed interest, as many inventions are not commercially exploited and their propensity to rely on markets for knowledge are still not clearly understood.

In the Antitrust Guidelines for the Licensing of Intellectual Property (US Department of Justice, 1995) markets for technology are defined as markets for "intellectual property that is licensed and its close substitutes, i.e. the technologies or goods that are close enough substitutes significantly to constrain the exercise of market power with respect to the intellectual property that is licensed" (US Department of Justice, 1995, p.6). However, there is not a unique definition of markets for technology. Arora et al. (2001) present a much broader definition, stating that these markets refer to "transactions for the use, diffusion and creation of technology", and that transactions are usually "arm’s length, anonymous and typically involve an exchange of a good for money", following the idea of Arora and Gambardella (1994) that technology disembodied from physical goods could be traded. More recently, Guellec and Pluvia-Zuniga (2009) say that markets for technology include "patents and other IP rights, know-how and patent licensing, knowledge that is not patentable or not patented".

1.1 The Choice Between "Exploit" and "Contract"

In markets for technology, firms exchange knowledge that may take several forms, ranging from ideas or concepts to well developed and stabilized technologies. Consequently, markets for technology are also known as markets for ideas or for knowledge (in the sequel those expressions will be considered as equivalent if not explicitly mentioned). Having in hands knowledge that they cannot afford to exploit on their own, universities and start-up
firms can follow three different strategies: shelving, (in- our out-) licensing or combine (in-
our out-) licensing and commercialization.

A "sleeping" or "dormant" patent is said to shelved when the patent holder decide not to
commercialize the technology and not to use it in-house. In-licensing amounts at acquir-
ing the right to use a patented technology either for direct use (the technology is a tool
or enters a final product) or for research purposes; in such a case, licensing amounts at
acquiring incoming knowledge not developed in-house. When out-licensing a technology,
the patent holder transmits the right to use the invention. If universities or firms believe
they are able to exploit the technology by themselves, they will not rely on a licensing
agreement; they will pursue a strategy of commercialisation.

Teece (1986) analyzed for the first time, the choice between commercialization ("exploit")
by herself or commercialization by another independent entity ("contract" or "license").
In the latter case, the patent holder (a "licensor") signs a contract (a licensing agreement)
with another firm that will developed and exploit the invention; the right to use his tech-
nology is transferred, under precise conditions, such as the payment of royalties or a fixed
fee, the possibility of exclusive license by the licensor, grantback or confidentiality clauses.
It results in vertical specialization: the inventor remains in the market for technology while
the firm exploiting commercially the invention stays in the market for product.

From a social point of view, licensing contracts increase the diffusion and use of knowl-
edge, and from a private point of view, they increase the incentives to innovate, as they
can be seen as an additional source of profits for the firms. However, when considering
them as "arm’s length transactions" one suspects that proximity between parties could be
very important, depending on the characteristics of what is "traded" and on constraints
existing for intermediation in knowledge.

To estimate the future profitability each option, the patent holder has to consider three
main factors: (1) the appropriability regime, (2) the control of downstream assets (Teece,1986)
and (3) the competition it creates in downstream markets (Arora and Gambardella, forth-
coming).

1. If on the one hand IPRs may reduce the transaction costs of trading technology, thus
encouraging licensing, on the other hand, if they are not strong enough, they may
have the opposite effect of discouraging licensing, since the revenues from licensing
will be reduced and firms have to find other ways of profiting from their innovation.

2. With respect to licensing they have to take into account additional characteristics
that impact the profitability: how many licenses and to whom should they license.
For that, and according to Arora and Fosfuri (2003), it is necessary to take into
account the rent dissipation effect (the decrease in the licensor’s profits due to the
entry of an additional competitor in the market) and the revenue effect (given by
the rents earned in the licensing agreement). The variations in these two effects will depend on the transaction costs, on the degree of product differentiation, on the strength of intellectual property (IP) protection and on the number of technology holders, and the dominance of one of the two effects will determine the strategy to follow. For example, when the revenue effect dominates the rent dissipation effect, firms choose to license to other firms, competing not only in the product market, but also in the market for technology. Therefore, there is a close relation between markets for technology and markets for products. In the first one, firms rely on licensing to sell their technology, thus creating more competition in the second, where they sell their products. Although licensing to competitors reduces industry profits, by increasing competition (rent dissipation effect), it also increases the licensor's share of profits resulting from the licenses (revenue effect).

3. Another factor that discourages licensing is the size of downstream operations: the rent dissipation effect will be higher if a new competitor enters the market when the firm has large sales.

1.2 Markets Prone to Failures

In the absence of markets for technology, if innovating firms want to extract the technology's value, they must exploit the inventions in-house (often investing in other complementary assets) and then commercialize the technology embodied in goods and services. However, inventors are frequently not the best at organizing technology commercialization; hence, there are many inefficiencies if specialization is not possible (Teece, 1986).

There can be several causes for market failures. First of all, there is the uncertainty about property rights. The fact that a buyer does not have full information about the extent of the property right or even if the patent will be valid, causes the buyer to ask for a premium in the form of a discount before the grant, while the seller will try to reach an agreement after the grant, to avoid this premium (see for example Thambisetty, 2007. See also Guellec, Prager et Madiès, 2010). The value of the technology is always difficult to assess: in the beginning firms cannot be sure of all its possible applications, about the value of possible substitute technologies or if it will be the design or standard that will become dominant in the product market. As these characteristics become clearer with time, the value of the technology will decrease with time. In an early stage it will be more competitive, once that, as time goes by, there can be new technologies that prove to be more efficient, making it obsolete, or it can happen that the dominant design is not the one the firm has in hands, thus reducing its value. Therefore, there are not only uncertainties within the technology itself, but there are also uncertainties related to the associated demand. It is also not clear either how to induce license holders to disclose more information about their license, or how much information should be disclosed. This brings us to another important point of market failures: the lack of protection in the case of infringement, and the lack of specialized institutions to deal with this litigation problems. Finally, another
problem related to the value of technology is the possibility of patent infringement. It may happen that a firm spends considerable resources in exploring a new project that is protected by several patents, without being aware of the fact. If this happens, the infringer is left vulnerable to exploitation by the patent holder. This reduces the incentives to innovate and to acquire new technology. Finally, there is uncertainty about the transaction process itself. Due to different valuations of the product, and due to the fact that the distribution of bids is unknown to buyers, these fear a "winner’s curse", and risk overpaying for a particular technology. Furthermore, not all inventions or innovations can be transformed valid patents. It can be the case that they are outside of what is generally accepted as patentable, as some genetically modified organisms, thus the need for specialized courts.

In order to overcome these market failures, the existence of experts to certify quality and of specialized courts is of major importance. The existence of intermediaries can also help to minimise the problems related to MFT functioning, once that, by searching for information and licensing possibilities and transferring it, they increase the probability of a match between supply and demand.

A complementary perspective is offered by Alvin Roth (2008) in Arora and Gambardella (2009), stressing that, as in centralized exchanges, well-functioning markets for technology should have the following characteristics: "thick (many buyers and sellers), uncongested (each party can deal with many others in the opposite side), and safe (transacting outside or engaging in strategic behaviour should not be profitable)."

The following table contains our hypothesis, to be refined, about conditions requiring proximity; it is an attempt to relate the main aspects of markets for technology presented in Arora and Gambardella (2009) with the variable distance. We try to explain the effect of distance in the two types of market transactions defined by the authors: assuming that proximity enables the monitorization of both parties, therefore increasing safety, an increase in distance increases the probability of facing contractual problems, either moral hazard or the difficulty of sealing a contract. Further assuming that proximity increases market thickness, then an increase in proximity will result in an increase in the probability to seal a contract for licensing deals. Focusing on the characteristics of well-functioning markets, thick, uncongested and safe, and bearing in mind that very often buyers and sellers of the same technology are not located nearby (as suggested by the evidence that most start-ups work in an international market, rather than a regional or national one), we hypothesize that distance is one of the causes for the malfunctioning of markets for technology. Considering the factors in which the licensing decision is based, the factor distance is closely related to the appropriability regime: proximity can be regarded as problematic in the case of weak IPRs, once that, if an increase in proximity results in an increase of spill overs, in this setting it can increase the risk of expropriation. In the presence of strong IPRs, however, proximity may not be seen as a threat and the firm may benefit from the resulting spill overs. If we are dealing with the framework described in Matsumura et al. (2010), where maximum differentiation is a pure strategy equilibrium, an increase in
proximity may result in an increase in competition in the downstream market. Arora and Gambardella identify three main types of uncertainty, which are barriers to markets for technology. If, as hypothesized by Duranton and Puga (2003) an increase in distance means a decrease in the transmission of knowledge, then proximity can minimise the problems related to uncertainty, by favouring knowledge exchange and reducing uncertainty itself, at all the three levels. Based on the idea that proximity potentiates spill overs, one can conclude that when proximity between parties increases, the information asymmetry will decrease, allowing firms to have a more precise valuation of the technology (both by having a better understanding of it and by knowing the value competitors place on it) and to have a more complete information about the state of the art.
<table>
<thead>
<tr>
<th>Key Aspect</th>
<th>Characteristics</th>
<th>Role of Distance</th>
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<tbody>
<tr>
<td>Market transactions</td>
<td>Ex-Ante</td>
<td>An increase in distance increases the Moral Hazard resulting from contractual problems</td>
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<td></td>
<td>Ex-Post</td>
<td>An increase in distance decreases the probability to seal a contract for licensing deals</td>
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<tr>
<td>Markets for Technology</td>
<td>Thick</td>
<td>An increase in distance increases the likelihood that the market is not thick or uncongested</td>
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<td></td>
<td>Uncongested</td>
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<td>Safe</td>
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<td>Licensing decision</td>
<td>Appropriability Regime</td>
<td>Proximity between licensee and licensor increases competition in downstream market</td>
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<td>Control of Downstream Assets</td>
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<td>Competition in Downstream Market</td>
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<td>Uncertainty about...</td>
<td>IPRs</td>
<td>An increase in proximity decreases information asymmetry, due to spillovers</td>
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<td></td>
<td>Transaction Process</td>
<td>An increase in proximity results in a better knowledge about the value competitors place on the technology</td>
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<td></td>
<td>Value of Technology</td>
<td>An increase in distance results in a better understanding of it, due to spillovers</td>
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<td></td>
<td></td>
<td>An increase in proximity with firms in the same field may allow to understand which patents about a given technology already exist</td>
</tr>
</tbody>
</table>

Table 1: Markets for Technology and the Role of Distance
1.3 Possible Solutions to Overcome Market Failures

Although there is not one good solution to overcome these market failures, several hypothesis have been suggested. Different licensing agreements, as for example the implementation of standardized licensing agreements or the creation of a secondary market for licenses may decrease transaction costs associated to technology transfer and encourage technology exchanges.

Public institutions may also play an important role in facilitating the working of markets for technology, as they can provide online databases that enable the search for information about licensable inventions or for a reliable seller; they can decrease the uncertainty regarding patent activities, quality and granting; lastly, they can give financial incentives.

Intermediaries\(^1\) are another important player in the functioning of markets for technology. According to Benassi and Di Minin (2007), intermediaries can not only help to improve the existing patents by adding their expertise and skills, but also help to develop markets for knowledge and the exploitation of ideas that would otherwise remain unexploited. Furthermore, they facilitate the exchange of information on technologies provided by different networks, therefore correcting information asymmetries, and they can also balance market imperfections, thus facilitating transactions. Furthermore, in some cases intermediaries may decrease the transaction costs associated with technology transfer through the creation of an online IP marketplace, for instance, and, according to Johnson (2008) the benefits from intermediation will be sufficient to overcome the possible negative aspects of triple helix collaboration (collaboration between academia, industry and government). According to the author, intermediaries are able to provide economic benefits in the form of cost reduction, risk sharing and research synergies, that are enough to overcome negative aspects such as partnership transaction costs, outgoing knowledge spill overs or mutual hostage scenarios, and the strategic and organizational aspects of triple helix collaborations can also overcome a negative transaction cost for the entire partnership.

Markets for technology can bring about several advantages. If we consider a market for technology at a global scale, then they can increase the potential for innovation and the competition among firms in less dynamic regions. Besides, by facilitating the knowledge of what is produced, they allow a worldwide monitoring of technology developments and they increase the penalty for duplicated innovations, thus discouraging the "not invented here" syndrome. Furthermore, markets for technology provide the innovator with a wider the range of options, since, for example, licensing becomes an available strategy; they may also lower barriers to entry, especially when they give rise to an industry of specialized technology suppliers, or induce a decrease in product life cycles. Nevertheless, markets for technology are not only prone to imperfections but also they can decrease the importance of technology as a source of competitive advantage, because now competitors also have

\(^1\)Intermediaries are defined by Benassi and Di Minin (2007) as "public or private companies bridging supply and demand of intellectual capital"
other sources to access innovative technology.

When markets for technology function well, then the innovator has more options. He may choose to rely on IPRs to sell or license the developed technology to others, or may choose to buy needed technology from others, instead of developing it in-house. However, the appropriability of the start-up’s IP faces some difficulties. The nature of knowledge, the easiness with which it can be imitated or replicated and the strength of the intellectual property rights regime are factors that can prevent the start-up from fully appropriating rents. For instance, licensing can be an effective strategy when the technology is easily codifiable (easy to transfer and replicate) but opaque (difficult to imitate due to its specificities), enabling the start-up to profit from its research even if it does not possess the complementary assets to further develop it.

 Teece (1988), however, defended a different point of view. In his opinion, the best strategy to appropriate returns from technology is not through licensing, but by embodying the technology into goods and products arguing that the greater beneficiary of a new technology is not necessarily the originator of the idea, but the owner of the needed complementary assets. Yet, he acknowledged later that markets for technology may change this view.

1.4 The Start-ups’ Perspective

Spin-offs, namely university spin-offs, are micro firms whose aim is to further develop and transform ideas and/or inventions resulting from university research. They usually begin by developing a proof of concept that may at a later date result in the development of a prototype of a new product of technology which can be commercialised. Frequently the expression start-up firms is associated with SME technology oriented firms, which, with limited resources (such as capital, labour or land) manage to achieve a high and rapid growth; also, most of their value comes from intellectual property which makes it crucial for them to have a strategy for protecting their intellectual capital and exploit it in the best possible way.

If start-ups decide to exploit their innovation in-house, it is likely that they will need to have access to complementary assets. This decision depends on the efficiency of both markets for technology and markets for the complementary assets, as the inability to acquire these resources cost-effectively has an important impact on the returns earned by a start-up innovator. One way to overcome the difficulty and cost of acquiring the complementary assets is to attract financing, through the equity market, research contracts, partnerships or venture capitalists.

Focusing now on the relationships between universities and firms and on the technology transfer mechanisms, it can be said that universities rely mostly on licensing agreements with private firms, on research joint ventures and on spin-offs to do so. A university’s successful licensing program is of absolute importance at a private and public level, since
future financial gains (such as funding, sponsored research or hiring of graduate students and post-doctoral fellows) and job creation in the region depend on that. Its success depends on a wide range of factors, such as the intellectual property policies, the university’s institutional structure, organisational capability and entrepreneurial culture, incentives to the researchers’ participation and a comprehensive start-up selectivity and support policy.

None the less, there are some barriers to the effectiveness of technology transfer from universities. Alongside the possible informational and cultural barriers, some optimal policies may not be feasible, due to the universities’ limited resources and their profit maximization strategy, as well as due to their risk aversion regarding financial and legal risks. As Roberts and Malone (1996, cited in Rothaermel et al., 2007) found, although a comprehensive selectivity/support policy is the optimal policy to foster start-up creation, most times it is not feasible; some other authors (Markman et al., 2005, cited in Rothaermel et al., 2007) found that, although an early stage technology combined with licensing for equity is one of the most efficient combinations for start-up creation, it is also the least likely to be followed by universities.

Teece (1986) was the first to question in which conditions can firms profit from technological innovation, and to try to clarify in which situations is preferable to follow a cooperation strategy and in which situations is preferable to follow a competition strategy. According to the author, if firms are to profit from their innovation, they will have to incorporate the knowledge in the final product, either by commercialising it by themselves or by licensing the technology, using a cooperation strategy.

Following Teece’s work, Gans and Stern (2002) also analysed the commercialization strategies for entrepreneurs. According to them, start-ups have two possible strategies: either they enter directly the market (pursuing a competition strategy) or they cooperate with established firms (pursuing a cooperation strategy). Given that both strategies are subjected to hazards, such as the possibility of expropriation, the choice of one of the commercialization strategies will rely on the nature of appropriability (weak IPR or strong IPR) and also on the type of appropriability (whether it is based on formal IPR, such as patents, or on informal ones, such as secrecy).

Due to their particular location in the production cycle, below the proof of concept stage, usually developed by universities, but above the commercialization stage, usually undertaken by established firms, start-ups can either enter the market and earn revenues at the market for products’ level, or they can earn revenues at the market for ideas’ level, by following a cooperation strategy. Taking the analysis one step further, Gans and Stern consider two distinct commercialization environments that can influence the strategy choice: excludability environment and complementary asset environment.

The former refers to a situation in which the innovator is able to incorporate a specific form of trade secrecy - non-imitability - in its product, thus imposing a relatively high
cost on potential imitators, and as a result, being able to exploit cost and market power advantages. The latter refers to the inability of the start-up firm to acquire complementary resources cost-effectively. If on the one hand it decreases the returns of competition and weakens the relative bargaining position of the start-up when contracting with established firms, on the other hand, if the start-up follows a cooperation strategy, it will avoid costly duplication investments. The strategic choice faced by start-ups and established firms is summarized in figure 1.1. Below we describe briefly each of the possible outcomes presented there.

- The attacker’s advantage: In a situation where IP protection is weak and where incumbents do not possess the complementary assets required for an effective commercialization, competition is likely to be strong. Start-ups may capture market leadership by following a "stealth" strategy, in which they position their technology in the market in a way that exploits the "blind spot" of current market leaders. Proximity may be a disadvantage in this framework, once that it potentiates spill overs and as the IP protection is weak, it increases the risk of expropriation.

- Ideas Factories: In this situation, a successful innovation precludes effective development by more established firms, which own the complementary assets required for effective commercialization. Here the returns on innovation depend on the start-up’s bargaining power: high disclosure decreases it, while a bidding war increases it. Due to the existence of a market for ideas, the start-up’s innovation is associated with the reinforcement of incumbent market power, rather than with creative destruction. Proximity may decrease the effectiveness of a bidding war, as the bidding firms may have a better understanding of each other’s valuation of the innovation.

- Reputation-Based Ideas Trading: In this case, incumbents own the required complementary assets, but the disclosure problem is severe. Even if the existence of a market for ideas allowed mutual gains, it is not easy to arrive at a cooperation solution, due to the risk of expropriation faced by start-ups. As a result, established firms have an incentive to set markets for ideas, supporting their well-functioning, for instance through the development of a "fairness" reputation. Proximity enables informal contacts as well as more formal collaborations, which help to establish and maintain a trust relation and thus, a "fairness" reputation.

- Greenfield Competition: In this last setting, start-up innovators can successfully preclude imitation and incumbents own complementary assets, although these are not relevant. Despite the fact that imitation is difficult and that returns in the product market are high (which makes competition an appealing strategy), the relative returns of competition over cooperation will depend on other factors, such as the potential future hazards associated with each strategy, at each stage of the value chain.

Nevertheless, for the successful commercialisation of the technology, firms must have access to complementary assets, once that innovations require more and more expertise
Figure 1.1: The Impact of the Commercialization Environment on Strategy and Competition

from different fields. This idea is complemented by Chesbrough’s idea of "open innovation". The concept of open innovation refers to the firm’s needs to seek externally additional knowledge in order to be able to develop their technology, i.e. if they want to successfully commercialise their innovation, then they have to find an optimal mixture of internal and
external knowledge, through patents, licensing agreements or joint ventures. Accordingly, in the open innovation paradigm, a firm seeks both an internal and external technology base, as well as technology insourcing and internal or external venture handling, to produce new products for its market. Additionally, these inputs will generate technology spin-offs in a new market and licensing to other firms (either in the current market or in a new one).
2 Entering the Spatial Dimension

2.1 Games & Models

The traditional point of view sustains that licensing is undesirable, once that it increases competition, implies transaction costs and implies that the licensor shares rents with the licensee. The reason for licensing is based on the assumption that a firm is not able to properly exploit the innovation. Arora and Fosfuri (2003) present a new point of view, under which they analyse the interaction between markets for technology and product market, and claim that competition in the downstream market creates strategic incentives to license upstream. In fact, on the one hand an additional competitor in the product market reduces industry profits, as it increases competition. However, on the other hand, it will increase the licensor’s revenues. Consequently, the incentives to license rely on two opposite effects: the revenue effect and the rent dissipation effect.

Despite of the interesting insights on why do firms license to competitors, this approach does not attempt to explain the role of licensing in the location decisions. Consider then a situation where there are two firms with equal marginal costs and facing quadratic transportation costs. d’Aspremont et al. (1979) show that in a Hotelling duopoly model the location equilibrium will be each firm locating at each end-point of the space. Ziss (1993, cited in Matsumura et al., 2010) showed that when there are sufficiently large cost asymmetries, the location game has no pure strategy equilibrium: the cost-efficient firm will prefer to locate as close as possible to the cost-inefficient firm, while this will prefer to locate as far as possible from the other.

Matsumura et al. (2010) introduce in the location equilibrium problem the possibility of technology transfer (based on a royalty policy), and they show that it has a significant impact on the location choice and that it ensures the existence of a pure strategy equilibrium. The authors develop a four-stage game, representing the different choices the firms make.

1. Firms 1 and 2 choose location, $x_1$ and $1 - x_2$, respectively.

2. R&D stochastically determines the marginal cost of each firm; cost difference between the firms occurs, $c_i = c - h_i$, where $h_i$ is stochastic, with density function $f(h_i)$. From now on, we will assume that the marginal costs are $c_1 = c_2 - \epsilon$ and $c_2$.

3. Decision about the transference of the cost-effective technology, where, if $G$ denotes the interaction in the model, $G_+$ indicates that licensing occurred and $G^-$ indicates that licensing did not occur.

4. Both firms compete in prices.

The existence of the third stage is crucial, as it guarantees that a pure strategy equilibrium in locations will always exist in the game, regardless the fact that after the technol-
ogy transfer firms remain cost-asymmetric. In this framework, maximum differentiation appears. Table 2 presents the profits for firms 1 and 2, when there is licensing in the third stage and when there is not. \( x_i \) represents the location of firm \( i \), \( t \) is an exogenous parameter representing the transport costs faced by consumers and \( r \) the royalty received.

\[
\Pi_i(x_1, x_2) = \frac{t(1-x_1-x_2)(3+x_1-x_2)^2}{18} + r
\]

\[
\Pi_i(x_1, x_2) = \frac{t(1-x_1-x_2)(3-x_1+x_2)^2}{18} + r
\]

\[
\Pi_1(x_1, x_2) = \frac{t(1-x_1-x_2)(3+x_1-x_2)^2}{18} + a
\]

\[
\Pi_2(x_1, x_2) = \frac{t(1-x_1-x_2)(3-x_1+x_2)^2}{18} + a
\]

Table 2: Profits \( \Pi^i(x_1, x_2) \) and \( \Pi^{-i}(x_1, x_2) \) for firms 1 and 2

A careful look at \( \Pi_i^1(x_1, x_2) \) shows that the payoff function of firm 1 is strictly increasing in \( r \). It can also be shown that firm 2 will accept the licensing agreement if \( r \leq \epsilon \). As a result, firm 1 will set \( r = \epsilon \) and thus, \( \Pi_i^1(x_1, x_2) \geq \Pi_i^{-1}(x_1, x_2) \). So, the cost-efficient firm has an incentive to license its technology to the rival firm. Considering now the second stage of the game, the results of R&D investment will only affect the value of \( \epsilon \) in \( \Pi_i^1 \) Let \( a \) be the expected gain from licensing; profits \( \Pi_1^i(x_1, x_2) \) and \( \Pi_2^i(x_1, x_2) \) now become

As it was seen, the decision to license-out technology can have several implications: it may increase profits in the upstream market for technology, while at the same time it increases competition in the downstream market for products; in the case of cost asymmetric firms, it reduces asymmetries, and, in the game devised by Matsumura et al., it is a central piece in the location decision of firms, being responsible for the maximum differentiation equilibrium solution.
2.2 Focusing on Licensing Agreement: Difference in Technology
Licensed Equals Difference in Location?

When focusing on licensing agreements, one can distinguish them according to the type of
technology being licensed: is it embryonic technology or a fully developed one, ready to be
commercialized?

As it has been emphasized so far, embryonic technology usually has a high content of tacit
and latent knowledge, while mature technology usually relies on fully codified knowledge.
Furthermore, the codification of tacit knowledge is often incomplete, which means that
face-to-face interaction, if not proximity, is required. In other words, technology transfer
is often underpinned by a complementary transfer of tacit or not yet codified knowledge,
hence the need for further interactions. In regard to mature and fully developed technol-
ogy, there are few new research paths to be explored, so interactions between creators and
manufacturers are much less critical.

Bearing this in mind, could the differences in the technology licensed be the determin-
ing factor to explain the differences in location choices? It is certain that this is not the
only factor that influences start-ups’ location choice, but it can be crucial. Since they are
SMEs, they rely heavily on the returns of their licensing agreements. As a result, they
have more incentives to monitor and put effort on the licensing agreement, because if it
does not reach any conclusion or if the partner is able to appropriate part of the start-up’s
ideas, then it can be a major drawback to the start-up.
Part II
Markets for Ideas

In this second part, the emphasis will be on Markets for Ideas and on Start-ups. Once that R&D is no longer "black-boxed", we take into account more variables that can contribute to shed light on the location decision of firms. Placing the start-up at an intermediate level in the "technology production branch", it is necessary to take into account both upstream and downstream interactions, with universities and manufacturing firms, respectively.

3 The Startup as a Nexus of Knowledge Flows

3.1 Science based Start-ups and Spin-offs: Relevant Traits

As it was said before, there is a renewed interest in the exploration and strengthening of the relations between academia and industry. If in the U.S. the focus was on giving universities a greater autonomy in spin-off creation and in allowing them to claim IPRs on their own technology (Bayh-Dole Act, 1980), in Europe the focus is on laying grounds for a better university-business dialogue (Lisbon Treaty, 2007). It is acknowledged that the interaction between research, education and innovation (the "knowledge triangle"), as well as cooperation between universities and the private sector (through the creation of science parks or the organization of workshops and science culture events) are efficient means of promoting innovation capacity in the regions where they are located. Spin-off creation involves the transfer of IP from the university to the spin-off or the establishment of a licensing agreement between them; as a result, they are seen as an instrument to foster university-firm relationships, to value research results and to overcome the lack of funding. Building upon the definitions of start-ups and spin-offs presented in section 1.4, we will establish the main characteristics of these two types of firms, comparing them.

There are many barriers to spin-off creation and growth: the stability and life-long employment at a university renders it more attractive to researchers when compared to the uncertainty of the future of a spin-off; it is difficult to obtain funding, and without it, the products' commercialization may be delayed or even cancelled; last but not least, often entrepreneurs have limited management skills, once that their main activity is in university research. Nevertheless, some authors, like Clarysse and Moray (2004, cited in Rothaermel et al., 2007), support the idea that it is better to coach the team and give them a chance to learn, rather than hiring a CEO.

Looking at spin-offs and start-ups, we can find both similarities and differences. When we look at their genesis we immediately begin to see differences: a spin-off is an enterprise created by a university to explore industry links and IPRs on a specific field; a start-up, on the other hand, is created by one or several individuals to explore or perfect an idea,
they believe to have market value.

From this analysis of their genesis, we can infer they will behave quite differently from the start: one (spin-off) is bound by the university purposes, intents and policy at large, being run by researchers, not managers, while the other (start-up) has total organizational and strategic freedom. This difference may explain the presence or absence of a business plan and the aggressiveness, or lack of it, in pursuing business opportunities and partners, as well as the differences in performance. Here it is not clear whether spin-offs would perform better than start-ups or vice-versa: a study by Shane (2004, cited in Salvador, 2011) finds that the former perform better than the latter, while a study by Salvador (2011) presents results that go in the opposite direction.

Despite the differences in their origin, start-ups and spin-offs share some common traits: although there are exceptions, the majority of these firms are extremely dynamic micro or SMEs that are working with basic knowledge or with a mix of basic and applied knowledge; they have a majority of researchers as staff; and, finally, they have a high international attitude and they are not dealing with the local market, instead they focus on the national and international markets. Most of them act at an intermediate level between the universities’ market for technology and the MNEs market for products: while, on the one hand they do not have all the relevant facilities to carry on big R&D projects, on the other hand they are not engaged in large scale production. Consequently, they might benefit from the access to (university’.) laboratories in order to conduct research, but they still need to find an enterprise able to commercialise their products. To finish, we have another similarity. In the end, they are both transitory: either they fail and vanish, or they succeed and transform themselves in something else.

3.1.1 Knowledge Production and Exchange as Causal Factors in Location Choice?

As it was said above, start-ups and spin-offs have close ties with universities. There are in- and out-flows mainly of basic knowledge, or, at most, with a mixture of basic and applied knowledge, exchanged between start-ups and universities. Due to these knowledge characteristics, it is not easy for universities to codify or to license it, and thus, start-ups and spin-offs work with an immature or even fuzzy knowledge, many times difficult to grasp, as it is common that these firms are making research in new areas or developing embryonic technology.

According to Almeida and Kogut (1997, p.22), one can find "substantial qualitative evidence supporting the role of small firms and individuals in introducing "radical" innovations." Other authors, as Fontes et al. (2009), highlight the fact that the competitiveness of (biotechnology) firms will depend "on the ability to constantly develop and renew their knowledge base". Considering the Georgia Tech example, one notices that SMEs seek new research findings which are still in a tacit stage (Yusuf, 2008).
As a result, in a first stage, face-to-face interaction is almost certainly needed to grasp complementary knowledge, crucial for the progress of research and, in a later stage, frequent visits to university may be needed to share not only results, failures and advances or new possible research perspectives, but also to share infrastructures. Recall that start-ups and spin-offs are young and small firms which, as Schumpeter (1934) noted, may be hampered by the lack of financial or physical resources (such as tools and infrastructures) or even by the lack of human resources, and that most times they rely on received funds to explore new technologies (Almeida and Kogut, 1997).

Given the need of face-to-face interaction for knowledge exchange and the need to share labs for knowledge production, locating close by universities may be beneficial for start-ups and spin-offs, since it will not only reduce displacement costs but also it will allow them to benefit from spill overs resulting from a more frequent informal interaction.

Considering now downstream relations between start-ups and firms, there are situations that might repeat here, as for example, the need of face-to-face interaction. This will be the case when the relations between start-ups and firms can be included in the Pasteur’s Quadrant, where a mix of basic and applied research is at play. It can also happen that the interactions between start-ups and firms are characterised by the transference of fully codified knowledge, used in purely applied research. Even though at this stage the knowledge is usually more codified and the technology more mature, one should not forget that tacit and codified knowledge are interrelated, and therefore, parties may feel the need to meet in order to exchange additional knowledge, which presents strong enough reasons to influence the location decision of start-ups.

3.2 Methodological Insights When Considering that the Characteristics of Knowledge Induce Proximity

3.2.1 Different Sources and Modalities for In-Coming and Out-Going Flows

Due to their characteristics, start-ups and spin-offs operate in an intermediate level between universities and big firms: they receive in-flows of basic knowledge and produce out-flows of more applied or mature knowledge.

The in-flows from (respectively, out-flows from) start-ups and spin-offs can be in two directions: either from (resp. to) universities or from (resp. to) firms. These flows can be seen from different perspectives: the type of knowledge (basic or applied, codifiable or not, ...) or the channels used to transfer it.

Linkages between universities and industry are a key factor in the start-ups’ strategic evolution. According to their nature universities contribute to basic research awareness and insights, producing and transferring basic knowledge that will be further developed by
start-ups. These, in turn, send upstream a mix of basic and applied knowledge, so that universities can try to find different applications for it.

Start-ups also transfer knowledge to downstream firms, but this is much more applied, and is usually fully codified, so that firms can either use the knowledge or commercialize the product immediately. Firms will also share some new knowledge with start-ups and spin-offs, in particular the knowledge resulting from R&D performed under licensing agreements.

We can also look at these flows in and out of start-ups and spin-offs according to the way knowledge is traded, which stems from the peculiar nature of technology as an economic asset and as potentially objects of exchange. The in-flows to start-ups and spin-offs can be in two directions: either from universities or from firms. In-flows from universities to start-ups usually take place through licensing agreements, research and recruitment or training partnerships; the in-flows from firms to start-ups are less tacit and are supported by out-licensing, standard training and research. In the case of embryonic inventions, it is not likely that the technology transfer would have occurred absent intellectual property protection (Colyvas et al., 2002, cited in Rothaermel et al., 2007) Out-flows to universities usually take place in an informal way, and the tacit knowledge is mostly protected by secrecy and by a few patents; out-flows to firms, in turn, take place mostly via patents and small personal secrets.

### 3.2.2 Which Characteristics of Knowledge and/or Modalities of Transfer Require Proximity?

Taking into account the aforementioned sources and flows of knowledge, one can easily see that neither do they have the same characteristics nor are they transmitted through the same channels, and hence, some of them will require more proximity than others.

When knowledge is more tacit and basic, a great share of it is usually non-codifiable and difficult to grasp. Therefore, the knowledge flowing from universities to start-ups and spin-offs transmitted requires proximity: since tacit knowledge is embodied by individuals, it is important that researchers/scientists from both sides interact and explain in detail their ideas or the procedures to follow and that cannot (or it is much more difficult to) be written down, explained via email or included in a patent.

Knowledge flows downstream have different characteristics: the knowledge being exchanged is more mature, and hence, easier to be codified. As a result, proximity is less needed, as typically, more mature knowledge or technology has less opaque areas, thus, there are less questionable points and less need of frequent interaction and additional explanations. One may say that most of the knowledge flows between universities and startups/spinoffs occur using non-market channels and in an informal way (through training and research agreements), though licensing also has some weight. The out-flow of knowledge from start-ups
and spin-offs to the universities often has to use non-market channels, as much of it is not easily codified (for example: progress reports may contain descriptions of failed experiments or dead ends reached and that qualify as "latent knowledge").

Looking now at the knowledge flows between start-ups/spin-offs and what we may call manufacturing firms we tend to find market channels used, such as patents, licenses and out-licensing agreements. This choice is made possible by the different nature of the knowledge being transmitted: it is now a codified, or an easily codifiable, knowledge. The reverse flow, between manufacturing firms and start-ups/spin-offs is, by the above mentioned reason, almost non-existent.

Having analyzed the flows of knowledge both upstream and downstream of a start-up/spin-off we can see that there are differing types of knowledge, using preferably different channels, and with rather different needs for proximity and face-to-face interaction. The upstream flow almost requires proximity and the downstream flow has minimal need of it.

![Figure 3.1: University ↔ Start-up ↔ Firm Interaction](image)

### 3.2.3 Start-ups at the Center of a Branch for Technology Production

According to what was said above, start-ups and spin-offs seem to play a central role in the production, transformation and exchange of knowledge. One can identify two knowledge branches: one relating universities with start-ups and spin-offs, and another relating start-ups and spin-offs with firms. In general, the former is characterized mainly by basic and tacit knowledge, passed on in an informal way, through non-market channels; the latter is characterized by mature and codifiable knowledge, transmitted via market channels. In broad terms, one can think of the "firms" as being larger than start-ups but not MNEs, whose main activity is the commercialization of fully developed products (in-house or not).

As we have seen, these differences between the two branches induce different needs for
proximity, and this will, in turn, imply different tensions when deciding where to locate. On the one hand, it may be better for start-ups and spin-offs to locate closer to universities, as frequent face-to-face interaction with university researchers will be needed, thus reducing costs; on the other hand, although the nature of knowledge allows a larger distance, start-ups and spin-offs should also locate relatively close to firms, so that they can monitor firms' actions (e.g., start-ups and spin-offs may want to monitor a licensee).

From inventions to final products there are two branches, separated/linked by the existence of start-ups and spin-offs. At first sight, one can be led to believe that proximity is crucial in the first and less important in the second. However, it will depend on the characteristics of knowledge being transferred, on the type of technology and on the channels used to circulate it.

Although the university may be seen as a pool of basic knowledge which is transferred to start-ups and spin-offs to be further developed, and thus proximity is needed, it may also be seen as a service provider, as start-ups and spin-offs may ask the universities to analyse the behaviour of a given product under some pre-defined circumstances or to search for some other circumstances where it has an interesting behaviour. In this last situation, models and applications are usually known, and, as a result, proximity does not play a significant role. The type of technology transmitted from start-ups and spin-offs to other firms is usually mature and codified, thus requiring little proximity. Nevertheless, both parties may engage in complementary R&D agreements, making proximity desirable.

Summing up, we can identify four main flows of knowledge between three different actors: universities, start-ups/spin-offs, and firms. Two of them, upstream, occur between universities and start-ups/spin-offs, and the other two, downstream, occur between start-ups/spin-offs and firms.

Universities produce basic knowledge that is transmitted to and developed by start-ups/spin-offs, which, in turn transmit a mix of basic and applied knowledge (or a more mature technology) to firms. These last ones will either fully develop a technology or commercialize a product. Thus, the type of knowledge or technology involved is probably the main factor when deciding where to locate. Due to their characteristics, basic knowledge or an embryonic technology will induce start-ups and spin-offs to locate closer to the party that supplies them. A more applied knowledge or a fully developed technology, in turn, is easily codified and transmitted, so proximity with suppliers of this type of knowledge/technology is of less importance.

3.2.4 Universities and Technology Transfer Offices

Youtie and Shapira (2008) note that the role of the university has been changing: in its early years, universities' main goal was to train students, being an "accumulator of knowledge". Afterwards, with the development of industry, universities were more and more
pressed to meet industry needs as they already had a core of researchers and laboratory capacity, and therefore, they started to do applied research, in order to better address more specific problems. Nowadays, besides the previous goals, universities are also expected to "actively foster interactions and spill overs to link research with application and commercialization" as well as "taking on roles of catalysing and animating economic and social development". As a result, if universities want to fulfil their role with the help of well-known TTOs and to make a bridge between cultural, ethical, scientific, technological and economical dimensions, then they have to evolve into entrepreneurial organisations (Grigg, 1994, cited in Rothaermel et al., p.27), at least in respect to transforming the knowledge generated into market value, a process which will be possible and which may be accelerated if there are stronger individual incentives to do so. (Henrekson and Rosenberg, 2001, cited in Rothaermel et al., p.29)

Universities have a particular interest in technology transfer offices (TTO), as they are an additional way to guarantee financial security and to have access to relevant industry assets, helping universities to fulfill their "entrepreneurial" role. It is widely agreed upon that a TTO is an important link between university and industry, facilitating the interaction between them (Rothaermel et al., 2007). As a result, the quality of TTO is of utter importance, as it can foster academia’s participation in commercialization activities, the validation of patents is somewhat related to the TTO’s quality and this can determine future funding. Several studies about the productivity of TTOs have been made. The main conclusions are that the licensing performance of TTOs depends on invention disclosure, the protection of the licensee, the total research income and the number of employees. Some other studies (Markman et al., 2005) show that there is a correlation between non-profit TTOs and the existence of university-based incubators, and that a licensing-for-equity strategy is correlated with new venture formation.
4 Choice of Location

4.1 Agglomerating SMEs Founded on Science?

As it was seen before there are key determinants, such as knowledge, science parks and cities, that can induce the need of proximity between SMEs, like start-ups, and universities or other firms, that, in turn, will have some influence on the location decision of SMEs.

Assuming that these determinants affect all SMEs in the same way, so that firms’ preferences are the same, and that cost heterogeneities are stochastically determined after the location is chosen (as in the model of Christou and Vettas (2005), cited in Matsumura et al., 2010), then spatial agglomeration can be an equilibrium solution. This conclusion does not seem plausible when one takes into account the possibility of technology transfer. As Matsumura et al. (2010) show, in this framework maximum differentiation appears. The model developed by these authors was presented in section 2.

Therefore, there must be another reason for the existence of agglomerations of SMEs, once that firms still prefer to locate close by others, regardless the fact that, since technology transfer is possible, they should prefer to locate as far as possible. Nevertheless, the need of proximity cannot, in itself, explain the existence of clusters of firms. The common intuition is that there must be externalities resulting from the agglomeration of firms, like knowledge spill overs or a pooled labour market. Economies of agglomeration relate to firms’ benefits and effects of locating close by, such as network effects or economies of scale.

Dating back to as early as Smith (1776), agglomeration and its benefits have been thoroughly studied; still, perhaps the most influent and the best known work on agglomeration is Marshall’s Industrial District Argument (1890). He defends knowledge spill overs, linkages between suppliers and producers and labour market interactions as the main sources of agglomeration economies. Accordingly, Duranton and Puga (2003) identify these three sources of agglomeration economies with three different mechanisms of micro-foundations of urban economies: sharing, related to linkages; matching, related to labour market; and learning, related to spill overs.

One of the most obvious arguments for the existence of agglomerations is the existence of indivisibilities. Either when thinking about cities or about agglomeration of SMEs, it is straightforward that neither citizens nor SMEs have enough financial capability to individually own all the infrastructures they need, from roads to leisure or health facilities. Focusing on SMEs, we see that the cost of sharing infrastructures decreases as more firms use them and that even the production costs may decrease, as firms can share a broader range of inputs provided by intermediate suppliers. Therefore, there are increasing returns at the aggregate level, which in turn lead to urban increasing returns. There are gains from diversity.
Nevertheless, not all firms in the agglomeration may benefit from these advantages. From a certain size on crowding will prevent some of the firms to benefit from them. There will be firms that will be located too far away to profit from the infrastructures or simply the infrastructures will be simultaneously used by too many firms, thus reaching their capacity limit. It is the combination of "localisation economies" (resulting from the reduction of the cost of using a given production process) with the congestion costs (resulting from the limit city size imposed by crowding) that creates static advantages to urban specialisation.

Increasing returns may also derive from individual specialisation. When a worker is specialised in a particular task as a result of a "learning by doing" process, his marginal productivity in that task increases. In this case, gains are internal to an individual rather than to an intermediate firm. Finally, firms can also share risks by benefiting from a pooled labour market when they are faced with productivity shocks.

In terms of labour market, agglomeration economies can result from two situations: an improvement in the quality of the matches and an improvement in the chances of the matches. When there is an increase in the number of workers and in the number of firms, it becomes easier for each worker to find an employer that matches better his expertise. Thus, the quality of the matches increases. If the matching function is subject to increasing returns, then a proportional increase in the number of job seekers and vacancies results in a more than proportional increase in the number of job matches. There will be more opportunities that a job seeker can investigate simultaneously, increasing the chances that one of them is suitable for him. This means that there will be less unemployed workers and open vacancies. Furthermore, the assumption of increasing returns implies that an increase in the number of workers will increase the matching rate.

If we look from firms’ point of view, the above explained situations work as an incentive to agglomerate, as by locating where other firms already are, they can have access to a pooled labour market, thus benefiting from the improvement in the quality and chances of matching.

The knowledge mechanism for urban agglomeration is subdivided by Duranton and Puga (2003) in three steps: knowledge generation, knowledge diffusion and knowledge accumulation. A diversified city enables a start-up firm to explore the different production processes without incurring relocation costs, until it finds the most appropriate process, point at which it can start mass production. The existence of such a production process while assuming the existence of relocation costs generates dynamic advantages from urban diversity. As for knowledge transmission and accumulation, there is also a substantial advantage in (if not need for) proximity. Once again, from a firm’s point of view, there are advantages resulting from agglomeration.

Also, as it was shown in Helsey and Strange (2002, cited in Duranton and Puga, 2003), if one adapts the case of urban matching to an innovation context, then innovation is facili-
tated by the existence of an established and dense network of suppliers, since it lowers the cost of developing new products.

Given the general understanding that firm clustering can promote innovation, several policies were developed in order to promote agglomeration between firms. The most common strategy used is the creation of science parks, since the general belief is that they are a means of establishing new and innovative firms, supporting at the same time their growth. As Helmers (2011) notes, the number of science parks in the U.K. almost doubled in ten years, increasing from 46 in 1999 to 85 in 2010.

There is also a significant literature modeling the use of urban land under spatial informational externalities (Beckmann, 1976; Imai, 1982; Fujita and Ogawa, 1982; Papageorgiou and Smith, 1983, cited in Duranton and Puga, 2003). Once that it is within the scope of this thesis to rely on Geographical Economics to understand the diffusion of knowledge, it seemed interesting to take Duranton and Puga’s (2003) approach of knowledge diffusion as a process of learning, and therefore, as a micro-foundation of urban agglomeration economies; in particular, we present their mathematical interpretation of knowledge diffusion. Typically, it is assumed that the productivity in location $s$ is a function of the density of economic activity at different locations, weighted by a decay function. In other words, it is assumed that the output is the product of a standard production function, multiplied by an externality term. This term is equal to the sum of output in locations other than $s$, weighted by a decay function. In Duranton and Puga (2003), the authors model the output of a homogeneous manufacturing good at location $s$ as:

$$Y_s = \int g(s, s') b[Y(s')] ds' \beta(l_s, r_s) \tag{4.1}$$

Where the first term is the externality, $g(s, s')$ is the spatial decay function, decreasing in the distance between locations $s$ and $s'$ and $b[Y(s')]$ represents the density of firms at $s'$. $\beta(l_s, r_s)$ is a production function having labour (l) and land (r) as inputs and exhibiting constant returns to scale. According to this equation, an increase in distance results in a loss in knowledge (due to the spatial decay function), which, in turn, results in a decrease in the diffusion of knowledge.

Following the arguments of Helsley (1990, cited in Duranton and Puga, 2003) stating that the knowledge produced in a location can be seen as a by-product of output, equation 4.1 can be viewed as a reduced form of a knowledge diffusion process, whereby knowledge diffuses through contacts between firms, whose costs rise with distance. The author also suggests that knowledge could be, at least partially, location-specific. Nevertheless, there is still not one completely developed model of the diffusion of knowledge in cities, which has good micro-foundations for the informal externality and its spatial decay.

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4.2 Agglomeration Externalities: Localisation vs. Urbanisation

There are two main currents regarding agglomeration economies: localisation and urbanisation. Yet, it is not consensual whether agglomeration economies arise from one or another.

Localisation (or specialisation) economies are basically a category of agglomeration economies based on proximity amongst firms in the same sector or industry. According to this theory, knowledge spillovers are a result of agglomeration of firms within the same industry, as it is the case of Silicon Valley or Wall Street. There are localisation externalities resulting from this type of agglomeration, the so-called MAR externalities (after Marshall (1920), Arrow (1962) and Romer (1990)). In favour of Marshallian externalities, van der Panne (2004) found that the development of new products is higher in regions and industries where the industry is more spatially agglomerated. Examples of these intra-industry externalities can be the existence of specialized suppliers that provide certain goods and services, the existence of a local pooled labour market, sustained by the local concentration of production, economies of scale in larger markets, forward and backward linkages, or simply spillovers. These are pecuniary externalities that can affect firms' profits, but that will not shift firms' production functions. Besides these pecuniary externalities, localisation externalities can also incentivise innovation: firms in the same industry may benefit more from the knowledge spillovers occurring within the agglomeration, and, according to Porter (1990) the subsequent competition may even result in an increase of productivity.

Urbanisation (or diversification) economies, defended by Jacobs (1969), are economies in which knowledge spillovers arise due to the existing complementarity between different industries. Accordingly, these economies give rise to the Jacobs (or inter-industry) externalities. In fact, the same initial knowledge may be applied in different industries, but it is necessary that there exist knowledge spillovers so that scientists from diverse backgrounds can have the idea of applying it to their field of expertise. It is the case of the laser, whose theoretical grounds were laid by Albert Einstein in 1917, and can now be used in areas as varied as medicine, industry, military or entertainment. The resulting urbanisation externalities arise from the increasing returns created by the diversified environment where firms are able to search and experiment different production processes or innovations. Relating Jacobs externalities with Duranton and Puga’s description of a diversified city, Glaeser et al. (1992, cited in Duranton and Puga, 2001) find that, not only do firms grow faster in cities that have smaller firms, but also that they grow faster in a more diversified environment.

Döring and Schnellenbach (2005, cited in Helmers 2011) establish an important difference in terms of the effects of these two types of externalities. According to the authors, MAR externalities lead to spatial economies of scale, while Jacobs externalities give rise to spatial economies of scope. As for which of these externalities is more innovation-conducive, there seems to be no consensus, although the study of van der Panne (2004) suggests that localisation spillovers rather than urbanisation knowledge spillovers affect positively regional
innovativeness.

Last but not least, it is also worthy to note that externalities do not affect all firms in the same way, as their effects depend on each firm's situation in respect to other firms whose interest areas if similar may originate a network effect. Most externalities are a result of informal face-to-face interaction between employees (or owners) of firms located close by (in a science park). It is not very difficult to imagine that it is easier to have a fruitful conversation when discussing one's work (with due regard for confidentiality and so on) if both interlocutors are working a similar area, which means that, even among firms located in the same science park, firms working similar areas will reap greater profits (externalities) than firms working very different areas.

Despite the fact that firms may greatly benefit from inter- or intra-industry externalities and that the majority of surveys and literature support the idea that firms are aware that they can benefit from agglomeration spillovers, there is also some evidence which shows that apparently agglomeration externalities is not the main reason for firms to locate in a science park. According to Helmers (2011), firms seek to benefit from the reputation of a science park and from its support. Consequently, the managerial decisions of the science park will affect firms' interest in locating there and which type of firms will join the park, i.e., if the science park is not specialised in a specific field, then it is likely that the criteria followed by the management are related to observable characteristics (size, age or business group affiliation) rather than business activity.

4.3 Determinants of Location Choice

In order to address the firm's problem of location decision, we take into account three different determinants, each related to a different strand of literature. The characteristics of knowledge, the existence of a science park (and its characteristics) and the characteristics of cities are key determinants of this problem.

4.3.1 Knowledge

The first strand of literature considers knowledge as being codified or not, case in which it is tacit. One possible definition of tacit knowledge is the one of van der Panne, according to whom "tacit knowledge is ill-documented, uncodified and can only be acquired through the process of social interaction" (van der Panne, 2004, p. 594), and it is this type of knowledge that gives firms or universities context-based and hard-to-replicate capabilities that will distinguish them from others. Teece (1981) states that tacit knowledge is difficult to articulate and it is hard to be transferred, unless those who possess the know-how in question can demonstrate it to others.
Codified knowledge, on the contrary, is easier to transmit and receive (Teece, 1986), as it "can be written down, peer reviewed or examined" (Youtie and Shapira, 2008, p. 1190), i.e., can be easily transmitted. Nevertheless, as Desrochers (2001) points out, it is expensive to codify knowledge and its codification may be too expensive when compared to the expected returns. Nonetheless, being codifiable is not a necessary condition for knowledge to be codified. According to Agrawal (2006) this type of knowledge "that is not codified but is codifiable" can be classified as latent. Under this category fall, for example, failed experiments, which help to learn and build a successful "final" experiment that will be reported.

Bearing into account these characteristics, the choice to codify can be a strategic choice for the inventor. As Teece (1986, p. 287) notes, codified knowledge "is more exposed to industrial espionage and the like". Gans et al. (2002) also remark that the commercialization strategy of a firm will depend on the strength of IPRs, as they show that firms that control IPR are more likely yo pursue a cooperative strategy.

Tacitness and codification are interrelated, and making a sharp contrast between them may be misleading (Amin and Cohendet, 2000, cited in Youtie and Shapira, 2008): frequently, to make good use of codified knowledge one needs the related underlying tacit knowledge; in a similar way, the application of tacit knowledge often draws on codified knowledge. Knowledge resulting from basic research and taking the form of an embryonic technology can be more difficult to codify when produced at the early stage of the research process. Hence, when considering the translation of the new technology into a patent, the inventors will face a difficulty: all the relevant information cannot be easily and adequately "formatted", some of it will be difficult to explain. As a result, if the inventor wants to license out its invention, he will have to commit to frequent contacts and face-to-face interaction; this type of interaction will be less costly if it is possible for the licensor and the licensee to be close to each other. In other words, proximity is important since, all things being equal, a closer location reduces the costs associated with these interactions. Note that one cannot preclude that the licensor will try to design the patent according to its use and hence, the reach of the patent will vary accordingly. Hence one could observe that patent assigned to different strategic uses (patent blocking, reputation, pure in-licensing, commercialisation in-house, etc.) will be different with this respect.

In order to benefit from an effective protection inventors rely on a combination of patent and know-how. Hence, not all technical knowledge will be disclosed in the patent and circulated in the patent system. It goes without saying that when firms choose to rely on secrecy (trade secret) and not on a patent (for process innovation that cannot be reverse-engineered this choice is frequent), no information circulate in the economy.

When firms rely on a strategy of portfolio that amounts, among others, at disseminating the relevant technological knowledge in different interrelated patent, the knowledge disclosed at the patent level is lower, as stressed by Parchomosky and Wagner (2009).
The patent distribution across inventors, however, is extremely skewed: the vast majority of inventors registers very few patents but a small number of inventors register a large number of patents. Menon (2011) defines the first type of inventors as "comets" and the second type as "stars". Typically, comet inventors are linked to firms whose main activity is not patent and star scientists are linked to R&D departments of MNEs or big companies; comets seem to be associated with diversified cities, while stars seem to be associated with specialized ones. Furthermore, he shows that comets are positively affected by stars, as there are externalities resulting from knowledge spill overs (both formal and informal), workplace contacts and attraction effects.

Firms are not only relying on in-licensing and/or on out-licensing to have access to knowledge. In an open innovation context, firms rely, articulate and manage different but complementary in-coming and out-going flows of knowledge. Research collaborations produce one of them.

As Katz (1994) shows, there are several factors that impact the creation of collaboration agreements and R&D alliances. Among them, we can find the variable distance: the number of collaborations decreases as a function of distance between parties. Accordingly, knowledge production via formal collaboration agreements can be limited to a restricted geographical area. Also, as it is widely agreed upon, scientific collaboration tends to be started in an informal way, resulting from casual conversation; as a result, proximity can foster collaborations, since it is more likely that this causal conversation begins if two potential collaborators are close.

Abramovsky and Simpson (2011) also found evidence of the importance of quality of university research in the location decision of firms: pharmaceutical and R&D-doing firms in the chemical sector tend to locate close to top research departments, and they are more likely to engage in collaboration agreements. University firm linkage is a "fluid, complex and iterative process involving many different actors", as Bramwell and Wolfe (cited in Yusuf, 2008) say, that affects the effectiveness of circulation of knowledge which is dependent upon both an intertwining of tacit and codified knowledge and the efficacy of knowledge networks to which the actors belong.

Albeit interaction between firms and universities is needed, there are several obstacles that impede them. University researchers / entrepreneurs find little incentives to commercialize their inventions, either because patenting it or finding a buyer is expensive and time consuming, or because the technology transfer office (TTO) has limited capacity; university’s bureaucracy and regulations are often a major obstacle. In addition, most SMEs are not actively seeking to acquire technology and they may lack specific enquires about university research, and so, high ranked universities must look for clients abroad.
4.3.2 Science Park

The International Association of Science Parks (IASP) defines a science park as "an organisation managed by specialised professionals" that has as main goals the "increase in the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions" through the stimulation and management of flows of "knowledge and technology amongst universities, R&D institutions, companies and markets". (IASP International Board, 6 February 2002).

Very often, science parks are related to a nearby university, that plays an important role in the establishment of their location and in their development since many university spin-offs will locate there, helping to maintain and strengthen the linkages between the university and their spin-offs which are fundamental if one is working in the Pasteur’s quadrant, besides the organisational and cultural ties.

According to the IASP worldwide statistics on science parks, in approximately two thirds of the associated science parks, more than five universities (and in 21% of the cases more than twenty universities) are located within a 50km radius from a science park and 44% of the associated science parks are either located inside a university campus or are owned by a university.

Many authors have studied firms located in a given science park (Salvador, 2011; Cantù, 2010), but few have studied the science park characteristics that render it (un)attractive to firms. From an university’s point of view, proximity with a science park is desirable, since there are several channels for university-industry technology transfer, such as the creation of spin-offs, hiring of graduate students or licensing of university owned patents by tenant firms, consultancy services and specific courses provided by the university for tenants, or joint research contracts between university and tenants. Moreover, science parks may be helpful for the university to build a stronger reputation, leading to the granting of more funds.
If a firm needs access to complementary knowledge, either from universities or from other firms, it may find it there in the science park, in the shape of conferences and seminars, or on a more informal basis, of spillovers. Nevertheless, being a knowledge pool may not be the most important (or the most obvious) characteristic of a science park: it also provides services that are useful for firms, such as legal or social support (like assistance in the management of companies or support to sportive activities, catering, cultural and recreation services), as well as physical infrastructures (like libraries or labs) and an attractive land rental system.

This last point, however, may also be a disadvantage of locating in a science park. While some parks claim they practice a favourable and flexible land rental system, authors such as Westhead and Storey (1994) found evidence that support the idea that "rents in science parks may significantly exceed rents paid for comparable premises in the surrounding area". Another unattractive characteristic of a science park from a firm's point of view is the increased competition for access critical resources, such as the management assistance provided by the science park or the consultancy services provided by the university.

Taking into consideration the structural differences between research centers of multinational firms and start-ups, it can be argued that MNEs have little interest in the services provided by a science park, as they have enough resources to have, for instance, their own IPR team. Start-ups, on the other hand, will benefit from these services and infrastructures, since typically they are recent firms, whose effort is directed to research. As a result, the incentives and motivations for locating in a science park may vary according to the type of firm. Cantù (2010) presents an interesting example of how a firm chooses a science park according to its characteristics: it is the case of Petroceramics that along its path had different goals and different needs, and, as a consequence, decided to move from a small science park with few connections to a bigger one, not too far away, with a broader network system.

The size of the city may appear to influence the location of science parks, as only 4% of the science parks associated with IASP are located outside cities (at a distance of at least 25km of them) and 58% are located in cities with more than 500 000 inhabitants.

4.3.3 Cities

Last but not least, the other determinant we consider is the characteristics of cities. Marshall, in 1920, presented three factors that could explain the concentration of industries in cities: the pooling of specialized labour demand, the development of specialized intermediate goods industries and knowledge spillovers between firms in an industry. In more recent years, other authors identified another factor that can not only explain industry concentration, but also explain the existing type of industry: the diversification or specialization of the city.
Duranton and Puga (2001) describe the so-called "nursery cities", where firms can explore the most suitable production process in a diversified environment without having the cost of re-locate, and once they find the ideal process, they can then move to a specialized city, where there is only one type of process, and start mass production. Locating at first in a diversified city ("nursery city") may be seen by the firm as a good investment: even though there are comparatively higher production costs in diversified cities due to crowding effects, and even though afterwards it may have to incur relocation costs, choosing to locate first in a nursery city allows firms to try a wide range of processes before finding the most suitable for themselves, before having to relocate.

Locating in a specialized city, where all firms use the same process type will result in cost-reducing localization economies. Also, firms may find it profitable to locate in a specialized city before finding their ideal production process if the cost advantage of this type of city is large enough. Furthermore, the type of activities developed depends on whether a given city is diversified or specialized: Henderson, Kuncoro and Turner (1995, cited in Duranton and Puga, 2001) show that in a diversified city firms develop newer and more innovative activities, while in a specialized city the activities developed are more mature; this is confirmed by Duranton and Puga (2001), who show that different economic environments are more suitable for different sectors and different stages of a product's life cycle: while more innovative sectors and early stages of a product's life cycle are likely to benefit the most from urban diversity, agglomerated sectors and fully developed products are likely to benefit the most from urban specialization.

Moreover, the pooled labour market resulting from cities leads not only to efficiency gains, but also to increased incentives for workers to acquire general and specific human capital when there are industry-specific shocks in a diversified city. As a result, the city will be better able to change and have a higher growth (Amend and Herbst, 2008).
4.4 Tensions in Start-up’s Location Choice

There can be several factors to influence the location choice of start-ups, ranging from the type of knowledge exchanged to the spill overs resulting from agglomeration, and traditionally literature focuses on this last factor.

There is a widespread literature defending the idea that urban agglomeration allows for agents to interact and learn from these interactions, fact that is enhanced by proximity, as it enables more frequent face-to-face interactions and consequently, the existence of spill overs (Jacobs, 1969; Henderson, 1974; Scott, 1992; Fujita and Thisse, 1996, cited in Duranton and Puga 2003). According to Keeble and Wilkinson (1999) and Simmie (2002), this learning process will have a stronger impact on new and small firms, rather than on established firms, for they lack the complementary assets needed to the development or commercialization of new product, and therefore, they will locate in areas where these assets are accessible.

Aydogan (2008) reinforces this idea, stating that the main mechanism by which firms learn and introduce new products in the market is by inter-firm contract. The contractual costs are dependent on geographical proximity, on the existence and characteristics of a network of contacts and on the type of knowledge exchanged. When the knowledge exchanged is tacit, the density of economic activity in the cluster may affect the way it is transmitted.

It seems reasonable to assume that spill overs play a central role in promoting entrepreneurship and innovative activity, which, in turn, draws the attention to the role played by universities and science parks in fostering spill overs. Audretsch et al. (2005) found that technology-based firms are more likely to locate close to universities, apparently to profit from knowledge spill overs. A similar conclusion is reached by Abramovsky and Simpson (2011), who argue that it can be beneficial for firms to locate their R&D departments near universities, once that it facilitates direct connections and the access to knowledge in an informal way, and by Anselin et al. (1997, cited in Abramovsky and Simpson, 2011), who find evidence of local spatial externalities between university research and high technology innovative activity. Baptista and Mendonça (2010) hypothesise that the number of universities in a given region has a positive effect in determining the entry of knowledge-based firms in that region.

Also highlighted by Baptista and Mendonça (2010) is the role of human capital. Considering universities as sources of qualified human capital, the authors try to relate the number of university graduates or students with the number of new firms in knowledge-based sectors, stating that regions with higher university graduates are more likely to have a higher number of new firms in knowledge-based sectors. Besides this influence in the clustering of firms, human capital is also crucial for the success of each firm individually, as a firm’s absorptive and productive capacities rely on it. Workers in a firm should be
able to absorb the spill overs resulting from clustering of firms, and transform them into valuable innovations. In this respect, Andersson et al. (2005, cited in Rothaermel et al., 2007) found that patents are responsive to the spatial distribution of workers at different levels of education, as well as to the distribution of private and university R&D facilities.

As for the role of science parks, Salvador (2011) divides them into three generations, according to the services provided. The first generation provided physical space and basic shared facilities; the second, specialised business support services; finally, the third generation of science parks works mainly as "network knowledge incubator". Regardless the fact that science parks are able to provide firms many necessary resources, be it managerial or legal services or infrastructures for firms' labs and conference rooms, they create good conditions for the development and strengthening of knowledge networks. Some authors, as Cantù (2010) reinforce the idea that there are other forms of proximity that support innovation. She identifies technological, cognitive and vision proximity as other forms of proximity that can influence firms' boundaries and the development of spatial relationships. Additionally, these other dimensions of proximity help to sustain knowledge networks.

We can identify some tensions concerning the location choice of start-ups. There are forces between universities and start-ups, and between start-ups and firms pushing in opposite directions. Considering first the interaction between universities and start-ups, we can identify three factors that induce start-ups to locate closer to universities: the transference of tacit knowledge; the access to infrastructures; and human capital pooling. As it is well known, the exchange of tacit knowledge requires frequent face-to-face interaction; therefore, and as traditionally universities deal with more basic research, start-ups may find it desirable to locate close by them, being easier to access to complementary knowledge. The access to universities’ infrastructures, such as labs or libraries, can work as an incentive to locate closer: most times start-ups are new firms, that may not own all the assets needed for their projects. Lastly, as Baptista and Mendonça (2010) note, not only are universities sources of qualified human capital, that can later be included in the start-up’s staff, but also university researchers can facilitate the contact between start-ups and their own networks of colleagues, broadening start-up’s knowledge sources.

Other forces push in the opposite direction. In contrast with a situation in which the knowledge exchanged is mostly tacit, the exchange of codified knowledge does not require both parties to be located close by. Additionally, the access to the universities’ infrastructures may not be a strong enough incentive. As it is highly likely that start-ups own the assets needed for a daily use, the use of these other assets will be a sporadic event, not frequent enough to induce a closer location. Yusuf (2008) remarks the lack of incentives for university-industry linkages, due to, for instance, the difficulties TTOs face when trying to sell or commercialize an invention or the lack of incentives for researchers to commercialise their findings. If there is not a sufficient amount of knowledge coming out of the university, then start-ups (and firms in general) will not find it attractive to locate nearby.
On the downstream side, considering the relations between start-ups and firms, we can also identify factors pushing in different directions. Favouring proximity between both of them, one can find the existence of science parks, which simultaneously provide good conditions for the establishment of start-ups and for the existence of spill overs, from which all firms can benefit. Besides, the need for complementary assets, following Teece (1986), can be seen as another factor favouring proximity, once that the successful commercialization of an innovation may depend on the access to these assets. Furthermore, based on the idea of Gans et al. (2002) and of Gans and Stern (2002), strong IPR reduce the risk of expropriation and increase the relative returns to cooperation. Proximity can then be seen as a way to increase the probability of finding the most suitable partner for a cooperation agreement, rather than as a way of being expropriated of their own innovation.

Finally, considering the forces that may induce a greater distance between start-ups and firms, we see that, contrarily to what was described in the previous, weak IPR increase the risk of expropriation: proximity with other firms increase the number of informal interactions and spill overs, thus being easier for competitors to learn about the start-up’s innovation. Another situation in which firms may find it preferable to locate farther away is the one described by Matsumura et al. (2010): when firms are allowed to exchange cost-efficient production technology through a royalties’ system, maximum differentiation appears in the market.

These tensions are summarised in table 3.

<table>
<thead>
<tr>
<th>University → Start-up</th>
<th>Start-up → Firm</th>
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<tr>
<td>Tacit Knowledge</td>
<td>Cooperation Strategy</td>
</tr>
<tr>
<td>Infrastructures</td>
<td>Need of Complementary Assets</td>
</tr>
<tr>
<td>Qualified Human Capital</td>
<td>Strong IPR</td>
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| Codified Knowledge                                         | Competition Strategy                                 |
| Sporadic Access to Labs                                    | Weak IPR                                             |
| Lack of Incentives for UILs                                |                                                      |

Table 3: Tensions in Start-up’s Location Choice
5 Intuitions about Partial Effects

5.1 Potential "Proximity Inducing Variables"

As it was seen before, start-ups connect the knowledge coming from universities to the knowledge used by firms. By definition a start-up uses basic knowledge and transforms it in applied knowledge, under the shape of a more mature technology or even a marketable product. Consequently it will need a seed to start working upon, which is provided, in most instances, by university research. Thus, start-ups work in the Pasteur’s quadrant, i.e. they are working in an environment that is a mix of basic and applied knowledge. That seems to be a powerful incentive to induce proximity, as much of the basic knowledge, as seen before, is not codified or easily codifiable, that from a start-up’s viewpoint.

If we try to grasp what can be the university’s viewpoint we can assume that proximity is also desirable, as there can be an interest on the part of the university to follow the development of an idea, if only to assess the limits and potential of the initial idea. A successfully developed idea coming from a university will not only increase the university’s reputation but it can also be an alternative source of funds for graduate students and lab equipment or another way of having new insights into their own research.

When thinking about start-ups’ interactions with commercializing firms, these have two options: either they follow a competition strategy or they follow a cooperation strategy. In the presence of a strong IPR regime, Gans, Hsu and Stern (2002) show that cooperation is a more likely outcome. At this point, if the technology transmitted is embryonic or if the knowledge is too tacit, the location decision of the start-up is amidst two opposite forces. One favours proximity, as there is the need of further interactions due to the knowledge characteristics; the other force allows a greater distance, since if the IPRs are strong enough, the risk of expropriation is reduced, and hence the start-up may locate further.

On the contrary, if the technology transmitted is mature or the knowledge codifiable, but the IPRs are weak, the nature of knowledge requires less proximity, while the weak IPRs make it desirable, since start-ups will need to monitor firms, in order to decrease the risk of expropriation (once that it cannot be decreased by IPRs).

But knowledge is not only basic, applied or a mix of both. It has other characteristics, such as latency or tacitness, upon which the follow up feedback of universities will be based. A knowledge which is too tacit or latent will require frequent face-to-face interactions, and consequently, proximity, in order to be grasped.

Inventions with this type of knowledge incorporated will, in general, be in an early stage of development and its codification will be far from complete, becoming more difficult to develop. If a licensee only has access to codified knowledge and lacks the tacit or latent knowledge needed to complement it, then he must seek complementary knowledge through
face-to-face interactions, whenever he wants to further develop it in order to commercialize an invention. Once again, proximity is desirable for the transference of this complementary knowledge.

5.2 Vertical and Horizontal Complementarities between several startup in terms of knowledge production

Teece (1986) has shown that if a firm, namely a small firm, is to successfully appropriate the rents from innovation it must rely, in a context of weak IPRs protection, on the access to complementary assets.

These complementary assets are not the same ones in different phases of bringing an idea to the market. We may consider, for the present purposes, only two phases: one in which the design is "floating", meaning that it is easy to alter and study alternatives, and another where the design is "frozen", i.e. the basic options have been taken and it is costly, or difficult, to alter it.

In the first phase, those complementary assets usually take the shape of firms that are working in similar research areas, or areas that somehow may influence the research undertaken, providing different inputs that may help along the search for the optimal solution. After that solution is reached, the needs also change: we now have a "frozen" design that we want to sell. As we are dealing with start-ups and/or spin-offs, it is not likely that these firms have marketing or manufacturing capacity, and that has to be found, through agreements, partnerships or other suitable forms that will enable the firm to reap the benefits of its invention.

So, we may consider two types of complementarity, related to two different phases of an innovation process and the type of research and knowledge being produced.

In the first phase, much of the work is still a mix of basic and applied knowledge, not easy to codify and to successfully transmit it, frequent face-to-face interactions are needed. The importance of face-to-face interaction at this point stems from the importance of latent knowledge in this first phase: a finding, even a small one, not directly related to the research goals of a firm may help along another firm’s research. That may be a good enough reason for start-up firms to seek proximity and could perhaps explain the attractiveness of science parks. In the second phase, we are dealing with codified knowledge, or easily codifiable, so proximity is not needed.

To sum up: there are two types of complementarity - horizontal complementarity and vertical complementarity. Horizontal complementarity deals with basic research and requires proximity because much of the knowledge being transmitted is latent, I feel it takes place predominantly in science parks, when the complementary firms are similar in size and purpose. Vertical complementarity, in turn, deals with applied research and does not
require proximity, once that the knowledge being transmitted is codified and the firms that complement each other are very dissimilar and almost all of it is out of a science park.
Part III
Case Studies

6 Case Study Presentation

6.1 Questionnaire Designed for Interviews

In order to better understand the main determinants and confirm (or not) the intuitions about the location decision of firms, interviews were conducted with three selected firms (Start-ups), in ITQB (Oeiras, Portugal).

The questions asked can be divided in four main groups, addressing the characteristics of the start-ups themselves, their relation with universities, with science parks, and finally, with intermediaries.

In the first group, about the characteristics of the start-up, the interviewee was first asked to explain the history of the start-up, so that we could identify the most relevant traits of each firm, focusing on the main in- and out-flows of knowledge and their characteristics.

Then, several questions about licensing (if they had licenses): when, why, what and how did they license or sought licenses? With these questions, we aimed at understanding which were the characteristics of knowledge involved in the license, why would they choose a licensing strategy (if it was to have access to complementary assets in research or because there were not research tools used for basic knowledge development) and if there was an exclusivity clause. Taking this one step further, they were also asked about the influence of proximity in their licensing decisions: did they prefer to license to firms closer to them, or the existence of intermediaries attenuated the importance of distance?

After introducing the factor distance, the interviewees were asked about the importance of distance when interacting both in an informal way and through a licensing agreement, either with universities or with firms. With these questions, we hoped to have a clearer view about the role of distance, namely the importance of proximity.

In the second group of questions, we focused on the interaction between start-ups and universities, since one of the characteristics of these firms is precisely their connection with academia. We tried to understand why do they choose to work with universities: because of access to complementary sources of knowledge, because of the evolving basic knowledge (mix of basic and applied), because of the universities’ infrastructures (labs, tools instruments,) or because of other types of proximity (professional, organizational or cultural). Recalling that institutional relations cannot always be smooth, we also asked which were the main problems the start-up faced when working with universities. To finish, we tried
to assess their valuation of the existence of a trade-mark, namely if having the start-up associated with one could be important for obtaining funds or if it could be a sign of the quality of the output.

We then proceeded to analyzing the relation between the start-up and the science park it was located in. The first and most obvious question was why they would locate in a science park. Then, we asked which were the characteristics of a science park that could influence their decisions: access to complementary knowledge from universities and/or other firms and spill overs or the existence of infrastructures (legal support and other services provided by the science park, the existence of a favourable system for the acquisition of land or physical infrastructures).

Last but not least, in the last set of questions we tried to understand the relation between the start-up and intermediaries. First we asked about the existence of private intermediaries inside the science park; later we tried to understand whether the start-up relied on them and which were the possible benefits coming from that interaction.

6.2 Interviews’ Results

In this section we will present the results of the interviews with three firms: GenIbet, ECBio and Silicon Gate. For each interview we will start by presenting a short history of the company to better put into perspective their answers.

The first two firms, GenIbet and ECBio are located in the campus of Oeiras. It is important to explore the dynamics of this campus, so that it is easier to understand some decisions of these firms.

iBET (Institute for Experimental Biology and Technology) is a privately held, non-profit biotechnology research organization that connects academia and industry. Its main partners are the Institute for Chemical and Biological Technology (ITQB) and Faculdade de Ciências e Tecnologia (FCT), from New University of Lisbon. ITQB is a postgraduate research institute of this university, whose mission "is to carry out scientific research and post-graduate teaching", and both of them are excellence centres, whose main areas of activity are Chemistry and Biology, as well as their application areas such as Health/Pharmaceuticals, Agroindustry or Agrochemistry.

In 1996 both ITQB and its associate institution iBET moved to National Agronomical Station (EAN), property of the Ministry for Agriculture, in Oeiras. Nowadays, they are located in the same building, fact that creates a link between fundamental research and industrial applications. As for the partnership between ITQB, iBET and FCT, a protocol between them was signed aimed at joint collaborations in undergraduate and graduate courses. iBET and ITQB are located in the campus of Oeiras (sometimes also called ITQB Campus, iBET campus, ITQB/IBET campus or Oeiras Campus of ITQB, IGC, iBET),
which is only 20km from Lisboa.

![Figure 6.1: Location of GenIbet and ECBio](image)

6.2.1 GenIbet

GenIbet is a biopharmaceutical contract manufacturing organization\(^2\) (CMO) that presents itself as "an integrated solution to take your product to the market". Therefore, it can be classified as a developer and a highly specialized service provider rather than a research start-up. GenIbet was founded in 2006 by iBET, which presently holds 45% of its shares. In 2009, GenIbet was granted a GMC certification for Biopharmaceutical Active Pharmaceutical Ingredient production, and as recently as 2011 it inaugurated two new suites. The dominant activities of GenIbet are the cGMP manufacture for phases I and II of clinical trials and the supply of materials to be used in pre-clinical and toxicology studies.

Since the bulk of its activity is services and not R&D, this start-up does not hold any license nor is it working based on any license. When asked about its interaction with universities and other firms, we were told that they deal with universities mainly through international projects, and that they deal with multinational firms through services rendered. The two main reasons for locating in Oeiras Campus were the link with iBET and the infrastructures. As it was already pointed out, GenIbet is a start-up from iBET, and iBET is its biggest shareholder.

GenIbet’s genesis was determinant for deciding to locate there, as it has strong organizational and cultural ties with iBET. The infrastructures existent in the science park also played a significant role, as the firm was able to find there suitable conditions for the establishment of its lab. Another important factor are the partners: they were gathered by

\(^2\) A CMO is an organization whose main activity is providing its clients in the pharmaceutical industry a wide range of services from drug development through manufacture
GenIbet itself, and it can use their resources, such as infrastructures, labs or workers, with no extra costs associated.

Finally, although it may seem that iBet acts as an intermediary, when asked about its relation with intermediaries or its need to rely on these, GenIbet stated that it did not need to contact any intermediary in order to obtain new contacts. Nevertheless, at least in an informal way, through its own contact network, GenIbet relied on a business development expert in order to find firms that could need its services.

6.2.2 ECBio

The second firm located in Oeiras Campus is ECBio, a start-up with a very interesting evolution. ECBio was created in 1999 and since then, it has been located in three different locations, according to different stages of the firm.

Its first location was in Tagus Park, a science park also located in Oeiras, and, at the time, the company provided consultancy services in biotechnology; venture capital entered and this fact, together with their activity, enabled them to raise funds for another project. Later on, in 2003, ECBio inaugurated its first R&D laboratory and moved to the IBET/ITQB campus; one year later, it opened a second laboratory in the aforesaid campus.

At this point, ECBio was no longer a consultancy firm, but could be defined as a biotechnological start-up doing R&D. Its two first patents on stem cell applications and on new anti-cancer compounds were granted in Portugal, in 2006. Two years after, ECBio successfully registers the MatrixStem® brand for cell therapy applications. Still in 2008, two new patents were granted and ECBio seals the first technology transfer agreement with Cytothera, a firm from Medinfar group (pharmaceutical industry group). In the beginning of 2009 the cryopreservation of MatrixStem® cells is firstly commercialized by Cytothera; later that year, a final agreement was reached with Medinfar so that a new ECBio R&D laboratory could be built at Medinfar premises.

Finally, in 2010, along with a new location of the start-up, a new R&D laboratory was inaugurated; a second technology transfer agreement with Karolinska Institutet was established, aiming at implementing GMP production process for MatrixStem® and to collect data for international certifications. Incidentally, as an aside, the financial crisis turned out to be helpful for this start-up, as it was able to buy the required high-tech equipment at a very low cost.

When they were asked about their location decisions, the answer was clear: they varied according to the different start-up’s stages and their needs. First, as a consultancy firm, ECBio needed an office to provide consultancy services. It was located in Tagus Park, a science park that integrates universities, R&D institutions and companies, and works as an incubator for start-ups; hence, it allowed ECBio to have privileged access to
Then, with the inauguration of the first lab, they decided to change their location. To this decision contributed not only the lack of needed infrastructures in Tagus Park at an accessible rental rate and the better infrastructures provided by ITQB, but also the proximity with this institute felt by its founders: they had taken their PhD at ITQB and had a good network of contacts there.

Later on, as the start-up grew, it needed more space for new labs; however, ITQB was not able to find a solution for this problem. In its new location, ECBio was able to design its own lab, according to its needs, having, additionally, the benefit of locating close by their licensee and R&D partner. This proximity was considered to be of extreme importance, as a result of the R&D and licensing agreements.

ECBio has several (national and international) external collaborations with universities, essentially medical schools. For this start-up, proximity is not a decisive factor, for when it chooses a collaborator, it seeks quality and excellence above all.

None the less, all of its partnerships are inside Europe (excepting one with Israel) on account of travelling time and transportation costs. During the interview, we focused more on the partnership with Karolinska Institutet, in Sweden, in order to better illustrate the role of proximity. In this relation, proximity is not needed in the majority of time because, as long as the institute has the required resources, it is able to collaborate with the start-up without locating close by.

For example, one of the tasks of Karolinska Institutet is to perform tests and analyse if there is one model more suitable for a given situation or not. The results of these tasks are easily codified and expressed in a clear way, with no need for the start-up to ask additional questions, since they result from well-known and established procedures. ECBio has two types of agreements with Karolinska Institutet: a Material Transfer Agreement (MTA), through which ECBio can, for instance, send frozen cells and other non-perishable materials to be used later on by the institute; and a Technology Transfer Agreement (TTA), taken under specific circumstances. When ECBio realised that further in their research project Karolinska Institutet would need its technology to perform the necessary tests, a TTA was needed. As a result, experts from the institute went twice to Portugal, so that scientists from ECBio could explain their (new) technology, how to proceed and how to work with it. In this situation, for the technology to be effectively transferred, it could not be done without face-to-face interaction; however, this was an exception. For a routine interaction, both parties rely on monthly videoconferences, as well as sporadic visits to each other’s facilities.

Moving on to the importance of distance when interacting with firms, it was clear that in this particular case, proximity is extremely important, as it can be seen by the start-up’s decision of relocating. Focusing on its main R&D partner (which is also its only
licensee), proximity is needed as there are multi-level exchanges of knowledge. Before the commercialization of a product involving MatrixStem® technology, such as the collection, processing and cryopreservation of stem cells, clinical tests and improvements had to be carried, thus requiring licensor and licensee to be close by.

Besides this, proximity was also important for the R&D collaboration: the pre-clinical development for several clinical applications requires frequent face-to-face interaction in order to assess the evolution of the clinical trials; it allows scientists from both parties to easily exchange ideas and to acquire different know-how ("sometimes one does not leave the preparation on stand-by before using it, but the other leaves it for one minute, and that produces different results"); last of all, it also enables a faster transfer of materials.

When asked about the importance of proximity with this firm, in the absence of the R&D agreement, we were told that it was likely that proximity would be less important, but we only got a hypothetical answer, not a definite one. As part of its management strategy, ECBio now outsources different parts of their projects.

6.2.3 Silicon Gate

To approach our third interview we first have to have some prior information about its surroundings, physical and intellectual. INESC-ID is a non-profit research institution, privately owned by Instituto Superior Técnico (IST) and Instituto de Engenharia de Sistemas e Computadores (IESC). It is located literally across the street from IST, one of the best engineering schools in Portugal.

In the domains of electronics, telecommunications and information technologies, we selected a start-up called Silicon Gate. It was founded in 2008, following an existing gap in the Analogue and Mixed-Signal IP and the network contacts of a professor from IST. Silicon Gate is located in the same building as INESC-ID. There were two main factors that impacted the location decision of this start-up: prior connections with INESC-ID and proximity with a university (IST). The CTO of Silicon Gate, who is also a professor at IST, has professional links with INESC-ID (all professors must be connected to a research institute); as for the second reason, there are several students from IST who are also doing their Master / PhD thesis in Silicon Gate; locating so close by enables them to work in both places, going quickly from one place to the other, without having to spend much time in moving.

This start-up does not hold any license, although it might hold a patent in the near future. It has been trying to have more information about the best way to do so, namely through IST’s Technology Transfer Office (TTO), but it is unlikely that it will rely on the TTO for that, due to an appropriability problem.

When asked about what were the main advantages from working with a university the answer reveals two types of advantages: physical and human resources. For one thing, specific software is traditionally very expensive; yet, most universities have it. Therefore,
by working with them, the start-up can access software at a lower price or even for free. For another thing, the start-up can also have access to university’s labs and infrastructures. However, this feature does not influence much the location decision, since the start-up holds the equipment it needs in a daily basis. The physical resources that a university possesses are only needed by the start-up from time to time, and in this situation, the start-up prefers to send a worker there for the necessary time, rather than to own the equipment. The main disadvantage pointed out about working with universities was the existence of restrictive rules about the creation of spin-offs imposed by the departments.

As for the human resources, being both the CTO of Silicon Gate and a professor at IST, he is in a privileged position to recruit the best students for the start-up.

Currently, Silicon Gate is growing and it needs to create a new lab, which is not possible at INESC-ID building. Therefore, it is searching for new installations inside a science park, such as Tagus Park. However, for the start-up’s budget, this science park did not have a good price/quality ratio: it would only be possible to rent an old area, which did not project a good image of the firm. This, associated with the loss of students’ inflows resulting from moving away from INESC-ID, are two of the reasons why it is still located there, despite the fact that those facilities are no longer adequate to the start-up’s needs.
6.2.4 Main Insights from Case Studies

Despite the fact that all the three start-ups have very different backgrounds and evolutions, the results of the interviews conducted come to confirm our intuitions: several factors may influence the location decision of start-ups, mainly the need of geographical proximity with other parties (which can be explained by the type of knowledge at stake), the existence of suitable infrastructures and cultural and organizational proximity.

As it was seen, two of the firms moved (or want to move) to a different location, that can better satisfy their needs. From the different location choices of the start-ups, one can understand that the characteristics of the start-up and the infrastructures and services offered by a science park are interrelated. Besides the fact that there are spill overs resulting from the agglomeration of firms and from their proximity, if a science park wants to attract new firms, it has to provide good infrastructures. Among our case studies we find a firm, ECBio, that has had three different locations, in three different science parks. Each of these provided the best services and infrastructures for each stage of the start-up’s development: in the first location, a good network that enabled the start-up to provide consultancy services; in the second one, suitable infrastructures for the establishment of labs; the present location, infrastructures that meet the expansion path of the start-up. Along with physical infrastructures such as labs, offices or conference rooms, it is important that it also provides legal support and other services or an attractive land rental system. We have some examples of start-ups that were forced to exit a science park because it could not offer enough space for them to expand and grow, or it did so at a too high cost.

The same two firms noted that proximity between them and the other players (either universities or firms) is important; finally, all of the firms pointed out that non-geographical proximity had some weight in their decision. Other types of proximity were stressed by all start-ups, which matches the work of Cantù (2010), for example. Suppose that a start-up is making its location choice, and that two different science parks offer the same conditions: good infrastructures, legal support, a favourable land rental system, and so on. The main difference between them is that one of them is already known to the founders of the start-up: they have studied or worked in that science park, have former colleagues that are working there. It is likely that this will be a decisive feature, and that the start-up will locate in the science park where it has a network of contacts. This kind of cultural and professional proximity can be the decisive factor in the start-up’s choice. The professional, cultural and organizational proximities were pointed out as a reason for interacting with universities and locating nearby in an early stage of the start-up’s life. Indeed, often the founders of start-ups are researchers at a university, and even more often they did their graduate studies there, fact that builds prior links with the university that are taken into account later on.

One of the reasons why start-ups choose to work with universities was the easier access to the universities’ infrastructures. Although the start-ups own all the equipment and tools
they need on a daily basis (and two of them noted that it was acquired over the internet, at low prices due to the financial and economic crisis), it might be the case that at one point or another they will temporarily need to access equipment from a university. However, working with universities may have its own difficulties, as for example the restrictions imposed by each department on the creation of start-ups and spin-offs.

Although ECBio does not find proximity with universities important, in the particular case of its relation with Karolinska Institutet, proximity does not seem to be important as the knowledge transmitted is, in general, codified and mature. When a new technology from ECBio had to be transmitted to Karolinska Institutet, face-to-face interaction was required. Therefore, Swedish scientists went to Portugal in order to better grasp the *modus operandi* of this new technology. It was a better option to locate in Portugal and sporadically visit the facilities of the partners than to be permanently located near them. In contrast with this situation, is the relation between ECBio and its licensee, Cytothera. Regardless the fact that, as with Karolinska Institutet, there is also a TTA between them, these two firms find it desirable to be located close by, contrarily to what happened with the Swedish university. This need for proximity may be explained by the fact that ECBio has multi-level contacts with its licensee: not only do they have a TTA, but also they are working together for the commercialization of MatrixStem® and they have established an R&D program. All these agreements require frequent interaction between scientists, and hence, it was more appealing for ECBio to re-locate, and move close by its licensee / R&D partner. This confirms our intuition that when the knowledge or technology being transferred is not sufficiently codifiable or codified, proximity and face-to-face interaction are needed; in turn, when the technology is well known to both parties and easily codified, it is less likely that face-to-face interaction will be needed, and proximity acquires a smaller role.

Noteworthly is also the fact that ECBio places some boundaries on geographical proximity: collaborations with firms and universities inside Europe are accepted but outside Europe they are not. The reason for this is that the transportation and displacement costs are lower in this region.
7 Eliciting the key determinants of location decision

From what we have analysed so far, it can be said that the type of knowledge, of science parks and of cities impact the exchange of knowledge. Furthermore, it seems that the location decision of firms is influenced not only by geographical proximity, but also by other forms of proximity (cultural, institutional, cognitive, ...). These factors are usually studied in the literature individually. Also, it seems that there are several levels of interaction between start-ups and universities and between start-ups and firms that require more or less proximity, as for example financial, material (in the case of a Material Transfer Agreement (MTA) or human (in situations which require training, for example).

We hypothesise that in order to make a location decision start-ups always take into account more than one level, with different weights in the decision process, and that the decision to locate closer to a university or closer to a firm will depend on the number of multi-level contacts with each party. Therefore, we take into consideration six possible levels of interaction between start-ups and universities, and seven possible levels of interaction between start-ups and firms: human, knowledge, financial, material, technology, other forms of proximity and commercialization. Focusing first on the interactions between universities and start-ups and on the start-up's viewpoint:

- **Human**: Universities are a source of qualified human capital (Baptista and Mendonça, 2010), and university researchers may have different roles in the industrial sector, such as employees, principals or consultants (Mowery and Ziedonis, 2007). Moreover, joint research contracts may lead researchers from both parties to work together.

- **Knowledge**: Most frequently, knowledge is transmitted through licenses or shared through joint research contracts. In the first situation, if the knowledge exchanged is too tacit, further face-to-face interactions are required, in order to better grasp additional underlying knowledge; if it is codified, then it is likely that face-to-face interactions are less necessary. In the second situation, and according to Katz (1994), proximity is required. However, it might depend on if, for instance, the access to the university’s infrastructures is required very frequently or not.

- **Financial**: In some cases, start-ups result from the university’s desire to exploit an idea or a prototype, thus being founded by the university and being linked to it. Here, proximity seems to be an important factor, once that, as Powell et al.(2002, cited in Youtie and Shapira, 2008, p.1201) note, "venture capitalists often desire that firms in which they invest are located nearby".

- **Material**: Start-ups and universities may engage in MTAs. The need for proximity will depend on the type (perishable or non-perishable) of material being transferred: perishable materials will require shorter distances, for obvious reasons.

- **Technology**: Start-ups and universities may also engage in technology transfer agreements (TTAs). Typically, proximity will be required in order to explain the func-
tioning of the technology, and also to monitor the other party, reducing the risk of expropriation. This risk, in turn, will also depend on the strength of IPR, as Gans et al. (2002) remark.

- Other forms of Proximity: As Fontes et al. (2009) acknowledge, geographical proximity per se is not enough for knowledge transfer; there are other forms of proximity, as social (sharing the same origin or affiliation), cognitive (sharing a knowledge basis), cultural or organisational that are central to the effective transmission of knowledge.

Focusing now on the interactions between firms and start-ups and still focusing on the start-up’s viewpoint:

- Human: Start-up’s researchers may need coaching, in order to improve the start-ups performance or they may attend complementary training sessions promoted by firms. Also, joint research contracts may lead researchers from both parties to work together.

- Knowledge: same situation as the interaction with universities.

- Financial: A firm may be a major shareholder of the start-up, and, as before, venture capitalists prefer that the start-up is located close-by.

- Material: same situation as the interaction with universities.

- Technology: same situation as the interactions with universities.

- Other forms of Proximity: same situation as the interactions with universities.

- Commercialization: The joint commercialization or the license to commercialize a product (following Gans, Hsu and Stern’s (2002) cooperation strategy to enter the market) may require face-to-face interaction, since there are plenty of details to study and problems to solve.

Based on these levels of interaction, and considering the examples from the case studies, it is possible to construct the following table:

Considering first the GenIbet’s case, this firm has human and financial level contacts with the university (IBET and Universidade Nova de Lisboa), as there are some research projects between the start-up and the university, and as IBET is its main shareholder; with other firms, this start-up does not have many contacts, as its main activity is as a service provider. Nevertheless, it shares knowledge with them when outsourcing part of their projects. With respect to other forms of proximity, there are social and cognitive ties with the university.

Moving now to the ECBio’s case, and considering first its relation with Karolinska Institutet, they hold contacts in two levels: material and technological. In fact, ECBio has a MTA and a TTA with this university. The MTA is about non-perishable goods, so it
Figure 7.1: Levels of Interaction of Case Studies

<table>
<thead>
<tr>
<th>Levels</th>
<th>Start-ups</th>
<th>Genbet</th>
<th>ECBio</th>
<th>Silicon Gate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
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<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>X</td>
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<tr>
<td>Financial</td>
<td>X</td>
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<tr>
<td>Material</td>
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<tr>
<td>Technology</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Other types of proximity</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Commercialisation</td>
<td>-</td>
<td>-</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Proximity?</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

do not require proximity. As it was already explained, the TTA only required proximity for a short period of time. Concerning the interactions with its licensee (the firm analysed), they have a joint research contract and a TTA, aiming at the commercialization of MatrixStem®; furthermore, they also have to exchange material, to warrant the progress of the research. As a result, both licensor and licensee have a strong human level contact, as researchers from both parties have to interact due to the transference of knowledge, material and technology, as well as the commercialization strategy. Although ECBio’s new lab was built on Medinfar’s premises and that could be considered as a “financial level” contact and a major factor for the location decision of this start-up, we will not include it as such for two main reasons. First, according to the definition proposed, a financial level contact with a firm concerns venture capital and not land use; second, it is not directly related to Cytothera, but rather with Medinfar, the group that owns Cytothera. One can also identify some other forms of proximity with the licensee, namely cultural and organizational ties.

The last start-up considered was Silicon Gate. Considering its relation with IST, the university is indeed considered as a source of qualified human capital, and researchers at Silicon Gate also work at the university; hence, there are human level contacts. Furthermore, there are other forms of proximity, namely social, cultural and organizational. At the material level, the use of IST’s labs is not frequent, albeit it happens some times. Regarding its interactions with firms, we analysed its interactions with INESC-ID, considering its start-ups as a whole. Given that Silicon Gate is located inside INESC-ID, there are good
reasons to believe there will be human level contacts, as well as the exchange of knowledge, although maybe not at a very formal level. INESC-ID is shareholder of the start-up, thus there are financial level contacts. Last but not least, there are other forms of proximity, namely institutional and organizational.

From this analysis, and with the help of figure 7.1, we see that GenIbet has three levels of contact with the iBET and one with "firms", and that proximity is present in the former, but not in the latter.
ECBio has two levels of contact with Karolinska Institutet and six levels of contact with its licensee. As a result, it is located at distance from the university, but it is close-by the licensee. Lastly, Silicon Gate has three levels of contact both with the university and with the INESC-ID, being located close both of them.

Although in GenIbet and Silicon Gate’s relation respectively with iBET and INESC-ID, there are few levels of contact, proximity exists. One possible explanation for this situation is the fact that the two institutions are major shareholders of the start-ups, and that GenIbet can even be considered a spin-off from iBET.
8 Conclusion

Why and when are university research effects localized is a recurrent question found in literature. The purpose of this thesis was the exploration of the possible geographical and spatial dimensions of Markets for Technology in the commercialization of university research.

In order to do so, in the first place two different strands of literature were surveyed, with the aim of identifying relevant conditions to observe proximity as an important characteristic of markets for technology. Then, this survey was complemented by interviews in three start-ups, with the intention of putting into perspective the different variables identified in the aforementioned literature.

Why and when is proximity needed? To answer our initial research question, we relied on two building blocks: a branch perspective useful for Science based industries and the mode of entry in the market for products.

Considering first the branch perspective, universities and clients firms act as two "attractors" for localization: proximity with either one will be needed due to the existence of complementarities (additional knowledge, physical infrastructures or qualified workers).

Therefore, the start-up will be more attracted to the university when it:

1. Relies on proof of concepts, i.e., when it is specialized in transforming proofs of concepts into prototypes;
2. Needs to have access to complementary resources available at university at lower costs (access to specific software, as for example in the Silicon Gate case study);
3. Needs to have access to a pool of qualified workers (from university).

The Silicon Gate case illustrates the combination of conditions 2 and 3.

On the other hand, the start-up will be more attracted by the client firm when:

1. The technology covered by a TTA requires the transference of complementary knowledge;
2. Licensing-out technology that requires further development and testing before being commercialized, i.e., that needs face-to-face interaction to be effectively implemented;
3. It is specialized in the perfecting of prototypes;
4. There is an R&D agreement.
The MatrixStem® technology in the case study of ECBio, for instance, is illustrative of points 2 and 3.

Considering now the second building block, the two different modes of entering the market for products, cooperative or competitive, will make a difference in explaining proximity (which is needed in the joint commercialization situation of ECBio).

The first case-study, GenIbet, is an example of a standalone organization where proximity does not matter to our best knowledge. Nevertheless, it belongs to a very recent business model, CMO, whose characteristics have not yet been clarified.

This research can be extended by designing a questionnaire for a quantitative analysis about the interactions between universities and start-ups; the interviews conducted only provided the main qualitative insights about the location decision of the respective start-ups. Future research needs to be done in order to clarify the location decision of firms taking into account the competitive configuration on, either the market for technology or the market for products. Finally, additional research is needed to understand the factors influencing the location decision of a contract manufacturing organization (CMO), given that it is a new and not yet studied business model.
References


