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DOTTORATO DI RICERCA IN
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**THE GOVERNANCE OF KNOWLEDGE
IN ACADEMIC SPIN-OFFS.
A COMPARATIVE ANALYSIS BETWEEN ITALY AND UK**

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Introduction

While it is generally agreed that innovation is a main vehicle of economic growth, an even more pressing question concerns the criteria by which knowledge-based economies differ from one another. Scholars of innovation suggest looking for answers in three directions: first, by acknowledging the varieties of knowledge that are engaged in modern economies; second, by accounting for the processes by which knowledge is produced and used; and, finally, by looking at the purposes to which knowledge is put to work. In respect of each of these the role of universities is of central importance together with a wide range of other agencies, private firms and public research laboratories to name but a few.

The positive influence of universities on technological innovation and on knowledge diffusion has been historically documented (Rosenberg and Nelson 1994); however recent interest in and concerns about universities contributions to local development has resulted in a strong emphasis on technology transfer activities. Among these activities the creation of Academic Spin-offs (ASOs) has received increasing attention. ASOs are new firms whose business is the translation of knowledge developed within universities into a commercial product. There are at least three reasons underlining the strong interest towards supportive policies aimed at enabling those firms around virtually all Western economies: the transfer of new knowledge into the market, the pursuit of revenue for universities, and the positive externalities on the local area (Etzkowitz 2001).

ASOs are first of all new firms, whose initial mission is to exploit research results conducted inside the university environment. The role of the ASO is seen as a bridge between university and industry allowing newly developed knowledge, some of which is usually tacit, to reach the market as a product (Fontes 2005). Several factors contribute to the successful completion of this route of development including policies,

physical infrastructure, researchers' previous industry experience and scientific productivity of the university, to name but a few.

Existing literature mostly concentrates on two aspects concerning the ASO phenomenon: on the one hand the incentive mechanisms that shape the rate of generation or the performance of ASOs and on the other the resource endowment that an ASO firm must own (or have access to) to be successful. The same two lines of investigation are also used to describe the differences among scientists, universities and regions. In the university setting, little however is known about the processes of transformation of a business idea into an established firm in the market. While academics usually emphasise the number or the performance of established firms, so far few studies have attempted to map or elaborate on the paths an ASO firm undergoes in its development (e.g. Vohora et al. 2004). Our work goes in this direction.

There seems to be an implicit assumption that such development follows a 'natural' trajectory when incentive alignment issues are satisfied and when the resources available to the team, to the university parent organization and to the local context are in place. This work seeks to fill this gap by qualitatively exploring the evolution of two self-contained populations of ASOs. Our key conjecture is that the development paths that unfold before an ASO are multiple. The aim is to enhance economic and management understanding of the processes of bringing an idea of business into an established firm in the market. Moreover we are interested in observing possible differences between two European contexts, in this case an Italian and an English region. Underlying different ways of development of two different sets of ASOs should allow us to understand how different contexts behave regarding the same phenomenon.

To elaborate these points we will first draw on alternative approaches to the 'theory of the firm', as they represent the theoretical background explaining the development and growth of such organizations, and then we will describe and analyse the mode of knowledge governance instituted within and across the ASO during the various phases of its development and reflect these upon the theories of the firm. Moreover the comparative analysis should allow reflections related to the specificities of the contexts. Finally some policy consideration will be put forward.

The thesis is structured as follows: the first chapter focuses on the main strands of the theory of the firm in order to evaluate why such organizations exist and how they grow; brief examination of the modes of knowledge governance will also be provided as well as considerations about the characteristics of the innovative firm. The aim is to conceptualize a framework that will be useful to contextualize the subsequent analysis. The second chapter reviews literature on ASOs, with the aim of exploring the profile of this type of firm as it emerges from existing academic studies. Finally the last chapter illustrates the results of the empirical analysis performed on two selected samples of academic spin-offs, one in the Emilia Romagna region in Italy and one in the Greater Manchester region in UK.

PART I
THEORETICAL FRAMEWORK

Chapter 1

Theories of the firm

Introduction

The neoclassical theory of the firm is a price theory where firms are seen as simple organisations carrying out a production function. Specifically, firms are ‘black boxes’ aiming to maximise their profits choosing that best combination of inputs which leads to an *ex ante* known output. This static relationship transforming inputs into outputs and governing the behaviour of the firm, is the production function. The neoclassical theory of the firm assumes actors to be perfectly rational and informed over their choices. The seminal contributions of Herbert Simon (1947, March and Simon 1958), acknowledging the inconsistency of the perfect rationality and information assumptions, undermined the foundation of the standard theory. Perfect rationality and information assumptions are crucial for the neoclassical theory of the firm to be able to explain the maximization profit output derived by an unquestionable choice of the combination of inputs.

According to Chandler’s contribution (1992a, b), three alternative theories stem from the critiques to the neoclassical theory of the firm: principal-agent, transaction cost and the evolutionary theory of the firm. The principal-agent theory, adopting the static and unique character of the neoclassical production function, assumes different level of information between the parties involved in a business relation. Focus of the theory is the asymmetry in the flow of information between a principle and an agent taking place as a transaction is negotiated (Akerlof 1970). The concept of moral hazard is highlighted and the theory mainly focuses on the possibility of drawing *ex ante* contractual form, able to overcome *ex post* moral hazard behaviours. Moreover, the

approach highlights the divergent objectives between a principle and an agent negotiating a contract (Alchian and Demsetz 1972). While the principal-agent theory concentrates on the relationship between a principal and an agent, and particularly on the asymmetry of information issues taking place between two parties inside the same organisation, the transaction cost theory concentrates on the information asymmetries taking place in a transaction, and particularly in market transactions. This strand concentrates on the cost of transacting and first explains the nature of the firm and then the reasons underlying the growth of the firm in terms of activity internalization that is verticalisation processes.

Whilst information inside or outside the firm was the focus of the previous theories, the evolutionary theory of the firm or capability view stresses its attention on the resources a firm possesses, stating that the boundaries of the firm are determined by this assets' endowment. The transaction costs theory concentrates on the transactions a firm must deal with and highlights the intrinsic frictions that are involved by transactions between two or more parties. In particular, this strand focuses on the exchange processes, whereas the capability view focuses on the production processes of the firm. The capability view also points to the need of taking the dynamic element into account if the aim is to explain the evolutive path of the firm. This strand of literature emphasises the trial and error processes and the historical patterns of evolution shaping a firm. The accent is therefore on the idiosyncrasies of the practices of each firm, which are also consequence of the environmental context in which the firm is embedded.

Only one of the theories discussed above seek to be dynamic in the approach. Dynamic means rejecting the assumption of convergence toward a static equilibrium point, that means agents (i.e. firms) are part of a process involving bounded rationality and historical and trial and error constrained choices. Only the evolutionary theory acknowledges the dynamic element as a crucial variable in order to delineate a useful theory of the firm. However, transaction costs economics (TCE), although static in nature, includes the variable time in its analysis. These two strands, TCE and capability view, share similarities and differences in the attempt to describe the boundaries of and the behavioural process underpinning the firm. This chapter explores these two strands of literature in their basic foundations with the purpose of building a theoretical framework on which the literature review developed in Chapter 2 will be based.

Additionally, this chapter includes a review of the characteristics of the innovative firm, as a needed step in order to reach the analysis of the academic spin-off firm of the next chapter. The works reviewed in this chapter also represent a connection channel between the second and the third chapter where the empirical analysis is undertaken.

Transaction costs economics

This theoretical framework is grounded in the seminal work of Ronald Coase (1937) who first addressed the question of what the nature of the firm is. This widely-known manuscript explores the reasons that make the market price system unsuitable to efficiently meet all the exchanges that are needed in an economic system; Coase also asked why organizations such as business firms might be better positioned to deal with certain kinds of transactions in a better way than others. The Nobel prize-winner economist analysed the problem by spelling out that the use of the price system, and therefore market transactions, involve costs; under particular conditions a firm exists because the price mechanism is inefficient with respect to the goal of aligning the incentives of sellers and buyers. In other words the existence of the firm is warranted when the conclusion of a transaction requires the intervention of a business organization, which produces higher cost advantages than if the transaction were carried out in the market place.

The label ‘transaction cost economics’ was first suggested by Olivier Williamson in two seminal works (1975 and 1985) which paved the way to a very popular and fruitful field of investigation. This theoretical stream uses transactions as units of analysis and seeks to establish the boundaries of the firm. Transaction cost economics concentrates on incentive issue conditions underpinning the existence and the scope of a firm. It is defined by the gap between the costs of using the market system compared to the cost of undertaking the activity internally. The firm mission is the minimization of transacting costs. Thereby when the price system works efficiently the firm will buy from the market place, while when transaction costs are higher than internal coordination costs the firm will internalize and choose to produce internally (Williamson 1975).

The TCE starts from the concepts of bounded rationality and opportunism. There is bounded rationality every time two or more parties have to align their incentives by processing information. Assuming the inconsistency of perfect information and of perfect rationality, the parties involved in the transaction will behave in their own self-interest, therefore opportunistically. Williamson assumes opportunistic behaviour to be intrinsic in each transaction. According to Lazonick (2000), in a Williamsonian perspective, the opportunism factor will lead individuals to rely on markets rather than hierarchies in order to carry out their transaction. This reason is given by the fact that in situation of opportunistic behaviour of one part the other will be able to find alternative partners in the market. Lazonick (2000, p. 8) continues to argue that the factor that “favors hierarchies over markets is ‘asset specificity’. Williamson introduced asset specificity as a *dues ex machina* into his argument when it became apparent that the assumptions of opportunism and bounded rationality provided an explanation for why *markets* would organize transactions.”

Asset specificity are assets developed in conjunction with two or more parties and are not retrievable in other transactions or by other users. This argument leads to the acknowledgment of a positive impact of continuity in the relationship between the parties involved if they want to take advantage of the joint investment. This sort of dynamic element leads to the conclusion that deeper is the specificity of the asset, higher is the probability the firm will internalise that activity in order to assure the continuity character.

It should be noted that in this theoretical perspective, production activities are assumed to be given *ex ante* that is to say, two firms undertaking the same activity will require the same inputs to produce identical output. The choice of which stages of the productive process are going to be carried out internally and which ones are going to be bought in the market place, is just a matter of transaction costs versus coordination cost trade-off. The firm is therefore viewed as a ‘nexus-of-contracts’ where coordination costs represent not the ability of a firm to deal with some particular situations but rather to align the incentives between two parties, both in the market place and/or inside the firm hierarchy (Langlois and Foss 1997). The difference between markets and within firm coordination is defined by differences in the nature of the contracts involved. The firms contracts are more unrestricted, therefore the buyer (e.g. the manager or firm

owner) provides a wage in exchange of choosing which functions the sellers will provide among a range of possibilities (Langlois and Robertson 1995, Langlois 2005).

TCE therefore provides a theory of the “adaptive firm” (Lazonick 2000, p. 10), in which “Williamson takes these cognitive, behavioural and technological conditions as given, and asks how those who control corporate resources optimize subject to these conditions as constraints.” In other words, as said before, TCE does not take into consideration all the production process side of the business, therefore it does not consider the role of resources and their strategic allocation in explaining firm boundaries and growth. Equally it does not take the learning element into account, which is “the dynamics of the accumulation and generation of new knowledge and competence” (Antonelli 2008, p. 122).

Although a continuity element is acknowledged as important in order to manage asset specificity, TCE can be considered a static approach of analysis. When dynamicity enters the analysis, the TCE shows some weaknesses. As noted by Langlois (1992, p. 105) in the long run learning effects should operate in such a way to diminish the costs of transacting: “one cannot have a complete theory of the boundaries of the firm without considering in detail the process of learning in firms and markets”. That is to say that in TCE making transactions, as well as any other activity undertaken by the firm, it is not associated with the firm’s characteristics. Moreover, knowledge aspects about the production activities are not taken into account by TCE, as productive technologies are considered exogenous and perfectly substitutable factors which are picked up just on the principle of minimising an *ex ante* known cost structure (Langlois and Foss 1997).

Resource-based view and capability view

If TCE views the firm as essentially a collection of contracts, the resource-based view (RBV) focuses on the set of resources possessed by a firm, including both technological and organizational ones. The landmark contribution in this camp is by Edith Penrose (1959, p. 24): “The firm is [...] a collection of productive resources the disposal of

which between different uses and over time is determined by administrative decision”. Like in the TCE the RBV is at the centre of a long and important tradition of scholarly research. Penrose noted that existing theories were not able to account for the fact that firms change their product output and undertake diversification strategies. She noted that some input resources needed in the production process are acquired in stocks and sometimes these resources are indivisible. The excess of resources a firm owns after the production process represents a surplus that can lead to different activities inside the firm. Penrose also noted human resources learn and the experience gained in undertaking some activities enhances the likelihood of carrying out those activities more efficiently in the future. On these grounds she concluded that firms are highly heterogeneous units and that this character of heterogeneity is due to the intrinsic idiosyncrasies of the resource base within each firm.

Technological knowledge as well as organizational knowledge are firm-specific assets and the behaviour of the firm shapes the pool of resources on which the firm operate into the market. Therefore learning and the processes of competence development inside the firm are crucial to competitive advantage. In this research strand the firm is viewed for the first time as a repository of knowledge: technologies, productive processes and coordination activities not only define the products a firm put in the market and the choice of making the correlated activities internally or buying them externally, but also represent, and more importantly, the knowledge base on which the firm activities is settled. The knowledge base forms the capabilities of a firm, mostly a collection of intangible assets: “organizations possess a pool of more-or-less embodied ‘how to’ knowledge useful for particular classes of activities” (Langlois 1992). The knowledge base, the capabilities of a firm, does not merely sum up the employees’ skills: an organization functioning makes use of collective behaviour, the so-called routines (Nelson and Winter 1982). Routines are the result of the learning of an organization and are understood to be tacit, sticky and idiosyncratic to the organization that developed them. Although routines and capabilities are different concepts¹, following Langlois and Robertson (1995), routines represent a capability of the firm.

¹ Langlois and Robertson (1995, p.16) state that: “*routines* refer to what an organization actually does, while *capabilities* also include what it may do if its resources are reallocated.”

Let us now explore the nature of the coordination mechanism. First of all, coordination mechanisms are of two levels, “coordination achieved ‘across markets’ and coordination achieved ‘within firms’”, which are hardly distinguishable from one another (Demsetz 1988, p. 155). The coordination mechanism is therefore partly accomplished via organisational routines and capabilities, partly via the strategic decision making process of the firm. This latter process is not about which alternative and substitute activities or paths are undertaken, but “is a matter of constructing something resembling a decision situation by defining which variables are relevant, which in turns requires making sense of the environment, setting up procedures for solving the problem, etc.” (Langlois and Foss 1997). Coordination issues are therefore an idiosyncratic element of the firm, that is to say that capabilities themselves are a coordination device of the firm.

Moreover the capabilities view acknowledges that knowledge is dispersed among many different agents and organizations, and that any agent or organization owns all the core and out-of-the core capabilities needed to undertake the productive processes (Hayek 1945). That means firms must be linked with other agents or organizations in order to acquire the required resources or capabilities owned by others: “the capabilities view of the firm suggests that the boundaries of the firm are determined (at least in part) by the relative strength of internal and external capabilities, that is, capabilities internal to the firm and those available through contract with other firms” (Langlois 1992, p. 109). To make matters clear, if in the TCE the choice of a firm to internalize or externalize an activity were determined only by a price cost difference between the internal coordination or the external transaction, the capability view of the firm adds that the needed capability must also be available, internally or externally. But when a capability not owned by the firm is needed at a certain point in time, the so called ‘dynamic transaction cost’ or ‘dynamic governance cost’ becomes relevant too. If that capability is not already available internally, the firm can choose between either building it internally, or searching for it in the market. In either case the firm will have to meet “the costs of not having the capabilities you need when you need them” (Langlois 1992, p. 113). But if a capability doesn’t exist, and therefore is not available in the market – as is the case in innovative situations – the preferred path will probably be building it internally; alternatively the firm could resort to the market, search for similar activities

and interact with the owner of these activities in order to transform and make them more useful to its established goals. Clearly searching for new capabilities in the market entails high levels of dynamic transaction costs. In this perspective vertical integration is likely to be adopted as a strategy when the market doesn't provide the right capabilities at the right time, and vice versa. Moreover a firm could also choose to build some capabilities internally if they are available in the market. For example, if the dynamic transaction cost of making or buying a certain capability are similar, pure transaction costs could lead the firm strategy to choose to internalize the activity, for instance because of agency problems like hold-up threats.

The element that likely defines the existence of dynamic transaction costs is the systemic type of innovation². Building on Teece's work (1986, 1988) we identify two alternative innovative scenarios: systemic innovation on one side and the so-called autonomous innovation on the other. A systemic innovation takes place when a change or innovation in one stage of production entails changes in other stage of productions, that is to say, where there is strong interdependence among the different stages of production. Systemic innovation entails high dynamic transaction costs, and the decentralized market coordination mechanism appears less suited. On the contrary autonomous innovation does not imply interdependence amongst different stages of production, and therefore the dynamic transaction costs are likely to be lower than in a market exchange scenario (Langlois 1992).

According to Lazonick (2000) the main problem of the Langlois-Robertson theory is to consider the firm as an individual, therefore not taking into consideration the organisational learning of complex organisations or of networked firms, which we discussed as coordination mechanisms. Economics and management theory overcome this problem by means of the concept of dynamic capabilities, "as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments. Dynamic capabilities thus reflect an organisation's ability to

² Lazonick (2000) argues that the systemic innovation is the "*deus ex machina*" of the Langlois and Robertson (1995) theory that explains the strategy of a firm to internalise a particular activity or not: "The appearance of a systemic innovation leads a firm that plays the role of systems integrator to convince independent suppliers that they must give up their interdependence. The implicit assumption is that when such a change in vertical relations occurs, the presumed benefits of systemic innovation will be to some extent offset by the 'dynamic transaction costs' of overcoming the resistance of highly individualistic firms" (Lazonick 2000, p. 14).

achieve new and innovative forms of competitive advantage, given path dependency and market positions” (Teece et al 1997, p. 509). A long run innovative firm must therefore deal with dynamic capabilities. Its ability to remain innovative requires the development of dynamic capabilities. Dynamic capabilities are not buyable in the market place and are not easily buildable (Teece and Pisano 1994, Teece et al 1997, Henderson 1994). Learning processes are the main source of dynamic capabilities, which evolve in a constrained path as regards the history of the firm (Teece et al 1997, Chandler 1992a, b); in other words innovation activities of the firm are path dependent, and, as seen before, also related to the context in which the firm is embedded. It has to be noted that the concept of dynamic capabilities has to be considered not only as a tacit development of organisational knowledge, but also of strategic decision-making processes (Zollo and Winter 2002, Hilliard and Jacobson 2003); in other words “dynamic capabilities emerge from the coevolution of tacit experience accumulation processes with explicit knowledge articulation and codification activities” (Zollo and Winter 2002, p. 344).

In regard to the theory of the firm, the evolutionary approach or capability view appears to be the one that inform scholars and policy makers more about the strategies and behaviours of firms. However the strong inductive character of this approach makes it difficult to largely test it. Moreover it does not accurately take into consideration the exchange processes side of the firm. Let us now explore a slightly different approach of analyses that attempts to overcome these limits.

An integrated approach

If the TCE and the RBV are considered important foundations in the theory of the firm, the capability view seeks to build on these to make a step further. The capability view proposes a dynamic perspective to the Penrosian RBV and argues that a proper theory of the firm should unify the capability view with the TCE, especially in the form of dynamic transaction costs (Langlois and Foss 1997). An important contribution in this direction has been given by Antonelli (2008). Continuing on the RBV clear

acknowledgement of knowledge and competences as key sources for capabilities development³, Antonelli (2006, 2008) stresses that in order to understand the boundaries of the firm it is useful to move the analysis from the firm perspective to the knowledge exchange governance as units of analysis.

The capability view of the firm already stressed the importance of the dynamic character and interdependence among the three main activities of the firm, that is, production processes, transaction activities and coordination mechanisms, in analysing the boundaries of the firm. However, in order to develop a framework capable of capturing how the boundaries of the firm take shape, attention should be focused on the variety of knowledge governance mechanisms that are possible in an economic system. The aim of the framework is to “study the broad range of factors that affect the governance of the firm viewed ... as a selective and selected combination of complementary activities based upon the capability to accumulate competence and knowledge” (Antonelli 2008, p. 125). Antonelli (2008, p. 125.126) continues by pointing to the firm perspective:

“Firms select the mix of internal and external products and services according to the combined costs of production and coordination on the one hand and the combined costs of purchasing and using the markets on the other. Coordination activities cannot be separated from firms’ own internal manufacturing of the products and services. By the same token transaction activities cannot be separated from the actual use of the market as an alternative means of procuring or selling some products.”

The firm is therefore a combination of activities carried out via exploitation of internally generated knowledge and/or externally acquired knowledge. Different activities are differently based on different combinations of internal and external knowledge, according to the interdependence amongst coordination, production and transaction activities. The learning and path dependency elements apply to each of the three activities. The firm will choose whether to internalise or externalise some activities according to the capabilities available internally, the capabilities available in the market place, the capabilities in coordinating and the capabilities in transacting. In other words,

³ According to Antonelli (2008, p. 130), who also refers to the work of Nooteboom (2000), “competence is defined in terms of problem-solving capabilities and makes it possible for the firm not only to know how, but also to know where, to know when and to know what to produce, to sell and to buy. Competence and knowledge apply to the full set of activities: production activities, transaction activities and coordination activities.”

for example, the higher the competence of a firm in internal coordination activities, the higher the tendency of the firm to rely on internal knowledge in order to accomplish the activity, *ceteris paribus* production and transaction capabilities.

As learning and dynamicity elements come into play, the new approach stresses the role of interdependence across factors. Accordingly, the adoption of new technologies and new capabilities will depend on the accumulated capabilities developed inside and outside the firm over time, and on the developed competences in using the market compared to using an internal coordination mechanism. The adoption of new technologies, that is the governance of the production processes, will be therefore influenced by:

- i. the accumulated competences inside the firm about the productive processes;
- ii. the availability of useful competences in the market;
- iii. the accumulated competences in transacting; and
- iv. the accumulated competences in coordinating.

Ceteris paribus these elements, TCE applies.

In order to understand the process of internalization versus externalization of activities and capabilities, the analysis must focus on the “wide range of mixed governance structures where varying mixes of transaction, production and coordination activities are at work” (Antonelli 2008, p. 136). The unit of analysis shifts therefore from the firm as a business unit to the firm as an organisation that produces and uses knowledge and information. *A fortiori* the attention also shifts to a wider class of knowledge governance mechanisms that are involved both within and across firms. Amongst this set of modes of knowledge not only transactions and coordination exchange, but also nested transaction (transaction taking place and affecting related activities not a direct object of the first transaction) and networking activities. This last set of knowledge governance mode is particularly important because it represents the set of knowledge interactions and nested interactions taking place both within firms and across firms amongst a wide set of actors in an economic system.

The approach described so far sheds light on the governance structure of the firm. Instead of studying only the internal firm trade-off costs the analysis now also includes the characteristics of the market about some particular factor endowment (therein including knowledge). For this purpose the concept of the ‘localized technological knowledge’ becomes relevant to appreciate “the relevance of the learning processes circumscribed in the specific and idiosyncratic locations, within technical, organizational, product and geographic spaces, of each firm at each point in time. The learning processes in such locations are the basic conditions for the accumulation of experience and the eventual generation of both competence and tacit knowledge” (Antonelli 2008, p. 130; see also Paul David’s classic book 1975).

The integrated approach proposed by Antonelli points to the fact that in order to understand the organization of knowledge inside firms, or better how firms organize the knowledge that is useful for their growth and innovation processes, it is useful to shift the attention from the perspective of the firm to a knowledge organization angle of analysis. If Langlois and Foss (1997) already noted that a static RBV is not able to fully capture the dynamic of the boundaries of the firm, Antonelli (2008) includes the governance mechanism of knowledge that takes place in the context of the firm. The evolution of where the knowledge of the firm is based, either internal or external to the firm boundaries, becomes the focus of the analysis of the firm growth. If we recognise the dynamicity of knowledge as a resource, it becomes useful to focus on the governance of knowledge as a variable that changes over time.

It is also worth emphasising that while TCE and RBV focus almost exclusively on the large-manufacturing-firm type, the view proposed by Antonelli also encompasses specialised information-based firms such as Kibs (knowledge intensive business services). The purpose of the present work is therefore to study the firms’ approach to the knowledge exchange modes taking place in different points in time within and across the firm. That is to say, first it is useful to map the different typologies of knowledge governance mechanisms working in the environment of investigation, and then delineate the firm governance structure in this framework.

Knowledge governance properties

Knowledge governance mechanisms are defined by the cross-analysis of knowledge in terms of tacitness versus codified with the forms in which knowledge manifests, mainly in terms of its indivisibility and related appropriability and commerciability (Antonelli 2006). Drawing from Polanyi (1958) knowledge is tacit when it represents an unconscious know-how: if knowledge is tacit, asymmetries of information and agency problems are relevant and the transferability of knowledge is difficult and slow, because it is intrinsic and idiosyncratic to the individuals or organization that produced it. This means that we can expect high levels of dynamic transaction costs, networking costs and coordination costs in managing tacit knowledge. Generally, the higher the level of knowledge tacitness, the higher the transfer effort that has to be made by the sellers: the degree of appropriability and of commerciability are low. On the other hand, if knowledge is codified the degrees of dynamic transaction costs and of networking costs are lowered by the comparative low level of agency problems.

Knowledge is indivisible when formed by distinct ‘bits’ of knowledge that only have value and meaning when treated together. If the production of these different bits of knowledge is dispersed among many different agents it is difficult to appropriate and properly share the revenue of an innovation based on indivisibilities. If these bits are codified, a well-functioning market for knowledge (Arora et al. 2001) helps reduce the dynamic transaction costs and therefore helps enhance the appropriability and diffusion of the innovation. If, however, these bits of knowledge are, at least in part, tacit, not only the governance, but also the appropriability and commerciability, are difficult and expensive in terms of dynamic transaction costs, coordination costs and even networking costs (Antonelli 2006). Furthermore, knowledge indivisibilities are analysed and decomposed in the properties of cumulability, compositeness and fungeability. Knowledge is cumulable when its management requires the conjunction of different bits of dispersed knowledge; knowledge is composite when it is the output of the conjunction of different bits of knowledge modules and it is fungeable when is applicable to many different uses.

Three main governance mechanisms for the command of knowledge, as shown in Table 1, emerge (Antonelli 2006): “quasi-hierarchies for tacit and sticky knowledge”, “constructed interactions for articulable knowledge” and “coordinated transactions for codified knowledge”. The characteristics of each scenario are based on the level of tacitness versus codified character of knowledge. The new knowledge generated shows different levels of appropriability and commerciability compared to the type and level of indivisibility.

Table 1: Governance mechanisms for knowledge generation and types of knowledge

Modes	Mechanisms		
	Quasi-hierarchies for tacit and sticky knowledge	Constructed interactions for articulable knowledge	Coordinated transactions for codified knowledge
Cumulative	Learning Intramuros R&D Open science Academic consultants	KIBS Procedural contracts Constructed trust within vertical clubs Technological districts Academic outsourcing	Patent thickening Content contracts Vertical clubs Academic outsourcing Epistemic communities Open source
Composite	Learning Upstream integration Intramuros R&D Open science Academic consultants Technological platforms Joint ventures	Procedural contracts KIBS as hubs University–corporation liaison centers Multi-industrial and metropolitan technological districts	Academic outsourcing Content contracts Technological clubs Standardization committees Open source Acquisition of high-tech small firms KIBS Markets for patents Markets for licenses
Fungible	Learning Intramuros R&D Downstream integration Open science Academic consultants KIBS Joint ventures Scientific entrepreneurship	Technological platforms Procedural contracts Academic outsourcing Inter-industrial joint ventures KIBS Centered networks Reputation M&A	Content contracts Academic outsourcing Cross-licenses KIBS Open source Acquisition of high-tech small firms Markets for patents and licenses Quasi-markets for licenses and markets for goods
Modular divisibility			

Source: Antonelli (2006, p. 240)

The first scenario of tacit and sticky knowledge is the one where the appropriability conditions are lower. The level of low appropriability leads the governance of tacit knowledge to be conducted mainly within the firm via internal coordination mechanisms; the exploitation of such knowledge is afflicted by a high level of transaction costs, and the appropriation of the revenues of the new knowledge produced are mainly gained by the embodiment of the new knowledge in a market product. The governance of the tacit and sticky knowledge also takes place in the university, which mainly produces knowledge that is tacit and restricted to a narrow number of experts.

It is different in the market for codified knowledge where firms can decide if to use or to sell the new knowledge produced. The functioning of a market for knowledge largely reduces the asymmetries of information affecting tacit knowledge and allows the exchange and trade of bits of knowledge as information products. In the scenario for the command of articulable knowledge, the level of appropriability is between the two scenarios described above. In this case the exchange of knowledge is affected by lower asymmetry issues than in the first tacit scenario, but substantial efforts by the parts have to be made in the exchange of knowledge. The networking activities are particularly important because they facilitate the transfer of the knowledge that, as already stated, requires a considerable involvement of the parties.

Universities produce not only tacit but also codified and articulable knowledge. The knowledge produced by universities reaches the market via several mechanisms. The higher the level of tacitness, the higher the level of transaction and networking costs and therefore the higher the required efforts of human resources in order to accomplish the transfer. When the exploitation of knowledge requires the deep involvement of the scientists that produced the knowledge, ASO firms are generated in order to accomplish the transfer. It also appears natural for an ASO to take place when the indivisible knowledge is dispersed in different human resources that need to be joined together in order to render the knowledge embodiabile in a marketable product.

Finally, the different characteristics of the knowledge inputs in terms of indivisibility make the governance of the new knowledge module dependent on different governance strategies. For example, when research results show the characteristic of compositeness, upstream linkages with the multiple sources of different bits of knowledge is fundamental in order to absorb and improve that new module generated; if it is

fungible the downstream market knowledge is more important because of the need of the knowledge to be applied to different scientific fields.

Let us now concentrate on the characteristics of different types of innovative firms in terms of their organizational structure in order to be able to match the characteristics of the innovative firms with the governance of knowledge taking place in the system.

The innovative firm

Economics of innovation literature acknowledges that innovative processes and technological change in the economic system are driven by several different sources (Nelson 1991, Metcalfe 1998). As we saw above different determinants have been identified. The boundaries of the firm in terms of both capabilities about the productive process and about the coordination mechanism, the external capabilities available in the market and the linkages between the two, that is to say transactions and interactions. Teece (1996) develops a framework of some different firm's organizational structures, called "archetypical categories", by analysing the "determinants of the rate and direction of firm level innovation" (Teece 1996, p. 208).

This work first identifies some organizational factors that influence the innovation process, then defines five typologies of firms that vary in the amount of organizational factors, and finally frames them in two opposite innovation contexts: the autonomous and systemic innovation scenarios. According to Teece the main firm's organizational factors or determinants influencing its innovative processes are: hierarchies, external linkages, organizational culture, scope and vertical integration. Hierarchies are forms of organization with a strong top-down decision making apparatus. They can undertake complex functions, but the intrinsic rigidity of these organizations, mainly due to heavy bureaucratic apparatus, low incentive systems and agency problems, hinders the innovative process and therefore some tactics have to be put in place within these organizations in order to help them cope with technological change and innovation. For example, strategies such as the generation of more autonomous cross-functional teams

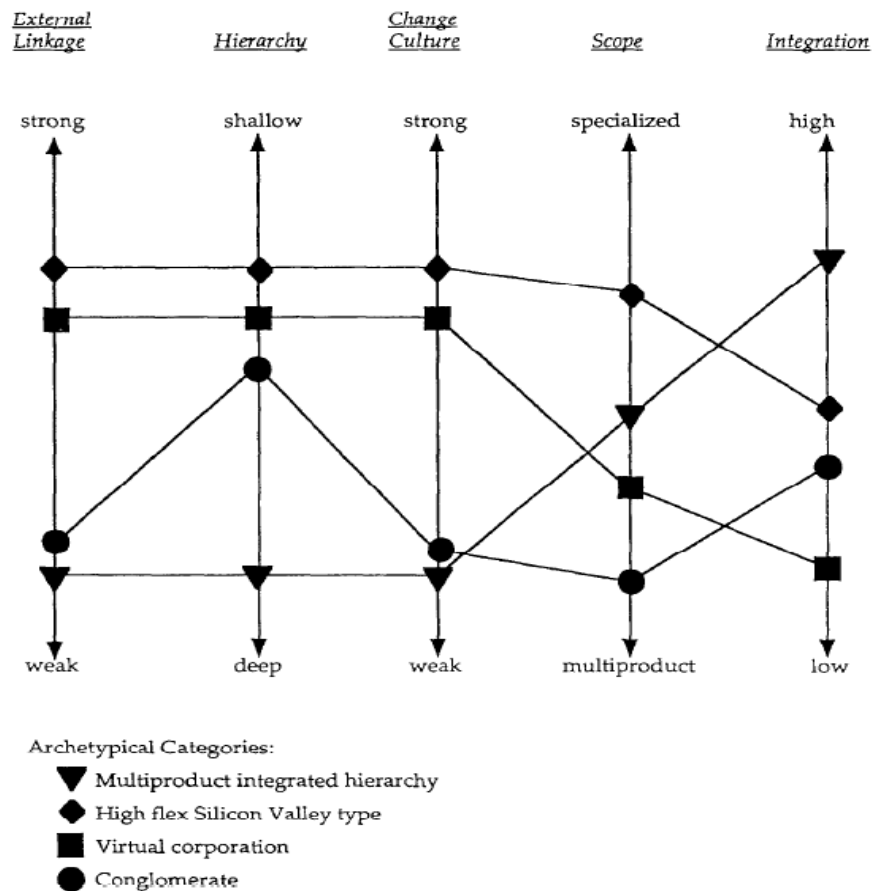
or the spinning-out of activities that could benefit from independence (also if only managerial and not of ownership) have been identified. External linkages are crucial for an organization to exploit the contextual knowledge. Particularly in the ‘localised technological change’ approach (Atkinson and Stiglitz 1969, Antonelli 2008), where knowledge is often indivisible and dispersed among different agents or organizations, it is critical to show high level of interconnections, not only upstream or downstream but also horizontally. External linkages are very important, for example, when complementary assets are needed by the firm to profits from the innovation. Complementary assets are those functions like marketing, manufacturing, support services or specialized research and development functions.

These kinds of capabilities can be generic on the one hand and co-specialized on the other (Teece 1986, 1988). The characteristics of these assets are reflected at different levels of innovation appropriability and different internalisation versus externalisation strategies. If these assets are generic they should already be available in the market while if they are specialized it means that they have to be adapted to the specific use they will serve. This means they need to have certain required unusual characteristics. Finally, if the assets are co-specialized it means that a significant amount of interaction has to take place between the parties in order to get the capability provided to the purchaser. Organizational culture represents the set of values, accepted behaviours and unwritten roles shared by the members of the organization. In order to stimulate the innovative process an *open* organizational culture is considered necessary but not sufficient. The scope of an organization consists of the output advantage obtained by employing inputs in a conjunct rather than separate fashion. A big Chandlerian corporation can therefore benefit from economies of scope in different ways: either by spreading the R&D outcome across different productive processes or products; or by integrating knowledge of different technologies and products; or also by reallocating the outcome of some activities to other, less productive, activities. Finally, as mentioned above, vertical integration plays an important role as being vertically integrated can be either a stimulus to innovation or an impediment, depending on the typology of innovation confronted by the firm. Being integrated is helpful to face systemic innovation, as it facilitates the coordination among different productive processes, while

autonomous or stand alone innovation is better managed in a small organization that is not integrated, because of the advantages of specialization.

The determinants of the innovation process just mentioned are observable across different firms to a different extent. Teece (1996, p.210) identifies five different archetypes: “(1) stolid, multiproduct, integrated hierarchies; (2) high flex “Silicon Valley”-type firms; (3) hollow corporations of various types; and (4) conglomerates of various types” and finally “(5) the individual inventor and the stand alone laboratory.” The multiproduct firm shows a high level of integration, deep hierarchies and not many developed linkages with external knowledge. Moreover, it is mainly based on its own diversified capabilities and has a strong organizational culture. Multiproduct firms are the most suited to manage systemic innovation, especially when external capabilities are not fundamental to the innovation. The high flexible type of firm is almost the opposite: it is deeply linked to the external context, has shallow hierarchies, is specialized and flexible in undertaking changes but is quite integrated, a little less than the multiproduct firm. This typology is common with a young firm that is highly innovative and deeply related to the external environment, especially because of the complementary assets. These assets are important because of the scarce level of integration of this kind of firm. Silicon Valley-type firms fit mainly in autonomous innovation scenarios; in the case of systemic innovation they appear to be successful when the capabilities on which the innovation is founded have to be created from scratch. Conglomerates and virtual corporation are less integrated than the two archetypes just highlighted. The latter is basically sub-contractor firm: it is not vertically integrated at all, nor specialized, but highly connected to the environment, flexible to change and has no hierarchies. A multiproduct firm or a Silicon Valley-type firm could also act virtually: particularly in cases of autonomous innovation where the firm is able to develop strong external linkages with the environment. Conglomerates are decentralized structures of firms, most probably highly connected together so to reveal conservative culture and low connections with the external environment, while hierarchies and vertical integration are at an intermediate level: “the conglomerate does not appear to offer distinctive advantages in environments characterized by rapid technological change.” (Teece 1996, p. 216).

Figure 1: Archetypical categories of firm by organizational structure



Source: Teece (1996, p. 209)

The stand-alone laboratories and the inventor-entrepreneurs face many problems in order to exploit profitably new technologies. According to Teece (1996) individual inventors need to protect strong intellectual property rights (IP) and their new technology if they want to benefit from the innovation. If this is not the case, the profitability expectation is low: if the technology is imitable, the appropriability of the revenue is proximal to zero; on the contrary if the technology is not easily imitable the problem stays in its transferability to the buyers that becomes difficult, because of the tacitness involved. Stand-alone laboratories are very similar to individual inventors but at least they can rely on a more integrated structure and on a collection of different skills and competences. It emerges that for the laboratory, as for the Silicon Valley-type of firm, the external context is a crucial factor for the profitability of the innovation,

especially if it is not intellectually protected, both in terms of availability of capabilities and in terms of interconnections with the sources of those capabilities.

At this point, once the insights about the different archetypes of the innovative firm have been compared with those of the governance mechanism of knowledge, it is useful to relate a firm's organizational structures to the different modes of knowledge governance within the context of the innovative process of the firm, and to seek to produce new insights about the characteristics of that firm.

Conclusions

The analysis carried out in this chapter described three theoretical approaches to the theory of the firm, and then sought to identify the characteristics of the innovative firm in order to build a framework of analysis that lead to the understanding of the modes of knowledge governance that affect a particular type of innovative firm, the ASO firm, which will be studied in the following chapters. While TCE points to the definition of the boundaries of the firm by a price trade-off between the two available choices of making or buying a particular activity, RBV identifies the boundaries of the firm in the resources a firm owns, where knowledge represents a fundamental resource. The two streams evolved together in the capability view *a la* Langlois and Foss (1997) where resource endowments and dynamic transaction costs are analysed together from a within the firm perspective, in order to get insights about the firm boundaries and behaviours. The acknowledgment of multiple modes of knowledge exchange and generation, not only captured by the transactions in the market or by the coordination mechanisms within the firm, shift the attention from inside the firm to the governance knowledge modes unit of analysis (Antonelli 2008). The approach proposed by Antonelli (2008) makes it possible to investigate the processes of building of capabilities that a firm undertakes in a specific context, the context of the localized technological change. It is not possible to capture this central aspect of the evolution of the firm when concentrating the attention inside the firm.

The types of knowledge generated and then exploited provide the acknowledgment of different mechanisms of knowledge governance. In each of the knowledge governance mechanism, different types of firm position differently in respect to their characteristics in terms of knowledge owned, knowledge available in the market and the linkages between the two. In other words firms differ in respect to the degree of internal and external knowledge adopted, and in the capabilities of obtaining the external knowledge and in coordinating the internal knowledge. By matching the analysis of the governance mechanisms with the analysis of the firm archetypes, we can expect that in a quasi-hierarchical scenario of tacit knowledge, multiproduct firms will coordinate the new knowledge produced internally and will probably be able to appropriate the rents of the innovation via embodiment in the final products. As already noted, the quasi-hierarchical scenario for the tacit knowledge is also the one where universities and the open-science mechanism of free disclosure and diffusion applies. In this scenario a stand-alone laboratory will probably have to rely on the market for knowledge, that is to say, it will need to be able to produce a divisible piece of protectable knowledge in order to gain profit. If indivisibilities apply, the stand-alone laboratory can only survive if strongly embedded in the environment by upstream and downstream strong linkages or if it can grow and internally integrate some complementary functions. The Silicon Valley-type of firm operates similarly: its main advantage compared to the stand alone laboratory is the higher degree of integration that allows the firm to be less dependent on external linkages and capabilities. In the coordinated transaction for the codified knowledge scenario the possibilities of licences and of using the market for knowledge are higher, and here also the stand-alone laboratories will be able to profit quite easily from their innovation, if the Intellectual Property (IP) system is strong and the new knowledge produced can be well protected. If indivisibilities apply the multiproduct highly integrated firm will have an advantage over the other types of firm if the innovation is based on internal capabilities, because of the low networking and dynamic transaction costs needed to exploit the innovation. If, on the contrary, the knowledge on which the innovation is based is dispersed in the environment, the flexibility and adaptability to change could favour the Silicon Valley-type of firm.

Because knowledge generation is a dynamic process based on learning and because knowledge evolves inside and across organizations and humans, a dynamic study of the

evolution of the firm must address the evolution of the knowledge within and across firms. The aim of the next chapters is to look at this evolutive path by measuring the ratio between dependence on internal versus external knowledge in order to carry out a set of firm functions at different points in time of the life cycle of a firm. The firm becomes the tool to study the governance of knowledge, which takes place within the context of the firm.

Chapter 2

The ASO firm

Introduction: The phenomenon

A spin-off firm is an organization created by an employee of a so-called parent firm. Spinning-off means literally ‘detaching’ from a parent organization; two sources provide the spin-off firm activity, a corporation or a public research institution. The first case represents a venture spin-off, while the second refers to the phenomenon of Academic Spin-off (ASO) firms. In economic literature different definitions of ASO have been identified: Pirnay et al. (2003) carried out a classificatory work in order to understand and give reasons for the different classifications adopted in literature. The work identifies the four conditions a firm has to satisfy in order to be classified as an ASO, it has to:

- (i) be a new company
- (ii) come from a university
- (iii) exploit some academic research results
- (iv) have a for-profit mission.

In very recent times other characteristics have appeared to play a critical role for classificatory purposes: the university has to detain a share of the ASO’s social capital (factor almost always enclosed in the university internal regulations), and there has to be a transfer of personnel from the parent organization to the new venture. For our purpose, the understanding of the knowledge governance mechanisms taking place in the ASO

formation and development, that is the process of exploitation of academic knowledge, these elements are not taken into account. The participation of the university in the ASO social capital does not represent a critical factor *per se*. The other condition, similarly, is not relevant *per se*, but as it will become clear, the tacitness of the knowledge to be exploited almost always requires the satisfaction of this condition.

Over the last two decades economic and business literature have significantly explored the phenomenon, both quantitatively and qualitatively (Rothaermel et al. 2007). The main approach to the topic is given by scrutinising the determinants of ASOs, from different perspectives of analysis, mainly concentrating on the university and Technology Transfer Office (TTO) level, but also on the individual, team and territorial level of investigation. The determinants of ASOs consist mainly in the already available factors that favoured the generation and/or the development of this kind of venture. These studies usually focus on comparative analyses that investigate the conditions that lead to the generation of more ventures in terms of numbers (see e.g. Di Gregorio and Shane 2003, Shane 2001, Lockett and Wright 2005, Powers and McDougall 2005) and/or better ventures in terms of performance (see e.g. Shane and Stuart 2002, Audretsch and Lehmann 2005). As a result, economic literature on ASOs identifies a wide set of factors that impact the generation and development of this kind of firms; different subsets of factors are at work at different levels and at different sets of levels. For example, scientific productivity has a positive impact on the number of ASOs created both at the individual level (Krabel and Mueller 2009) and at the university level (Di Gregorio and Shane 2003). Moreover these determinants illustrate both the ‘ideal environment’ where ASOs take place and the reasons that lead to the spin-off activity instead of other ways of university knowledge exploitation, such as licensing, consultancy, research contracts, etc.

One of the conjectures proposed in this dissertation is that a theory of the ASO firm doesn’t exist *per se*. Nevertheless, from literature it is possible to derive some insights about how the ‘best practice’ of the ASO firm should be. The next section provides a brief discussion of the determinants of ASOs in order to delineate the profile of the ASO firm most used in the literature. The aim is to match the characteristics of the ‘ideal ASO firm’ emerging from the literature with the knowledge governance mechanism taking place at the ASO level.

The determinants of ASOs

Probably not fundamental, but apparently greatly important for a university based invention to be successfully exploited in the market place is a strong IP (e.g. Colyvas et al 2002, Shane 2004) and wide in scope protection (Shane 2001). Patenting an invention means codifying the knowledge involved and, therefore, it also means providing the innovation with strong appropriability and a commercial character. If in place, patents are therefore considered very useful in the ASO creation and development. Many studies are based on samples of patent-based ASOs (see e.g. Di Gregorio and Shane 2003, Shane 2001, Lockett and Wright 2005). For example in a comprehensive book about the ASO phenomenon, Shane (2004, p. 171), in describing the formation of an ASO, writes: “If a new firm is formed to license the invention, then a university spin-off is born” and then: “approximately 14 percent of the time, new ventures are created to exploit university intellectual property” (Shane 2004, p. 173).

Patents and their exclusivity appear to be very useful in order to assure the return to a university based invention when it is highly embryonic (Colyvas et al 2002), and according to Shane (2002) ASOs are second best solutions to the exploitation of a patented invention: when a patent is effective⁴ the invention is exploited via direct licensing mechanism between the university or TTO and the industrial world; only when the market is not able to coordinate the exchange of technology between the parties, it means there are high levels of transaction costs⁵ and the invention needs to be licensed back to the inventor that has to transfer the innovation to the market via ASO creation, in order to reduce moral hazards and opportunism problems (Shane 2002).

The relevance of patents in fostering the transfer of knowledge confirms, and is given by, the previously noted high level of tacitness that characterizes the output of academic research (Antonelli 2005). Although patents contribute in codifying part of the knowledge involved in the invention and therefore reduce dynamic and pure transaction

⁴ Patents are effective when they offer powerful protection throughout their duration.

⁵ The paper is based on a pure transaction costs approach.

cost issues, transferability often requires significant efforts (Fontes 2005). University research results, both in terms of publication and commerciable invention, are highly tacit in nature, because the understanding is restricted to a narrow number of experts. We also saw how indivisible the knowledge produced by universities is in nature, and therefore significant levels of coordination costs are involved in the governance of that knowledge. If, for example, an innovation to be exploited requires the conjunction of different complementary bits of knowledge, it could be difficult in terms of coordination costs for a university or TTO to exploit the potential invention because of the high level of coordination costs involved in the process of making the invention ready for the market (Antonelli 2006). In this case some inter-departmental divisions or other organizational solutions could take place to manage that knowledge.

ASO decision-making and therefore part of the coordination function is usually undertaken by individuals with academic background (Chiesa and Piccaluga 2000). This creates a first coordination problem derived from the lack of capabilities in coordination of the individuals that have to carry on the decision making function of the firm. Scholars agree on the importance and positive role of having accumulated competences in industrial experiences, in IP protection activities and in other commercialization activities, both at the individual (Landry et al. 2006, Krabel and Mueller 2009) and at the university level (Lockett and Wright 2005, Powers and McDougall 2005). The accumulated competences in coordination favour the creation and performance of the ASO firm: several works investigate the trade-off between training the scientist with managerial capabilities or involving a surrogate entrepreneur (e.g. Franklin et al. 2001, Clarysse and Moray 2004). Clarysse and Moray (2004) find that making the academic into a CEO is probably the best choice for technical reasons and team recognition. However, the team learning process is slow, come mainly by external changes like market preferences, and often involve significant variations in the organization of the decision making process.

If indivisibilities apply, other coordination costs can become problematic: the cost of coordinating the networking interactions and transactions. High networking costs emerge because strong external linkages are needed (upstream, downstream or horizontal) to manage the fragmented and dispersed pieces of knowledge that form the invention to be exploited. Complementary assets represent an example of

complementary bits of knowledge that produce networking transaction costs, and if specialized or co-specialized, also produce high networking interaction costs. In this case, the previous connections an individual, a team or a university have with the industrial world are particularly relevant because they are an expression of the presence of linkages and of experience in networking and transacting, which reduce the costs of dynamic transaction costs on one side and the networking costs on the other. At the institutional level of the university, Colyvas et al (2002) and Friedman and Silberman (2003) find that the developed network with industry represents a crucial factor in determining the exploitation of an academic research result; these insights are confirmed at the ASO firm level (Walter et al. 2006, Grandi and Grimaldi 2003). Zucker et al (1998, 2002) find that new technological knowledge will be exploited mainly where star scientists are located, because of their distinctive capabilities in making the knowledge transfer and exploitation happen. At the team and at the individual level a similar conclusion is reached: Krabel and Mueller (2009) find that the individual scientists of the Max Planck Institute are more likely to become academic entrepreneurs if they have previously worked with industry. Furthermore Jain et al (2009) affirm that making relationships to delegate tasks is positively related to the success of an ASO firm. Finally, significant relevance is given by scholars to the networking assets provided by a venture capitalist (VC) investing in the firm: the benefits of obtaining VC funds are not only concerned with the financial need, but also for the various managerial capabilities support, including the networking assets of the VC (Shane and Stuart 2002).

Up to this point, we have seen how transaction costs and transaction capabilities on one side and coordination costs and coordination capabilities on the other side, represent important mechanisms that influence the development of ASO firms. Adopting a framework where localized technological knowledge and localized technological change represent the mechanisms that drive the innovation process, the territorial context has to be taken into account in order to understand the firm's process of building and acquisition of competences and capabilities. Scholars found several relevant determinants of ASO from the environment. One of the most investigated issue is the experience of the university and/or TTO in dealing with technology transfer issues (Friedman and Silberman 2003) and ASO creation and development (Lockett and

Wright 2005, Powers and McDougall 2005). Also very important are the policies put in place at a national (Baldini et al. 2006), regional or university level (Di Gregorio and Shane 2003), the VC availability (Chiesa and Piccaluga 2000, Powers and McDougall 2005, Henrekson and Rosenberg 2001) and the industrial context in terms of characteristics and positive externalities and spillovers (Friedman and Silberman 2003).

University and TTO experience, mainly measured by the age of commercial activity of the university or by the existence of a TTO, influence the commercialization activity of a public research institution (Friedman and Silberman 2003) in a positive way. Also when the determinant is related to ASO firms, the relation appears to be of impact, especially in terms of numbers of ASO developed at the university of investigation (Powers and McDougall 2005, Lockett and Wright 2005). Similarly, the scientific productivity of a university, but also of an individual researcher, plays a positive role: Di Gregorio and Shane (2003) reveal that the intellectual eminence of a university is one of the determinants that explains why some universities produce more ASOs than others while Powers and Mc Dougall (2005) reach the same conclusion by investigating the scientific quality of faculties. At the individual level Krabel and Mueller (2009) and Jain et al (2009) find that the scientific excellence of a scientist is positively related to the probability of undertaking a venture creation path; different results are founded by Landry et al (2006), where the scientific productivity of the individual, in terms of publication assets and the academic rank of the institution of affiliation of the scientist, do not influence the likelihood of ASO creation by the scientist.

Regarding the impact of policies on the commercialization activity of universities, there is a lot of talking in economics and management literature (Mowery et al. 2004). Over the latest three decades virtually all Western economies have developed policies to incentivize technology transfer activities, among which ASOs have been the subject of growing interest (Shane 2004). In some cases these policies appear to have had an important impact: Baldini et al (2006) find that the Italian regulation of 1996 about university IP rights produced a substantial rise in the university patenting activity and that the university internal regulation about IP rights strongly pushed the number of patent applications at university level. Friedman and Silberman (2003) and Chang et al (2009) reach similar conclusions and find that the attitude of the universities toward the

support of technology transfer activities plays a positive role in the research commercialization volume of output. Moreover the presence of policies is also seen as important in shaping and changing the role identity of the researcher from an academic to a more entrepreneurial profile (Jain et al 2009). Di Gregorio and Shane (2003) reach different findings about internal policies: they reveal no impact of an internal policy on the number of ASO firms created at a university level. They also find, in accordance with Lerner (2005), that the availability of an internal VC at the university does not have significant impact.

Anyway VC availability, mainly in terms of funding assets, but also of organizational and managerial capabilities, is widely considered a positive if not critical factor (Shane and Stuart 2002, Henrekson and Rosenberg 2001, Powers and Mc Dougall 2005, Lockett et al. 2005). Moray and Clarysse (2005), describing the managerial approach evolution of IMEC research centre in Belgium, find that governing the process of spinning-off with a VC approach, in terms of selection and management, is useful in order to create more powerful ASOs. The presence of a VC in a local area is an indicator of the innovative activity of the area. The innovative profile of the area, in terms of numbers of high tech firms, is considered a crucial factor in enhancing the commercialization activity of a university because of the easiness of the networking activities already in place (Colyvas et al 2002, Friedman and Silberman 2003). That is to say, an area with high numbers of high tech firms indicates a less networking costs.

The ASO firm life cycle

ASO literature has addressed mainly two stages in the phase of the development of the firm: the creation, which most studies have focused on, and the development, where scholar's interest has recently risen substantially (Mustar et al. 2006). Concerning the creation stage, works have been widely concerned with the determinants of ASO creation, as described in the previous section. Few works address a different question about the creation of ASO, that is the reasons why the academic spin-off firm has been chosen as an exploitation way instead of going to the market via other commercial

routes. As already described previously, Shane (2002) answered this question via TCE analysis, and the results of his work reveal that an ASO takes place when market for knowledge does not work for the new developed technology because of market failure problems and therefore an agency issue reduction has to be carried out by the entrepreneur bringing the new knowledge directly to the market. Similar findings have been reached by Fontes (2005) who, by basing the work on the tacit nature of the knowledge to be exploited and by highlighting the agency function undertaken by the scientist, finds three main roles in ASO academic tacit knowledge transformation activity. Knowledge transformation needs to be done by scientists in order to be adapted and brought to the market, in order to increase the accessibility of that knowledge in the industrial world, and finally in order to diffuse scientific knowledge by undertaking a knowledge intermediary function (that we could argue is similar to the activity of some Kibs). Another important result behind the motivation to exploit scientific and academic knowledge via ASO is given by the Lambert Review (2003) and Minshall and Wiscksteed (2005). They find that it is related to some intrinsic characteristics of the invention for example when the invention is a platform technology and in need of further development, both in terms of technology or in terms of IP rights, or when the technology is associated with a high level of fungibility (when a technology has many different applications).

For what concerns the development process of ASOs, studies are, again, mostly related to the identification of the determinants of the successful performance of the ASO, and therefore almost always relate *ex ante* available and known factors to the situation in a fixed point in time in the life cycle of the spin-off firm. To this end, investigating the role of initial resource endowments on the organizational structure of the established firm, and on its performance, Shane and Stuart (2002) find that the social capital of the entrepreneurs is crucial and probably the main determinants of the ASO performance. An initial extended social capital makes the ASO able to get VC funds, and this causes long-run perspectives and life for the ASO. To a similar end, but investigating the influence of different kinds of universities on successful ASOs, the paper by Audretsch and Lehmann (2005) finds that there is no difference in ASO performance if the firm has been generated by a technical or a general university.

Regarding the new venture life cycle, the seminal work by Roberts (1991) identifies three main stages of development, mainly related to the capacity of getting financial investment funds: start-up, initial growth and sustained growth. Some papers recently investigated the issue at ASO level (see e.g. Vohora et al. 2004, Clarsse and Moray 2004 and Shane 2004). Clarysse and Moray (2004) undertook a deep analysis of the general new venture start-up phase which an ASO follows, by examining a single case study very accurately. The authors indentified four phases in order for a team to be able to carry a market efficient productive activity: idea, pre start-up, start-up and post start-up. The paper explores the evolution in the decision making process and in the human resources organization of the firm. The findings reveal that hierarchies are very flattered until the third phase and to reach the fourth phase a slow learning process, which leads to the institutionalization of the organizational structure of the firm is required. Moreover they also investigate the reasons for this adaptation route. Market preferences and external shocks appear to play a main role in shaping the decision making process and its organization.

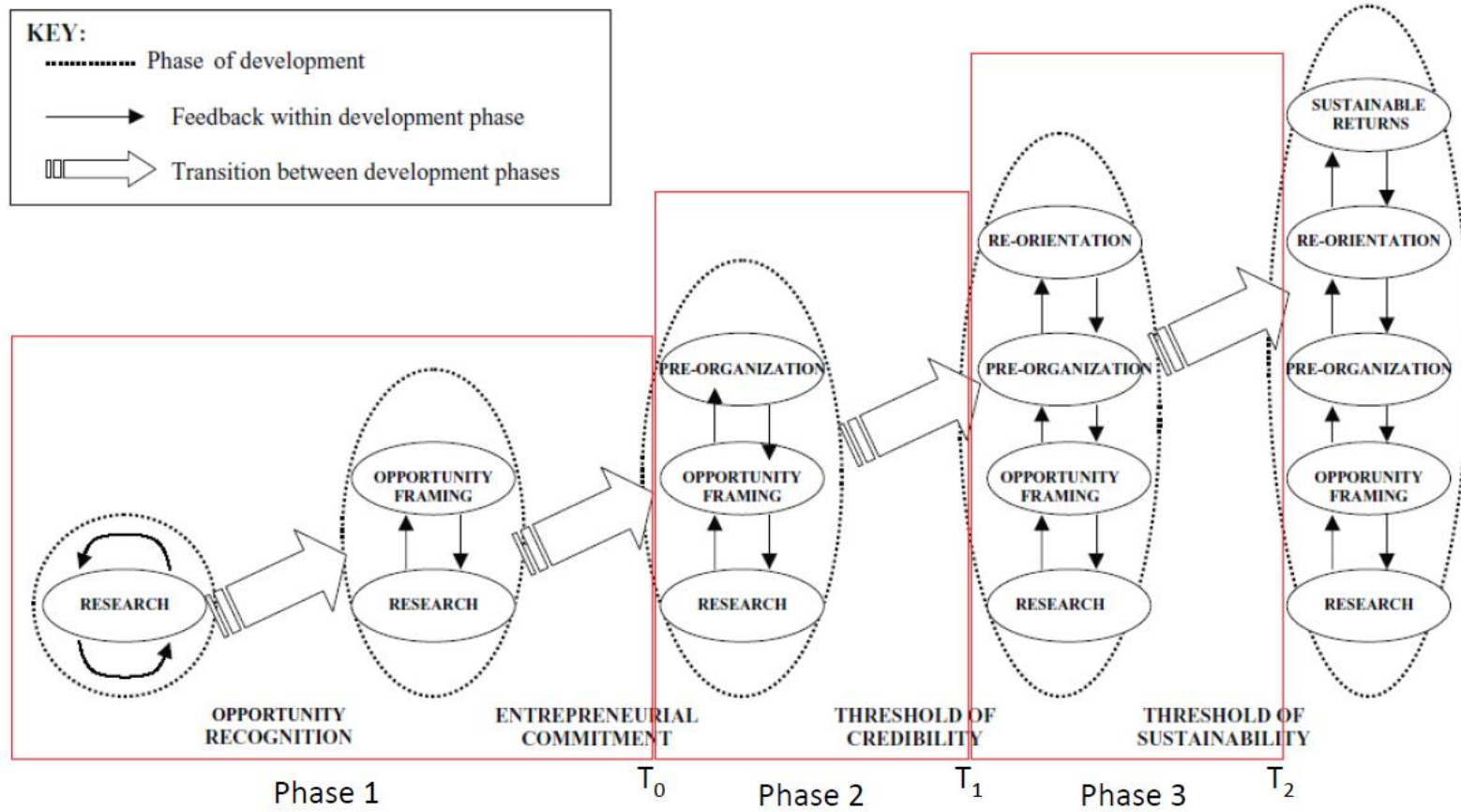
In a more comprehensive work about the evolution of an ASO firm, Vohora et al. (2004) propose a dynamic perspective on the acquisition and building of capability processes during ASO creation and development route. By pointing to the importance of different sets of knowledge in different points in time during the ASO life, they identify five phases and four critical objectives to be reached in order to pass to the next phase of development. The life cycle of the ASO firm starts in the academic research context, where the recognition of a business opportunity represents the critical step to pass in order to get to the next phase, that is the so-called opportunity framing. The first critical juncture is given by the acquisition or availability of some knowledge about the market characteristics, in order to be able to recognize an opportunity of business. The second phase, the opportunity framing stage, consists of shaping the business idea into a firm perspective, and to reach the next phase, the ASO team needs entrepreneurial commitment. Two main routes to accomplish this task: hiring a surrogate entrepreneur or make a scientific entrepreneur in order to develop an appropriate level of entrepreneurial commitment. The third phase is called pre-organization and consists of the development of targeted strategies and their implementation, that is how to structure the firm in order to develop the needed capabilities to accomplish the developed

strategies. This means making choices about which capabilities to develop, which are done internally and which are done externally, and it probably represents the fundamental phase of the ASO life cycle. It is the phase where a core product is established as the main activity of the firm, and where complementary assets and their coordination become crucial. Networking activities are therefore fundamental in this phase. Once the main strategies are settled the firm needs to be able to obtain financial investment in order to further develop the technology. Again the academic background of the academic entrepreneur can represent a limit, and the network assets represent a positive influencing factor. This critical step is called *credibility*, and once it is obtained, the ASO reaches the fourth phase, called re-orientation, which consists of bearing the ability by the firm of continuously managing the identification, acquisition and adaptation of useful resources. When the ASO reaches a sustainable rate of growth, the last critical juncture is overcome, and the ASO reaches the last phase of development, the 'sustainable return phase', where the firm is able to dynamically respond to market needs and changes, in a Teece et al's (1997) dynamic capability perspective.

The life cycle adopted here is not related to some technological evolution as the traditional contextualization of the life cycle (see e.g. Utterback and Abernathy 1975). The purpose is not to identify a dominant design or standard, but the attention is posed on the evolution of the firm in terms of the capabilities it needs to build or acquire to proceed in the growing stages. In this work we adopt a simplified scheme of the ASO life cycle as proposed by Vohora et al (2004). As shown in Figure 1 we selected three main stages. The first one consists of the development, by the team of inventors, of an opportunity frame and of an entrepreneurial commitment, that end in the ASO generation moment (time T_0 in the following empirical analysis). This phase always takes place inside the university. The second phase of our study is pre-organizational and represents the critical step in the development of the ASO firm. It is in this phase that the firm needs to develop a first organizational structure in order to face the market. This means "taking decisions over what existing resources and capabilities to develop, what resources and knowledge to acquire now and in the future, as well as when and where to access these resources" (Vohora et al. 2004, p. 156), and we could add that it also means the developing processes (routines and capabilities) of implementation of these decisions. In this phase the firm has to gain *credibility* in order to pass to the next

phase (time T_1). According to Vohora et al. (2004) credibility is given mainly by the capacity of getting funding from investors in order to acquire the needed resources. In our analysis we broadened the concept to the capacity of putting a product in the market that give revenues and incentives to go further in the growth and expansion of the firm, with connected organizational changes and adaptations. The third and last phase is the where “the entrepreneurial team faced the challenges of continuously identifying, acquiring and integrating resources and then subsequently re-configuring them” (Vohora et al. 2004, p. 157), until they get to a sustainable rate of growth (time T_2). In this phase, as we will discuss in more detail later on, the organizational structure of the firm should evolve through the Silicon Valley-type of firm, that is to say, the ASO should develop some forms of hierarchies in order to coordinate the growth and the probably related vertical integration; the external linkages always remain very important because they allow the flows of external knowledge into the firm and make it possible to respond to the changes in the environment. Flexibility in cultural change is a strong point of Silicon Valley-type firms (Teece 1996).

Figure 2: ASO firms life cycle



Source: adapted from Vohora et al. (2004, p. 152)

The Vohora et al (2004) study contributes to the understanding of the evolution of an ASO firm. The authors have highlighted, in great detail, the challenges an ASO has to face. They argue that the stages identified are characteristic of the ASO life cycle. This is suggestive of a unique pathway and indeed Vohora et al (2004) do not explore the heterogeneity of routes ASOs take in order to get from a business idea to a market set company.

Moreover the idiosyncratic environmental context is not taken into account by these life cycle studies, but, as pointed out in the previous chapter, the context characteristics and endowment is relevant to understand the knowledge governance mechanisms taking place around a firm or a set of firms. The next section will provide a brief description about how the environmental context is relevant and influential to the development of firms, and in this case to the evolution of ASO firms.

The regional dimension

As demonstrated in the previous chapter the concept of localised technological change (Antonelli 2008) is useful in order to appreciate the innovation processes taking place in the ASO firms. The notion has its foundations in the concepts of learning, which characterizes the evolution of technological knowledge, taking place at the individual, organizational and systemic level. Similar to the capability view, the localised technological change approach recognizes the importance of the dispersion of knowledge among different and dispersed agents and the uncontrollability by a single organization of all the knowledge for itself relevant (Hayek 1945), therefore giving external knowledge a primary role. Knowledge generation is no longer only the output of R&D and productive functions but emerges also as an output of the interaction processes (where we also include the set of transactions) (Metcalf and Ramlogan 2005). The firms approach to the governance between internal and external knowledge becomes a source of firm competitive advantage. It is now easy to understand that the local context in its constraints and idiosyncrasies plays a crucial role in the generation

and diffusion of new knowledge and therefore in feeding the innovative process and the technological change. Proximity of actors in terms of roles, cultures and values, or in other words of formal and informal institutions, enhances the interaction processes and therefore the learning process of an economic system, where innovation is the result of both intentional and non intentional behaviours of the actors of the system (Antonelli 2008).

Technological change and local development is therefore localised in a geographic dimension and moves along a technological trajectory where cumulability and path dependency apply and where institutions, both formal and informal, contribute to the shaping of the technological development trajectory in the local area. According to Antonelli (2008), the regional level of proximity, both geographically and technologically, positively influences the generation of knowledge, both directly and indirectly. The policy making process taking place at the regional level plays an active role in shaping the incentives of the actors, and therefore directing the development process. Aligning actors incentives means reducing transaction costs, which leads to an increase in communication and interaction among actors, therefore to a higher division of labour and specialization of firms.

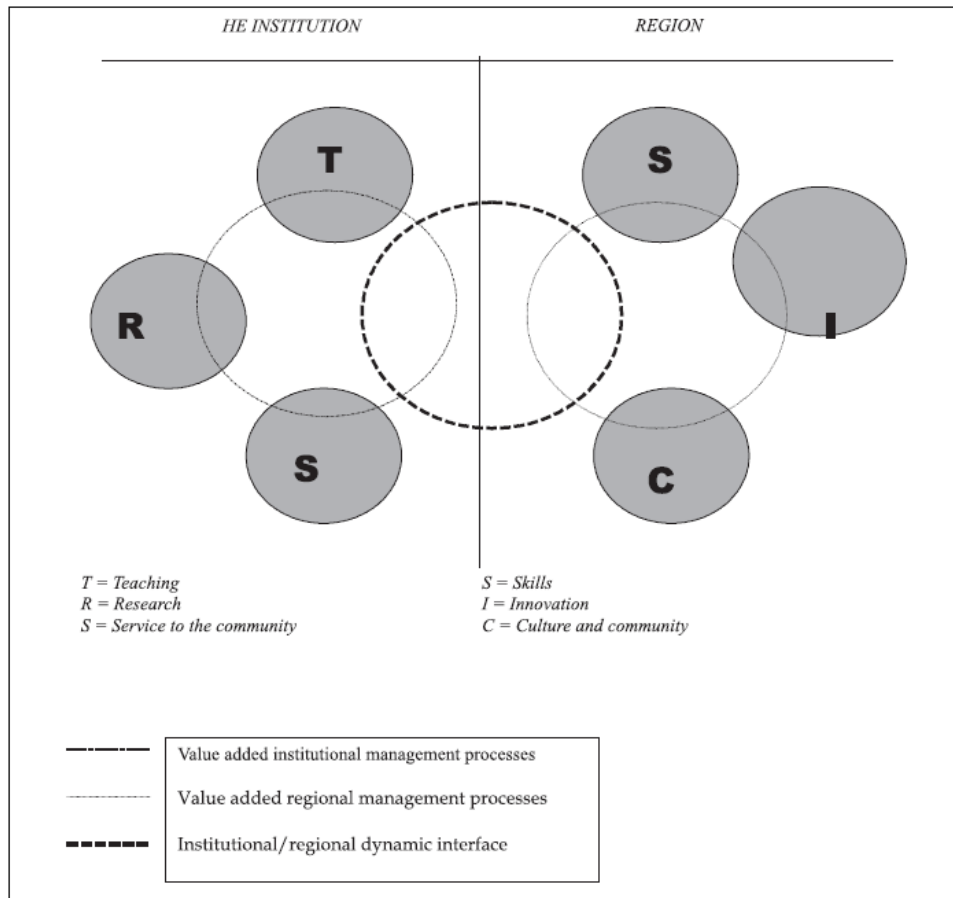
A primary role in the local development is held by universities. These organisations are nowadays required to directly intervene in economic development, not only by the accomplishments of the two traditional functions of teaching and research, but also by the third mission of taking part in technology transfer activities (see e.g. Gibbons et al 1994 and Etzkowitz 2001, Etzkowitz et al. 2000). Universities evolve in the economic system like other actors and organizations: the acknowledgement of the systemic nature of innovation on one side (Kline and Rosenberg 1986) and the two way direction of the scientific versus technological knowledge production (Rosenberg 1976) on the other side, make us aware of the importance of the interaction between universities and the other actors in the system. It is acknowledged in literature that knowledge generated inside universities tends to spillover in a local distance context (see e.g. Acs and Varga 2005, Feldman 1994). Moreover, the tacitness and indivisible nature of the scientific and technological knowledge output of university activity elevates the importance of considering its influence over the regional dimension. Moreover to be part of an already

developed network, it represents another important element that favours the transfer of knowledge from academic institutions to market places (Varga and Parag 2008).

According to Chatterton and Goddard (2000) three main factors enhanced the university behaviours in concentrating on regional needs: the demand for specific professional figures, the trend towards localization of teaching and research that is increasingly financed by local needs and the increasing participation of academic staff in local economic activities. The first point regards the teaching function of the universities that historically was directed more towards the big manufacturing type of corporations, while in recent years it has also moved towards the needs of small enterprises, often characterized by local specificities. The presence of technological clusters or districts in a particular area, for example, can give a nearby university the incentive to develop *ad-hoc* courses. The second point regards the organization of the research functions that experiences a high increase in the variety of forms in which it contributes to local development. Universities are called to organize their research functions in order to connect the university research output with the external environment, that is the local system. The generation of different forms of organization activities are emerging in virtually all western economies, like for example TTO, IP offices, Science Parks, but also inter-faculty research centres, ASOs and the development of “new cluster activity” (Chatterton and Goddard 2000, p. 14). Finally a set of complementary services are put in place by universities in order to respond to regional needs, from tangible assets like sport or cultural facilities to more intangible aspects like the generation of social networking between local and non-local key actors and the production of voluntary services in the area.

Using the framework by Chatterton and Goddard (2000) (Figure 3), we can appreciate connections among universities, firms and institutional support for local development. The figure by Chatterton and Goddard (2000) represents a generalization of a kind of process of which the ASO phenomenon we are interested in, is one particular type of connection taking place between universities and the regional context.

Figure 3: Interaction of institutions within the regional system



Source: Chatterton and Goddard (2000, p. 482)

We can argue therefore that in the localized technological change of a region, universities play a crucial role dispersed among several functions. The generation of ASO is one of these functions, inserted in the overall capabilities of a regional university system to answer and feed the local needs. The capability of creating the required competences and generating useful and useable knowledge to the system are complementary and equally important functions, also for the development of the ASO activities, often related to local specificities. Alongside university activities, as previously highlighted, many other factors shape the localized technological development. For example local policies aimed at creating the needed incentives in order for academics to undertake entrepreneurial careers.

The ASO firm profile

Our objective in this section is to describe the characteristics of the ASO firm as they emerge from the literature. We seek to understand the degrees of hierarchy, vertical integration, scope, changing culture and external linkages characterizing the typical ASO firm. It appears that literature refers to ASO as a middle ground-type of firm in between the previously analysed stand-alone laboratory and Silicon Valley-type of firm. To this regard Debackere (2000, p. 327) affirms: “The biggest disadvantage the academic entrepreneurs face is a lack of size, scope and complementary assets when they start their companies”. Let us consider each of the organizational determinants in the ASO firm.

In terms of culture, ASO firms can be considered as Silicon Valley-type of firms, because of their highly innovative nature and their intrinsic high level of adaptability: ASOs are new firms that have to find a way into the market and the ability to be able to adapt to this new scenario is vital. Relative to the hierarchy the ASO firm appears to behave like a stand-alone laboratory: hierarchies have not been the subject of significant investigation within ASO literature. However, it is possible to presume that an initial spin-off firm will have a mainly flat hierarchy, that will probably develop with the growth of the firm (see e.g. the case-study explored in Clarysse and Moray 2004). In terms of vertical integration it is natural to presume that a new innovative firm will be quite specialized and not integrated: the newly created firm will base its production process on a main product, that is to say the scope is highly limited and specialized.

One of the main organizational factors impacting the ASO creation and development are external linkages. The highly technological and innovative character of most new products requires the development of horizontal as well as upstream and downstream linkages. The literature just analysed shows how industrial relationships are fundamental in order to develop an ASO idea, mainly because having worked for industry means knowing the industrial requirements in terms of product development, but also because means knowing about the availability of different capabilities in the

environment. Industrial systems mainly provide the downstream and horizontal set of linkages. They are therefore very important on one side because of the complementary assets eventually required by the spin-off and on the other side they represent the source of market knowledge necessary to get a product in the market. The upstream linkages with the university is also important for three main reasons. The first reason is the facilities an ASO can usually benefit from in the beginning of its life; the second concerns the networking assets a university or a TTO can provide to the ASO firm; and finally universities represent a source of scientific capabilities in the development path of a spin-off, both in terms of research results and human capital.

Another relevant element influencing the generation of ASO is the external environment: Two main factors are indicators of the environmental strength, these are policies and high tech firm concentration. Supporting policies appear to play a fundamental role in improving the rate of commercialization activity of university and individuals. National and local policies appear to play a stimulating role without disagreement among scholars, while university internal policies do not always lead to a significant impact on the ASO output. Nevertheless policies and supporting tools for ASO creation and development can be considered as contributors in shaping a favourable external environment to the ASO. The environment is then favoured by the presence of high tech firms or at least firms that transact and interact with ASOs. The main reason is again the networking activity between these firms and the university for the reasons explained before, and between these firms and the ASOs. In other words placing the ASO in an area with high tech firms should significantly reduce the networking costs and the connected coordination and transaction costs on one hand, and provide wide availability of capabilities in the context of the ASO on the other hand.

The ASO firm profile emerging from the ASO determinant literature is similar to the Silicon Valley-type of firm with some characteristics of the stand-alone laboratory (Teece 1996) described in the previous chapter. In particular the organizational factors of hierarchy, changing culture, scope and external linkages appear to be very similar between the Silicon Valley-type and the ASO firm structures, while the vertical integration level of the ASO firm appears to be closer to the stand-alone laboratory profile, that is with very low levels of integration. Another factor leading to similarities

with the stand-alone laboratory is the emphasis put on protecting the invention with a patent, because of the difficulties in exploiting highly tacit knowledge. Finally, the environment where ASOs are usually studied, appears to be similar to those of Silicon Valley-type firms, because of the high concentration of high tech firms needed in order to get high networking activities.

To sum up, literature on ASOs shapes a profile of the ASO firm mainly by snapshot analyses referring to resources and behaviours at certain points in time. The literature highlights the difficulties on one side and the determinants on the other side of the ASO process, identifying some common elements that an ASO firm should have in order to succeed:

- The knowledge exploited is partially tacit and the possibility of protecting the invention with a patent increases the likelihood of ASO success; the tacit knowledge involved in the new invention gives the entrepreneur an agency reduction problem mission;
- Several factors play a role in shaping the capability of an area, an institution, a team or an individual in undertaking ASO processes; amongst these we acknowledge policies, linkages with the industrial sphere, previous industrial and patenting experience, and networking assets;
- In the first stages of life ASO firms resemble the stand-alone laboratory type of firm: flat hierarchies, highly deverticalized, deeply related to the upstream source of knowledge and with the necessity to develop downstream market knowledge;
- The normal evolution of ASO firms appears to lead the firm towards becoming similar to a Silicon Valley-type of firm, where hierarchies and verticalization become significant, and where the external linkages appear to be more concerned with the downstream source of knowledge;
- The scope appears to always remain specialized, and the changing culture always high;

- The external linkages remain important, although in the beginning they are especially upstream and later on especially downstream; horizontal linkages are important depending on the specific need of the firm at different points in time and are highly related to the firm production specificities.

The path of evolution that leads first to the generation of an ASO, and then the passage from a stand-alone type of configuration to a Silicon Valley-type of firm configuration appears to be highly influenced by the contextual resource endowments, by the external linkages of the inventor, the team and the institutions have and develop during the ASO life cycle, and by the firm's approach to decision making and coordination versus transaction mechanisms. Our objective is to investigate the paths an ASO firm undertakes in order to get from an idea of business to a stand-alone laboratory and then to a Silicon Valley-type of firm.

The reasoning made by the theoretical contributions examined so far reveals that the TCE is useful in order to understand the firm's cost trade-offs taking place between the choice of coordinating inside the firm, or transacting the required activities with the external market. Agency issues in the price mechanism framework are the main tools of investigation of this trade-off, and the theoretical framework concentrates above all on the investigation of the contractual forms taking place in the alignment of incentives between the parties involved in the exchange, either inside the firm or in the market. In other words the TCE seeks the description of the boundaries of the firm by a static comparison between the only two available solutions for making the needed activities inside or buying them outside. The RBV, on the other hand, focuses on the resource endowments of the firm, and on the mechanisms by which these resources allow the firm to embark on innovative paths of growth and development. The RBV, and the capability view in which the framework evolved, recognize the importance in the dynamic element, but lack in considering it in the empirical analysis. As the ASO literature review showed, works adopting a capability approach consider the resource endowments in a static framework, where the process of acquisition and development of the resources are not taken into account in a dynamic approach.

In order to understand how a group of firms evolves, that is investigating the patterns by which the firm's capabilities are developed (and not only acquired) it seems useful to

focus on the activities that enhance the creation and application of knowledge, and relate them to the agency issues and resource endowments of the firm. As discussed in Chapter 1, investigating the knowledge governance mechanisms taking place in the firm context (Antonelli 2008) at different points in time in a firm's evolution seems to provide an answer to the difficulties encountered by the TCE and RBV approaches in dealing with dynamicity issues. A self-contained population study must take the contextual influence of both resource acquisition and resource development into account because its characteristics influence the agency issues and the circulation of knowledge and therefore the development of capabilities.

On the base of the ASO literature review and consideration of the theory of the innovative firms, let us propose a unifying framework that brings together relevant aspects of both. Our objective is to appreciate how ASOs develop as they engage in business procedures. The next chapter will analyse the knowledge exchange governance taking place in a population of ASO firms installed in the same contextual environment. We are interested in understanding how different Penrosian resource endowments shape the development paths of those firms. In order to accomplish the task the study will concentrate on the combination of external and internal knowledge on which some basic firm functions are managed by the firm: the evolution of this combination will be our lens of investigation of the development of the ASO firm. The next chapter will use these conceptual elements to frame two different contexts, an Italian and an English region.

PART II
EMPIRICAL FRAMEWORK

Chapter 3

The governance of knowledge in ASO firms

Research design

This research project investigates the development route of ASOs in terms of knowledge governance. The methodological approach is partly deductive and partly inductive. It is deductive because it is based on a life cycle of the ASO that has already been developed, and it is inductive because it draws the governance of knowledge adopted by the firms from carefully gathered observations. The study is based on a comparative analysis between the situation in an Italian region and a British region. The multiple case study analysis aims at some *theory building* considerations (Yin 1994). The Italian case study is based on eleven face-to-face interviews and the British study is based on ten. In all cases, the founder or main director of the ASO was interviewed. The aim of this was to describe the approach of the firms towards knowledge governance for different business activities in various periods of time in the life cycle of the firm.

The research aims to analyse the degree of internal knowledge compared to the degree of external knowledge by means of which the firm accomplishes some main business activities, in different points in time of its development. Five activities have been identified: R&D, productive processes, commercial function, training of employees and IP issues. Consequently, the overall governance is derived as the sum of the previous degrees of internal and external knowledge. The level of internal knowledge was studied for each business activity in the three stages of the ASO life cycle identified in the previous chapter. A business activity is considered to be based on internal

knowledge when the accomplishment of that activity is mainly conducted by skills and competences the firm has internally. On the contrary, when an activity is carried out with the involvement of skills and competences external to the firm, the business activity is considered to be based mainly on external knowledge, i.e. based on a low degree of internal knowledge. The internal knowledge of the firms has been classified as: high (H), intermediate (I) and low (L). It is intermediate when the knowledge involved in a business activity is more or less equally shared between internal and external skills and competences.

In order to identify the level of internal knowledge adopted by each ASO for each business activity at each point in time, the analysis of the historical events and strategies that shaped the conduct of the firm has been explored. The data is therefore represented by the historical events that describe the approach of the firm based on internal, intermediate or external knowledge of the various business activities. Once the data was collected, its elaboration was then preceded by a clarification of what is considered an internal or an external to the firm knowledge approach. This also allows a replication logic mechanism (Eisenhardt 1989, Yin 1994) across units and across the two cases here developed, that is the definition of a unique way of interpretation of the strategies of a firm. In other words, a classification of events that defines the evaluation of the knowledge governance has been defined. Nevertheless, we acknowledge the possibility, in a probable further case study approached with this methodology, that unexplored events may have happened and need to be classified *ex novo*.

Among the series of events explored, some turned out in several instances. Some events are also longitudinal to all the business activities identified. For example, the internalisation of a professional figure in a particular role or the presence of supporting policies. If the role of the new internalised figure is the main driver of one activity, as could be the commercial function when a new sales and marketing director is appointed, we consider the governance approach as based on external knowledge for the period in which the figure was hired, becoming internal (*ceteris paribus* other events) in the following period of time. Again public policies and consequent state initiatives led, when influential, to an external governance of knowledge for the activity the policy is directed to. Let us now explore each business activity identified in order to first define

them and secondly to classify the main events leading to an interpretation of the internal, intermediate or external knowledge approach.

Research and Development: At the university level, it represents, by definition, the activity an ASO comes from. ASOs are usually created within universities, which led to identify the approach to knowledge governance as external to the firm at time T_0 , relatively to the R&D function. This consideration is given by the fact the ASO business is the result of the exploitation of a school or department research output, generally wider than the team of founders. Moreover, the highly disclosed academic environment is by nature usually significantly influential on the upstream technological development of the ASO business. We therefore consider the R&D function as usually based on external knowledge when the ASO first begins. In the following periods of time, the ASO usually moves from the university laboratories and generally transfers the R&D function inside the premises of the firm. Nevertheless, some elements can shift this common approach to a more decentralised one, like the influences on product development and innovations of the interactions between the firm and academic or consultancy partners. For example, financing PhD students or research fellowships at the parent department represents an important factor that can shift the governance of knowledge making it intermediate or external.

Productive processes: They represent all the processes needed by the firm to materially produce the product to be sold on the market. We can consider all the non-R&D activities concerned with production as part of this business activity, which, usually, are mainly developed from manufacturing and/or service activities. When an ASO business is only concerned with the development of R&D projects, we consider R&D as the upstream basic research activities and productive processes as the more applied downstream activities, related to the adaptation of the R&D outputs to the market requirements. For example, the generation of a product is part of this activity. Nevertheless, often the boundary between R&D and productive processes is not so well-defined, especially, but not only, in the initial phases of ASO development. In this category we also take into account entrepreneurial skills: if they are provided or enhanced by some supporting policies, for example, they are considered external to the firm; if a member of the ASO had previous industrial experience, they are considered to

be based on internal knowledge; if instead they are brought in by the appointment of some professional figure they are external in the period of appointment and become internal in the following period. Moreover, the function of the productive processes is sometimes made in partnership with some complementary assets owners. When these assets are of the general type, i.e. easy to find, and the productive processes are almost entirely outsourced to external firms, the governance of knowledge is external. When on the other hand the outsourcing is secondary, as generally happens in service based ASOs, the productive processes are considered as based on internal knowledge. Finally, there is the case when the complementary asset owners are specialised or co-specialised. In this case, by definition, ASO is involved in the interaction with the external firm. In this case there is a high level of knowledge exchange between the ASO and the external firm, and the business activity is considered to be based at least on an intermediate level of internal knowledge, of course other elements remaining influential.

Commercial function: The commercial function basically represent the way the firm gets to customers and raises funds. For the first point, an internal knowledge governance is mainly represented by the founder's previous network of partners. It becomes external when the firm undertakes some practices to get in contact with the external environment, for example by employing a specific commercial figure, or by the organisation of or participation in conferences or other events, or by the outsourcing of marketing strategies to external companies, or finally when new customers are gained through the network of old customers. Roughly the same can be said about the capability of raising money, like a VC investment. If the academic network is the main channel to get to the funds, an internal knowledge approach is acknowledged, while it becomes external if the investors are found through other channels, like TTO or new professional figure network assets. It is intermediate when the influence of the previous academic network is as important as other ways of finding customers/funds.

Training of employees: This represents the degree of training new staff receive when appointed by the firm. It is quite common to hire new employees from the parent organisation department. In this case, we can consider the function, except different specifications, to be based mainly on external knowledge. It is also considered to be based on external knowledge when a particular school, not the parent organisation,

produces a very suitable professional figures for a particular ASO. Moreover, if internal network assets are the main driver behind the hiring of new figures, we consider the training as mainly external, because we assume the newly appointed figure to be known already and therefore to be also trained. On the other hand, we can consider the process based mainly on internal knowledge when the origin of new employees is not important. In this situation, new employees are hired through advertising or other recruitment mechanisms and usually the person interviewed highlights the centrality of the learning processes within the firm. Another element moving the balance towards internal knowledge is the experience of new employees. If they have just graduated, the balance will move to an internal management, while if they already have experience, the balance is towards an external knowledge mode.

IP issues: Everything concerned with the management of IP is part of this activity. As we will see later, this activity represents the main externally managed activity. Every single activity inside the firm concerning IP management shifts the governance of knowledge of this activity towards internal management. One example is the patent screening one firm established during its life.

The empirical analysis presented in the present section is organised as follows. First a general description of the two analysed regions is provided, then the work will move to the case study analysis. Each of the two case studies will be structured as follows: first an introduction to the specific policies will be provided and then each ASO interview will be summarised in a description of the salient historical events and strategies approached by each firm at each point in time of their life cycle. Then each phase of development of the ASO group will be briefly examined in order to compare the different behaviours of the ASOs in each context. Finally, there will be some concluding thoughts followed by the provision of an illustrative summing up figure. In conclusion, a comparative analysis between the two studied contexts is put forth accompanied by some policy implications.

The analysed regions

Following the NUTS region classification provided by the European Commission (2007), our analysis compares two ASO populations in two NUTS II European regions: Emilia Romagna situated in the North of Italy and Greater Manchester situated in the North West of England, in United Kingdom. The two regions appear to be quite different in terms of surface and population, because Emilia Romagna is spread over more than twenty thousand square kilometres while Greater Manchester is just an urban agglomeration of less than fifteen hundred square kilometres. The population dimension is closer where Emilia Romagna has a population of just over four million inhabitants and the population of Greater Manchester is two and half million.

However, the two regions appear to be more similar if we look at the main economic indicators. Both regions show economic and innovation indicators above the European average: made 100 the average EU-27 GDP (Gross Domestic Product) per inhabitant in 2006, Greater Manchester reveals an indicator of 111 points and Emilia Romagna of 126 points; compared to the 2001 values the GDP decreased by 23 points in the Italian region against the decrease of 1.5 point in the English region; R&D expenditure as percentage of GDP is 1.17% in Emilia Romagna and of 1.76% in Greater Manchester⁶; the human resources linked to the 'science and technology' sector as a percentage of the active population is 31% in Emilia Romagna and 24% in Greater Manchester, while the percentage of employment in high tech and medium tech manufacturing is estimated at 10% in the Italian region and 5% in the English region; finally patent applications to the EPO per million inhabitants appear to be more numerous in the Italian region than in the English one: 168 versus 43 (Eurostat 2009).

The two regions show some differences in economics and in the science and technology indicators. Emilia Romagna appears to be slightly more innovative than Greater Manchester in terms of static indicators comparison, but reveals a less decreasing rate in terms of GDP change per inhabitant from 2001 to 2006. In other words, Emilia

⁶ This value is referred to the whole United Kingdom, as it is not available the regional value

Romagna shows slightly better innovative performances, but the two regions seem to be converging.

In terms of supporting policies the two contexts adopted substantially different strategies, but from the ASO point of view, the provided supporting tools do not differ that much. While the Emilia Romagna region is an active government tool in supporting ASO formation and development, in the English region the supporting tool appears to be more on university level. Moreover, while in Italy only national, regional and institution policies act, in UK there is one more level, the NUTS I (in this case represented by the North West region of England), which is not very politically active in Italy (Nord East region of Italy). It is worth noting that while in Italy the regional NUTS II level is particularly active in creating supporting policies, in UK the NUTS II level is not so involved. From the ASO perspective there are two main types of supporting policies: management/organisational support and financial support. As it will be showed later in the empirical analysis sections, the Italian context provides almost only supporting tools of the first type, that is management and organisational support, while in the Greater Manchester scenario financing incentives are developed to the same extent as organisational aids. Let us now move to the empirical analysis in which each context will be described in more detail.

Emilia Romagna

There are five universities in Emilia Romagna: University of Bologna, University of Ferrara, University of Modena and Reggio Emilia, University of Parma and University of Piacenza. The total number of filed patents by the regional universities is 156. The number of active ASOs in Emilia Romagna was 96 in 2008, but the ASO regional monitoring tool handles data for only 83 of them (Aster 2008). Seventy of them come from universities and the rest come from other public research institutions (like CNR – National Research Council, or ENEA – Italian National Agency for New Technology, Energy and Environment). A first selection was made by concentrating on university

spin-offs⁷, while a second choice was made from a sector type selection. The overall ASO database was first divided into two groups, according to the origin of the university and then each group was divided into sub-groups by sector. A sub-database was then created. For each university group, only the most populated sector was taken into account until there was half the number of university ASOs. This selection process resulted in a new database of 45 ASOs. Each university group was made from a number of ASOs, ranging from 8 to 12 firms. At this point indicators of performance, including turnover volume, turnover growth rate, number of employees (where available), patents, if present, and years of existence were analysed in order to create a sort of hierarchy of ASOs in terms of performance.

Once the list of potential ASOs had been produced they were contacted by phone. ASO phenomenon has become fashionable in recent years, and the amount of interviews these firms receive per year is impressive, making it more difficult to arrange a direct interview. While around half of the ASOs in the database were initially enthusiastic about the prospect of being interviewed, in the end the firms were unable to spare the time to undertake a face-to-face interview. At least two firms per university were reached and directly interviewed using a semi-structured questionnaire (see appendix for the questionnaire). The average time of the interviews was one hour, ranging from 40 minutes in a couple of cases to more than 2 hours in one case; at the end of the research we obtained more than ten hours of recorded audio-material. Before each meeting interviewees were approached by e-mail to inform them of the conceptual gap that this research seeks to fill.

The Emilia Romagna region is shaped and characterised by certain factors meaning that the region can be considered as a self-contained economic system. The limited geographical area in which a high number of SMEs are involved in robust networking relationships, including the consequent high level of labour division inside the region and the elevated level of institutional activities, have resulted in scholars acknowledging the presence of internal patterns of idiosyncratic evolution (Brusco 1982, Leonardi and Nanetti 1990). Institutions played and continue to play a central role in the evolution

⁷ The University of Piacenza activated only one ASO (Aster 2008) and for this reason has not been considered in the rest of the work.

and behaviour of the regional economic system. The Emilia Romagna region is shaped by a significant amount of intermediary institutions that enhance information transfer in the environment, by the important presence and influence of government institutions that learn and evolve inside the system and by self-monitoring and evaluating tools that produce idiosyncrasies in the local institutions and practices (Bianchi and Giordani 1993).

In recent years the region has developed an institutional framework with the aim of governing and coordinating the networking activities among universities and public research centres; a unique regional innovation policy in the national context (Poma and Ramaciotti 2008) has been put in place in order to promote innovation and knowledge networking activities inside the region. Within this framework, in the sphere of the POR (Regional Operative Programme) under the third objective of the ESF (European Social Fund), the ‘Consortium Spinner’, activated in 2000 aimed at the promotion of employment in research and technological innovation positions. The Consortium represents the five universities and the three public research institutions of the region. The objective of Spinner was to create projects aimed at the valorisation of human capital, promotion of research, technology transfer and innovation activities, also, and above all, by the creation of new ventures. The first Spinner Programme took place between 2000-2006, while the second started in 2007 and will last until 2013. Moreover, in 2003 the first regional policy (PRRIITT, giving practicality to the 2002 Regional Law number 7) was activated in order to sustain innovation and technology transfer processes. Again a new round of PRRIITT was activated in 2007 in order to continue the promotion of technology transfer activities. We shall now focus on the history of each regional ASO firm.

Firms development description

Firm α

Firm placed in the pharmaceutical and wellbeing sector carrying out research projects mainly for pharmaceutical companies.

Time T_0 . Starting in 2001, the University of Ferrara put notable emphasis on third mission activities and, in particular, on the creation of ASOs. One of the most productive research groups of the School of Pharmacy had the specific incentive to follow this commercial path for the research output of the School. In 2003 an ASO firm took place from the initiative of a professor and a post-doctoral student of the research group, with the aim of developing and commercialising some university patents given to the company in exchange of company shares. The initial activity was based on the generation of synthetic molecules/reagents and the idea was to sell patents of the aforementioned synthetic procedures on the market. Very soon the team realised that in order to get these molecules on the market, significant further development was needed. Consequently, they sought to sell their embryonic invention to firms willing to develop it. However, market firms wanted more proof, more information and more investment. The product was at too early a stage of development. Therefore, the patents remained in house and have not been exploited, nor has it been extended outside Italy. The initial activity was the result of several years of research and was mostly about selling the R&D know how of the research group at a time when R&D outsourcing was a growing practice. The R&D and the productive processes were conducted entirely in the university laboratories, with the help of some students in the department, who were involved by means of research contracts and PhD scholarships (R&D, productive processes and training of employees based on external knowledge). Although the idea of business did not take off, the company had some clients and produced enough revenue to develop new molecules. The main clients were connected to the two founders (commercial function based on internal knowledge). The entrepreneurial commitment was reached by the founder (post-doctoral student), who devoted substantial time to developing management skills through the supporting regional policy

Spinner (confirmation of productive processes based on external knowledge). Spinner also supplied the IP consultancy service (IP issues based on external knowledge).

Time T₁. A few years later the company still had to take off. The new product development was entirely driven by internal decisions and was not directed by projects from external companies. The team decided to extend the core activity of the ASO and expanded towards the field of natural products and cosmetics. The firm therefore entered this second phase by organising the business in two directions: the chemical-pharmacological on one side and, on the other, a new natural oriented one. While the original core activity was developed inside the research group labs due to the extremely high costs of infrastructure, the second activity moved into another university premises, which meant that the ASO was now renting a room from the university. The original core activity is still organised as it was before and is extremely linked to the university research group activities. Instead, the new activity is more autonomous and a few people are hired to work on the development of natural products and cosmetics (R&D activities still mainly based on the research group activities, which means they are based on external knowledge. Productive processes can be considered to be based at an intermediate level of knowledge because they are more autonomous and closer to the final customers: this is clearly driven by the founders, in terms of knowledge, but is partly influenced by the external knowledge of the new hired people and of the sponsored university staff). The new appointed researchers in the cosmetics and natural division came from the best students of the research groups (training of employees externally-based). There were no changes regarding the IP issues, which were still managed by consultants. The commercial function remained substantially based on the previous network of the founders, but a significant percentage of the new clients came from the ASO developed network, particularly in the new natural and cosmetics market (commercial function based on an intermediate level of knowledge). The founders claimed to be scientists and not entrepreneurs. Although one of them, the post-doctoral student mostly involved in the business, was trained to develop management skills, the strong academic background remained the main drive of the business activity. Moreover, the firm is expected to move from the university rooms at the beginning of 2010, because of internal university roles. They expect to only keep the natural segment

of activities, leaving, or entirely outsourcing to the parent school, the initial core pharmacological activity.

Firm β

Service firm with biological background mainly linked to the territorial features.

Time T_0 . In the late nineties a group of unstructured staff at the Department of Biology of the University of Ferrara had an idea for a business activity. Four contract lecturers of the department, each with a different specialisation, decided to unify their skills in order to offer an integrated service that was missing from the market. The value added of the new business was in the integration of different skills from different members to create a unique product-service. A supporting tool, which was an important aspect of setting up the business, was a Biology Department grant (Spinner was still not active at the time). In 1999 the ASO took place. It was established on the university premises from the very beginning and was based on the activities of the members. One of the members had already developed some management skills as he had worked in industry (productive processes based on internal knowledge). Nevertheless, for the first two years of the ASO activity, all the members also worked as contract lecturers for the department, and the influence of the department on the R&D was significant (R&D considered therefore based on external knowledge). It is interesting to note how the firm was linked to territorial characteristics. The Province of Ferrara has a natural park and the biggest national river outpouring of Italy. The Department of Biology has been involved in the territorial context for a long time. The ASO therefore benefited right from the very beginning of the 'fame' of the department in the territorial necessities and based its network of clients on the previous network of the parent organisation. This was increased by the fact that the professor involved in the business who represented the university was also the director of the department of Biology. Therefore, he was well-known in the Province (commercial function based on internal knowledge). IP issues are linked to the copyright and brand activities, but managed by external consultants. Some fixed term contracts were activated in the initial years, with people

coming from the university, where the members still had a teaching function (training of employees external to the firm).

Time T₁. The ASO first expanded in mid 2000s, in particular with the appointment of two members from the previous network of the university representative (external knowledge factor for the productive processes). These two figures and a fish cooperative took part of the share of the ASO, with the University, the other four members and a National Park of the territory. These two figures brought into the firm two specific service skills, adjacent to the other specialisations of the ASO. Nevertheless, one particular specialised sector, has represented the main source of revenue of the firm since the very beginning and is related to the fishing activity, still based in the province. It moved to the creation of the fishing cooperative in the firm (productive processes therefore based on an intermediate level of knowledge: external for the new skills internalised but partly internally based as the main source of revenue is an old resource). From these new skills within the firm, the ASO was able to offer a more complete product. Integrating these new skills into the products led to an increase in revenue and to the extension of the market. The ASO started working in the regional context and not only in the province. The founders affirmed that at this stage the R&D activity was not carried out and the links with the university did not concern technical knowledge and that it was only a source of contacts and employees. The ASO continued to remain a source of work for some students in the department (at this point only temporary contracts), and an internship activity is still in plays at present, which started at this stage (intermediate level of knowledge about training of employees). The commercial function is still partly based on the previous network of university representatives, but is also partly related to the fame and developed networking assets of the ASO (commercial function to be considered based on internal knowledge). IP issues are not taken into account at this stage.

Time T₂. The ASO in late 2007, early 2008 experienced further restructuring. The idea was to grow to a critical mass point, to move to an expansion of the area of the market and also to almost redesign the core activities. One of the two figures joined the team in the previous stage was not as profitable and did not produce as many new jobs as expected. The firm was very close to moving the figure from the company. Moreover

three new employees were appointed. They were two technicians and an administrator, the first permanent employees of the ASO. The two technicians first joined the company through an internship from the department, and were then hired (training of employees can be considered governed on an intermediate level of knowledge, because of the external training carried out inside the university department and the internal training carried out during the internship). A new product has recently been developed, and still did not influence the productive processes to a great extent, but influenced the IP and the R&D functions. This new product represented a new related to fishing techniques and was developed with another company. This led to a patent that was developed through external consulting activities, and it is still in the testing phases (intermediate level of knowledge about R&D as the new product was designed in conjunction with the ASO and an external company; productive processes mainly based on internal knowledge, because the new product and the new employees had a marginal role compared to the five operational members of the ASO; IP issues based on external knowledge). The firm complained that there is not a commercial dedicated figure, but also explained the difficulties in institutionalize a figure like that. The problem is that each member is the commercial agent of the own specialisation segment, and finding a figure who knows enough about all the specialisation to carry out a commercial function, appears to be unworkable (commercial function therefore based on an intermediate level of knowledge, still benefiting from the department networking influence).

Firm γ

Contract Research Organisation in the pharmaceutical sector

Time T_0 . In early 2000s a pharmacology professor found a new, in the Italian sector, postgraduate course at the University of Ferrara, on the idea that the market was requesting some particular formative courses. The course was directed towards the development of Clinical Monitor figures to be employed mainly in CRO (Contract Research Organisation) companies. Quite soon after the establishment of the course, the professor had the idea of starting a business where he could employ the newly qualified

students after they completed the course. An ASO operating as a CRO took place in 2003 from the action of two professors of the University of Ferrara, Department of Pharmacy. The idea was that a direct link with the academic environment could represent a value added compared to existing CRO firms. A CRO is a type of firm that conducts monitoring and supporting activities to pharmaceutical companies or scientific bodies. An imperative was to be closely linked to this market sector. The commercial function in the beginning was from the previous network assets of the founders (commercial function based on internal knowledge). The operational side of the firm was given from the know how developed at the university (R&D based on external knowledge) and by the activity of the founders unified by some temporary employees coming from the course and undertaking an internship in the firm (training of employees based on intermediate level of knowledge). Spinner also had a role, especially in the provision of management skills to the founders (productive processes based on intermediate level of knowledge: external knowledge from Spinner combined with the internal technical knowledge of the founders in conducting the business activity). Spinner also provided IP issues consultancy that was mainly directed towards the brand and some form of copyright protection (IP based on external knowledge).

Time T₁. After a few years of activity the ASO team realised that the idea of employing people from the postgraduate course was not a very profitable strategy. The market needed more experienced figures who knew the market and were able to put the necessary professional bodies and actors in contact. In other words the only academic networking assets were not enough to carry out a profitable and growing business. A new figure from the networking assets of the founder entered the team, taking the place of the less involved academic. This figure had worked in a pharmaceutical company, so he knew the requirement of the pharmaceutical company and the weaknesses of the average CRO present in the market place (training of employees considered based on external knowledge). This new figure had an impact both on the productive processes and on the commercial side of the business (productive processes considered based on external knowledge because of the management skills brought to the firm by the new figure; commercial function based on an intermediate level of knowledge, because of the influence of this figure on the still important previous network of the founder). The firm is growing but only in terms of revenue and not in terms of staff. There are no

employees but only the team members working in the ASO. The future prospects are to continue the growing path, but there is still no plan to expand in terms of people.

Firm δ

Environmental services related to GIS and Web GIS cartographies and a complementary activity aimed at supplying specialised satellite images

Time T_0 . Three post doctoral student, believed it is very difficult to find future employment in the university and therefore decided to set up a business which was able to make them exploit the know how developed in the education programme (R&D based on external knowledge). They looked for a professor to be included in the team of founders in order to become an ASO. In 2002 the team secured Spinner supporting tool. The policy provided support in terms of management skills, IP issues and commercial and technical issues. The activity was set up inside the university (productive processes based on external knowledge, commercial function intermediate, because of the influence of the external support of Spinner, but also based on previous department network assets). The initial idea was to develop a main software product with the help of the Spinner consulting activities and provide two related service activities. The easiest activity carried out was related to the service activities, and the main software product was, at this stage, in a development phase with the aid of the parent organisation. The activity was partly carried out through internship from the parent organisation (training of employees based on an intermediate level of knowledge).

Time T_1 . The software product that should initially have been the core product did not end up as expected and the activity was abandoned. The two service activities become the only business of the ASO (R&D not conducted and not influential any longer). Some new people were hired, also with temporary contracts and by initially doing an internship (training intermediate and productive processes internal as conducted mainly by the active members). The commercial function and the link with the market place became a primary issue and were always conducted by the same members, initially trained by the Spinner supporting tool. However the main current customers remain the oldest ones, coming from the professor and academic network (intermediate level of

knowledge because of the external knowledge brought into the company by the commercial figure connected with the market place, but also internal given by the previous network). The IP issues were conducted through consultants in the beginning and any longer considered after it was understood the software did not work as expected. The firm is now enlarging its customer portfolio because it is becoming established in the territorial market place; nevertheless, due to the economic crisis, the rate of growth is still not as fast as the team had intended.

Firm ϵ

Physical diagnostic technologies applied to electrical equipment

Time T_0 . On an overall university push on third mission activities in the late nineties and on a solid know how developed from twenty years of research at the electric engineering department, in 1999 an ASO was formed with the aim of designing and building physical electric devices. The ASO was formed by a well-known professor, his most brilliant Ph.D student and four more academic members. The activities were entirely carried out from the university laboratories, both in terms of research and design and in terms of manufacturing prototypes (R&D and productive processes externally based knowledge). Initially the notorious fame of the professor made it possible to go and test some initial products to some early customers; the commercial function was conducted by the brilliant student, however, the professor's fame worked as the main lever of customers and partners (commercial function based on internal knowledge, because of the previous network of the academics). The initial product was a hardware product made by assembling already existing parts (general complementarities) and ad hoc software was run on it, where the value added was embodied in the idea and in the know-how involved. The firm worked for a couple of years inside the university laboratories and collaboration with academics was very high and very influential for the development of the product. The IP issues were deeply faced mainly through one consultant that was an ex-Ph.D student of the research group (IP issues based on external knowledge). During this phase the company moved from the university laboratories and some engineers from the parent organisation department

were hired to build a design team (training of employees based on external knowledge); a couple of patents were filled and in approximately 2004 the company expanded for the first time.

Time T₁. Expansion in 2004-2005 took place after the first revenue was secured. The innovative product was very appealing for big organisations, but its implementation and improvement required the exchange of knowledge between the ASO staff and client companies. The developers, at this stage, were therefore also undertaking a kind of service activity that provided both advice for the clients and feedback flows to the R&D and productive process activities of the ASO firm. The new employees were mainly engineers from the parent organisation involved in internship programmes, and then sometimes appointed by the ASO (training of employees based on intermediate level of knowledge). Moreover a manager was appointed at this stage. His initial role was to introduce controlled accountability into the firm, but his role was soon embraced by a wider set of activities. In particular, he ended up providing the firm with an organisational structure, producing labels and defining roles for people and divisions. Therefore a design division concentrating on the development of the product was recognised, and supported by a service division (R&D done by the designing division, therefore based on internal knowledge). On the productive process side two new products were developed in this phase, not only in terms of software development, but also in terms of manufacturing design. The idea was to manufacture a hardware optimised for the goal of the software. While in the previous stage, the main feedback on the product development had been from the upstream technological side of the business, at this stage the market feedback mainly in the form of services flows of knowledge was the main driver behind the development of the product. Moreover, some specialised complementary assets owner were needed at this time, where exchange of knowledge with the external environment took place and were very important in order to build a well functioning product (productive processes based on an intermediate level of knowledge, given the combination of the internal skills already settled in the company and the feedback from the market place). The commercial function was now importantly carried out by the founder brilliant student, although the fame of the new technology, embedded in the professor and department fame, still played a central role (commercial function therefore based on an intermediate level of knowledge). The IP

increased in importance in this phase, and were still managed by the same consultant (IP issues based on external knowledge).

Time T₂. In 2007-2008 another main restructuring activity took place. The firm was rapidly growing and some divisions of the ASO detached from the firm and became more autonomous. These were the services division and the generation of an energy division. The energy market was a natural expansion of the activity of the firm where the ASO moved recently into. The brilliant student left the job, and the commercial function continued to be mainly conducted by the service people and by a new appointed manager (commercial function based on external knowledge). This new expert manager came into the firm to manage the feedback from the service to the R&D and to coordinate the different section activities (R&D based on internal knowledge because unchanged from the previous phase; productive processes still based on an intermediate level of knowledge because of the important influence of external management skills introduced by the new expert appointed figure). The new employees sometimes came from the parent organisation, and sometimes from normal recruitment procedures. The firm is very much independent of the influence of the university. The university left the company and the firm is planning a merger or acquisition strategy for the near future (therefore internal knowledge for the training of employees).

Firm ζ

R&D projects related to the chemistry of the solid state drugs

Time T₀. In 2004 a big chemical company offered an important research contract to an academic research group. The research project would have altered the share of applied compared to pure research in the group. Two young researchers, one just graduated and the other at the end of his Ph.D, created a venture with the aim of working on that project while setting up a company. Spinner supported the initial stages of venture creation, through grants to the two active founders and through training courses. These two students formed the initial team, with the professor at the head of the research group and three more academics, who were not actively involved in the company. The university did not have a share because in 2004 the University of Bologna approached to

the ASO activity changed compared to the late nineties and did not support this sort of activity. The main training activities focused on marketing and management skills. In 2005, the firm was created on the university premises (therefore the R&D and productive processes are based on external knowledge, depending on the job done inside the research group; Spinner management support would function as external knowledge but it seems that at this stage this formation did not have an important weight because the research contract the team had before the ASO creation means that the management skills to carry out that job were already inside the research group. Finally, the commercial function is considered as based on internal knowledge because the research contract source is the fame of the research group, especially of the professor leading of the group). The staff was represented by people from the same research group at that time (training of employees based on external knowledge).

Time T₁. In 2006 the firm moved from the university laboratories due to investment of the first job revenues and a bank loan. An important marketing activity had been undertaken from the initial stages, consisting of the organisation of a yearly exhibition event, which was organised at national level for the first two years. This, along with the fame of the professor, helped the firm grow quickly (commercial function on an intermediate level of knowledge: combination of the external knowledge provided by the exhibition activity with the internal network of the well-known professor). The firm organised its activities internally, because of the lack of university facilities support. Contacts with the university were given by the relation with the professor and the financing of fellowships, at this time only at the parent organisation department (R&D based on intermediate level of knowledge. The R&D activity was conducted internally with the influence of the university research programmes financed; productive processes were conducted mainly internally, therefore based on internal knowledge). The first chemical technicians were hired as temporary workers because a small firm needs time to find the right people to employee (training of employees based on internal knowledge). The IP issues were at this stage carried out with the help of an international company that took care of administrative matters, while the ASO furnished the know how contents (IP based on external knowledge).

Time T₂. The firm showed a positive growth trend in terms of turnover and clients. The exhibitions provided new clients and the two later editions were held at international level. These two events produced an amount of dozens of customers that asked to the ASO not only standard chemical research projects but involved them in problem solving activities (commercial function based on external knowledge because of the high influence on the marketing activities of the exhibitions). The firm business expanded both in terms of services offered and in terms of people. New temporary technicians were hired through normal recruitment practices (training of employees based on external knowledge) with skills alongside the core activities (in this case pharmaceutical and related specialisations). (The new figures had an important role in the R&D and productive processes, but their weight is nevertheless marginal compared to the two young founders and the technicians hired in the previous phase. Therefore, we consider the R&D and productive processes as based on internal knowledge).

Firm η

Prototypes and services related to the human-machine interaction

Time T₀. An interdisciplinary research centre was established in 2001 in between the department of engineering and the department of communication studies of the University of Modena and Reggio Emilia. The centre was funded mainly by research contracts, and was therefore keen to market issues. In 2002 a big research contract was secured by the research centre and two students and two academics started thinking of building an ASO to manage this and future contracts more flexibly than a para-university organisation. The ASO started in 2004, still working on this research contract. In the mean time, Spinner supporting tools were used by the two founder students. The initial activity was carried out in the research centre infrastructures (productive processes and R&D based on external knowledge) and with the complicity of the whole research centre staff. The commercial function was mainly from the academics involved who were able to secure the main first contract research that created the firm and also in bringing some more clients (commercial function based on internal knowledge). Spinner support was mainly directed at both management and marketing

activities (while the productive processes was already considered externally based knowledge, the Spinner marketing support had a role in the commercial function, but considered marginal compared to the influence of the previous network of the academics, therefore leading to consider the commercial function to be mainly based on internal knowledge). The employees were staff of the research centre (training of employees based on external knowledge) and the IP issues were at head of the big company seeding the firm.

Time T₁. The firm initially developed early stage product prototypes, but client firms frequently asked to go further in the development of the products or to face new problem solving issues, in this way alimending new contracts with the ASO. The firm grew importantly. An initial differentiation of departments inside the firm took place: the engineering and ergonomic division were separated. A first core product was established and consisted as a service in the form of software. A regional grant was obtained at this stage in order to fund the development of a new product that matured with the important influence of the research centre as the spin-off was financing almost all the research centre activities (R&D and productive processes based on external knowledge, because of the research centre and the regional policy). In the productive processes, there was also the influence of very general complementary assets owners as the software produced relied on hardware easily obtainable in the market place. An initial fund raising activity was set up and conducted by the general manager and by an administrator who also partly took care of the commercial function. This function shifted towards becoming more independent of the internal networking assets (intermediate level of knowledge for the commercial function). Some engineers were hired. The new employees of the firm had different background and did not come from particular sources at the time, and were found through advertising procedures in the market place (training of employees based on internal knowledge). IP issues are mainly concerned with copyright and keeping the software source code secret (IP managed externally).

Time T₂. The firm continue growing and the firm split into three separate divisions: design, development and ergonomics. The fund raising activity became more important and a further division alongside the other three was established, to which two people

were entirely dedicated (commercial function based on external knowledge). On the other hand, the R&D and the productive processes were more and more integrated within the activities of the firm up to the point that the ASO in early 2008 undertook the practice of also developing within the firm the manufacturing phases of the prototype development. This is the result of the strategy of making optimised pieces of hardware on the one hand and using these techniques as a platform for other product development on the other hand (productive processes based on internal knowledge). The research group worked almost only for the ASO and only a few people worked in the research centre, who were not employed by the firm but by the university, although they still are financed by an ASO fellowship to the university. The R&D function was therefore divided between the firm and the research centre (intermediate level of knowledge for the R&D). The firm expanded significantly in terms of employees, that now are around 18 in the firm plus 6 in the research centre. At this stage the new ASO employees all came from the same school, the mechatronic faculty of the parent university. These new figures have been very important for the firm because the hardware internal making activity has been internalised because of their skills, spread amongst electronics, informatics and mechanics (training of employees based on external knowledge). Moreover a patent screening figure has been introduced in order to be informed of patenting activities related to the products of the firm (the peculiarity of this procedures that we saw only in this firm, led us to consider the IP issues as based on internal knowledge).

Firm θ

Informatics tools for disabled people

Time T_0 . In 2003 a disable engineering student was carrying out research about the development of some tools for disabled people in his graduation thesis. During this time he saw some potentialities in terms of value of the research outcome, and with a student colleague he applied for Spinner support. A two-persons' grant was obtained and the two students set up an ASO without the participation of the University. The Spinner courses focused on management, IP issues and marketing (we can therefore

acknowledge external knowledge factors concerning the conduction of productive processes, IP issues and commercial function activities). During the thesis the disabled student developed two product prototypes, of which one become the core product of the ASO firm constituted in late 2004. Although the development of the product was mainly carried out by the student, the R&D function relied significantly on the university environment during the development stage, but moved entirely inside the firm at the ASO formation (R&D therefore considered intermediate). The main product was software applied to some existing hardware devices, which were easy to find in the market (generalised complementary assets). The product however had to be adapted to each individual customer, and a service activity was immediately put aside the software product (productive processes based on an intermediate level of knowledge, given the balance of the internal knowledge made by the software developers and the external knowledge given the feedback generated by the service activity).

Time T_1 . When the ASO started finding some customers the disabled student only took care of the service activity while the other student concentrated entirely on R&D and product development (internal knowledge for R&D function). The firm started to grow in revenues: although some competitors are present in the local area, the ASO value added is given by the connection with an R&D function. Competitors simply commercialise products that already exist. The first growth period was directed towards the expansion of the company in terms of people and products. Some people were hired with general recruiting procedures, and directed to administrative and commercial duties (training of employees based on internal knowledge and external knowledge factor for the commercial function, but productive processes were still carried out mainly by the two founders, so productive processes based on internal knowledge). IP issues remain important and continue to be carried out through external consultants (IP issues based on external knowledge).

Firm t

Acoustic measurement instruments

Time T₀. An important product innovation was developed inside the university laboratories in early 2000s. Three temporary researchers and two academic staff gave birth to an ASO in 2003 in a university that was not showing particular interest in the spin-off phenomenon. The first product was developed inside university premises, but the not secondary manufacturing and testing phase was conducted internally when the business had already settled (R&D externally based and productive processes based on internal knowledge). The business did not get any important funding, but the Spinner support. Marketing and management formation courses were mainly undertaken from this support, and IP consultants were found (factor of external commercial function and productive processes that can be therefore considered to be based on an intermediate level of knowledge; IP issues based on external knowledge). A commercial figure was appointed from the very beginning (external factor for the commercial function), although the academics involved in the team were important sources of potential customers (therefore intermediate level of knowledge for the commercial function). A service activity started together with the business activity, in order to produce cash flows to finance product development. All staff, except the commercial figure, came from the same engineering department (we can therefore consider training of employees based on external knowledge).

Time T₁. Soon after it was set up, an important structural change took place in the firm. A big multinational company asked the ASO to sell the new technology. The members of the ASO were divided, and two of them left the company with the technology licensed, and the rest continued with similar projects in the ASO firm. The consultancy services of the business became particularly important (factor of internal knowledge for the productive processes), and led the R&D to develop two new products, which represented some form of extension of the licensed one. To this purpose some grants from a regional policy were secured in order to buy specific infrastructures and some fellowship at the University were funded (factor of external knowledge for the R&D and productive processes, which can be considered to be based on intermediate level of knowledge). Nevertheless, the R&D was entirely carried out within the firm (therefore R&D based on intermediate level of internal knowledge). The commercial function is now carried out entirely by a specific figure inside the business (commercial function based on external knowledge). Some new temporary employees were hired, mainly as

technicians, but their contribution to the final firm output is quite marginal; moreover they were hired after an internship (training of employees based on intermediate level of knowledge). The IP issues continue to be based on external consultancy.

Firm κ

Environmental services

Time T_0 . In 2003 three temporary academics with two non-academic persons set up an ASO with the mission of finding an alternative to the difficult academic situation of the time. The ASO was not the exploitation mechanism of a particular research output, but was mainly the will of having an independent business activity related to the background education (R&D based on external knowledge, which was the years of formation of some of the founders). However, a fairly innovative product was in the development phase and consisted of a physical device, a multimedia information package. The product should have been compatible with the many multimedia objects already available on the market, such as mobile phone, mp3 players and so on. The idea was to offer an informational product to be easily integrated with some common everyday objects. The targeted market was naturalistic environments. The job of the ASO should have been to supply the scientific contents with the device (the productive processes can be considered to be based on an intermediate level of knowledge, because of the internal knowledge of the scientific contents, and the external knowledge of the hardware support, which can be considered as provided by a specialised complementary assets owner). In the beginning, the product was in the development phase and the ASO lived off a complementary service activity, given by a network assets of the founders that were able to secure some jobs in order to keep the company alive. Moreover, in support of the commercial function, the Spinner supporting tool had a role, leading to the development of some form of web based marketing strategies (commercial function based therefore on intermediate level of knowledge). IP issues are, as usual, managed through external consultants, such as the active employees of the ASO all came from the same parent organisation (training of employees and IP issues based on external knowledge).

Time T₁. After a few years the ASO realised that the multimedia product did not work as expected. The market did not yet appear to be ready for such a product. The services were the only activities keeping the firm alive and in 2005 the firm structure and mission changed significantly. First it abandoned the multimedia business, two members of the team left the company and one other joined. The networking assets of the ASO members in the local area and the marketing activities of the ASO itself led to a new important services activity, consisting of the management of a natural park in the area (commercial function based on an intermediate level of internal knowledge). A regional grant was secured in 2005, in order to support the business (productive processes to be considered intermediate, because the external influence of the policy grant balanced the internally supplied services). No R&D and IP issues were conducted at this stage. Some people were temporarily hired by the ASO, especially related to the last service activity produced. All the new employees were hired through personal networking and normal recruiting activities (intermediate level of training of employees).

Firm λ

Air and water quality monitoring tools.

Time T₀. In the mid nineties the son of an established company concerned with the implementation of environmental monitoring tools started a physics degree. In the late nineties he embarked on a thesis on the development of innovative monitoring devices. In 1999, finishing his degree, he set up a company sponsored by the university. In the company there was the participation of: the university, the student as CEO and CTO, his family company and a local Bank (factor of internal knowledge about the commercial function). The ASO function was to design and build innovative monitoring tool devices, compared to the ones acquired from the external market by the family company. In order to develop the products, the research group where the student was enrolled had a fundamental role in driving the technology development (R&D based on external knowledge). There was already a thick network of supporting links at the formation of the ASO team. In particular, the family company provided orders for the

firm to grow in the market. At the very beginning the only customer of firm λ were the *parent company* and an employee of this company moved in the ASO in order to manage the commercial function (commercial function based on internal knowledge). The productive processes never took place inside the university premises, and did not receive the university influence that the R&D function had. However the productive processes required the intervention of complementary assets owners, all of them already known by the family company, therefore easy to find (in our analysis this element can be understood as general complementary assets owner). The parent company influence in the productive processes is also given by the management support. Moreover a mathematician has been hired very soon in order to develop the software for the first ASO market product (we acknowledge a prevalence of external knowledge in the conduction of the productive processes). The mathematician has been hired through normal recruiting services and was an already expert figure (intermediate level of knowledge about training of employees). IP issues have been investigated through external consultants to get to the acknowledgment of the impossibility of patenting the product, and relying on secret and leadership in order to protect the eventual competitive advantage.

Time T_1 . The ASO grew quite fast and the initial revenue were directed towards new technology development and firm expansion. The R&D and productive processes were at this stage entirely inside the firm and connected with the CEO family company as the downstream main customers and specialised complementary assets owner (R&D and productive processes based on internal knowledge). Two physicians were hired from the parent university department (training of employees based on external knowledge). The commercial function did not change much so far, because although a particular figure is devoted to this function the parent company remain the far larger customer of the ASO (internal commercial function). In this regard the parent company is awarded of a big product development product from an European call in 2004. An important part of the project is directed towards the ASO firm (internal network, therefore internal knowledge about the commercial function) in order to develop extensions of the core technology. At this time a new products development start, while the firm is getting established in the market place through the first and so far core product.

Time T₂. A new technology embedded in new products was developed mainly through the European project. The firm expanded further, in particular hiring designers and developers, coming both from the university parent organisation and from recruitment procedures (intermediate level of knowledge about the training of employees function). The R&D continue to be organised as previously, mainly based on internal skills (R&D based on internal knowledge). The productive processes require a large involvement of external knowledge compared to the previous stage where only the first core product was in production. The diversification strategy produced an important stream of feedback that produced several adaptation elements to the new products (therefore we acknowledge an intermediate level of internal knowledge in conducting the productive processes). The ASO firm also gained its own fame in the market place, developing its own network of customers, aside the always vital presence of the parent company (we therefore acknowledge an intermediate level of internal knowledge concerning the commercial function).

Findings

It seems clear that the organisational structure of the ASOs in the initial phase is very decentralised, as the literature we reviewed has shown (Teece 1996). The similarities with the organisational structure of the stand-alone laboratory are quite evident. There are low levels of vertical integration and hierarchies, possibly there is some horizontal integration given by the different skills assembled together (in our population this is mainly represented by the firms only providing consultancy services), quite a specialised scope given by the exploitation always of few and related products, and above all high dependence on the external environment. The high number of 'L' registered at this stage, over 65% of the total recorded signs, confirms these considerations. In particular upstream to the firm activities, which is mainly the R&D function, appear to be closely linked with the parent department context, registering an 'L' value in ten out of eleven firms. On the contrary, the downstream linkages appear to

still be underdeveloped at this stage, and this is explained by the seven ‘Hs’, three ‘Is’ and one single ‘L’ registered in the commercial function.

Table 2: Governance of knowledge in ASO firms at time T₀, Emilia Romagna

	t _{0,1}	t _{0,2}	t _{0,3}	t _{0,4}	t _{0,5}	t _{0,6}
R&D	L	L	L	L	I	L
Prod.	L	H	I	L	I	I
Comm.	H	H	H	I	L	I
Training	L	L	I	I	x	L
IP	L	L	L	L	L	L
Gover.	L	L	L	L	L	L
Firms No.	4	1	2	1	1	2

Moving on in time, all eleven Italian firms get to the pre-organisation phase. The businesses change significantly towards the exploitation of internal skills. However, a multiplication of different knowledge approaches is notable. A high variety of different configurations is present, ranging from structures that are based on highly internal knowledge (configurations t_{1,12} and t_{1,16}, firms ζ and λ) to configurations that are highly decentralised knowledge (configurations t_{1,7} and t_{1,9}, firms α and γ). The main finding at this stage regards the acknowledgement of a common path towards a higher dependency on the external environment in conducting the commercial function. We find that eight out of eleven ASOs register a similar combination of intermediate knowledge in carrying out the commercial function, while only one ASO (firm λ) remains linked to an internal governance of knowledge for the commercial function. This highlights the perspective towards the development of market knowledge.

Table 3: Governance of knowledge in ASO firms at time T₁, Emilia Romagna

	t _{1,7}	t _{1,8}	t _{1,9}	t _{1,10}	t _{1,11}	t _{1,12}	t _{1,13}	t _{1,14}	t _{1,15}	t _{1,16}
R&D	L	x	x	x	H	I	L	H	I	H
Prod.	I	I	L	H	I	H	L	H	I	H
Comm.	I	I	I	I	I	I	I	L	L	H
Training	L	I	L	I	I	H	H	H	I	L
IP	L	x	x	L	L	L	L	L	L	x
Gover.	L	I	L	I	I	H	L	I	L	H
Firms No.	1	2	1	1	1	1	1	1	1	1

The changes in the governance structures towards a more centralised configuration seem to indicate that a significant number of firms of the population undertake a verticalisation path. In particular, this trend is given by the internalisation of the upstream functions, which is represented by R&D and productive processes. The rest of the business activities remain highly linked to the external context.

The evolution process selects five firms reaching the following and last phase of development. Some firms did not reach the last stage, that is they did not reach a credibility point for two main reasons. One reason is the relatively young existence of the ASO and therefore the product exploited did not yet produce enough revenue to make the firm develop further along the ASO life cycle, which is the case of firms γ , δ , θ and ι . The second reason is given by the inability to get established in the market despite having been on the market for sufficient time (firms α and κ).

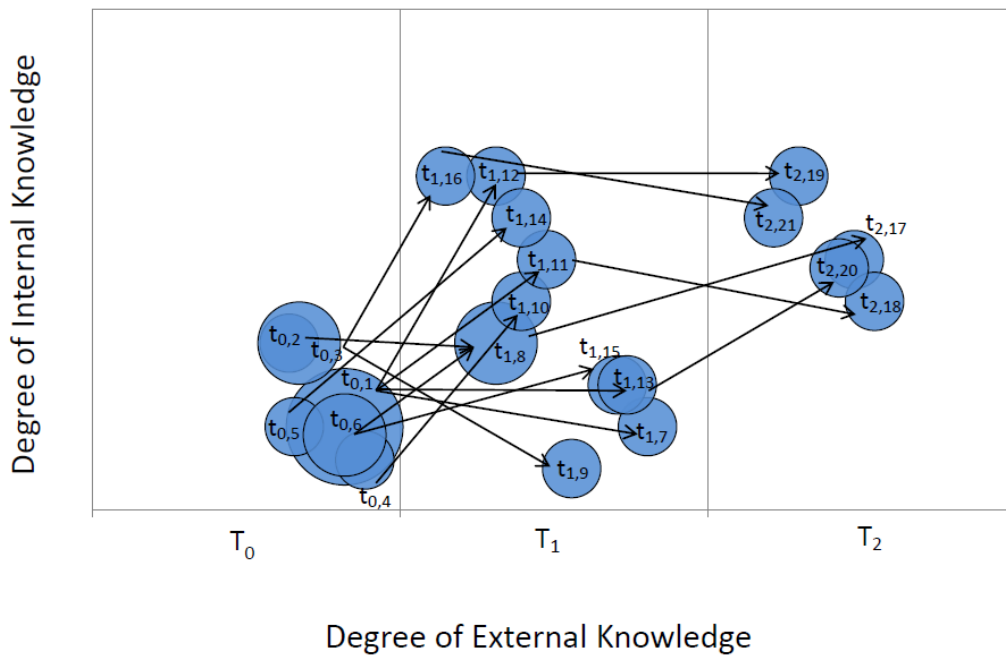
Firms reaching this phase show quite similar configurations in terms of overall combination between internal and external knowledge approaches. As expected, no firms only rely on internal knowledge for the commercial function and no firms only rely on external knowledge for the R&D and productive processes functions. Our analysis of the Italian case study seems to confirm an evolution towards a similar structure resembling the Silicon Valley-type of firm. The intermediate level of internalisation/verticalisation means that some hierarchies are present, although the firms are still flexible and open to the external environment.

Table 4: Governance of knowledge in ASO firms at time T₂, Emilia Romagna

	t _{2,17}	t _{2,18}	t _{2,19}	t _{2,20}	t _{2,21}
R&D	I	H	H	I	H
Prod.	H	I	H	H	I
Comm.	I	L	L	L	I
Training	I	H	H	L	I
IP	L	L	L	H	x
Gover.	I	L	H	I	H
Firms No.	1	1	1	1	1

The figure below – only developed for illustrative purposes – summarises what has been discussed so far. It highlights the variety of paths in which each organisational structure evolved from T_0 to T_1 , and the selection process that reduced the typologies of organisational structures from reaching T_2 . More broadly, it is an illustrative explanation of the dynamics taking place in the processes by which a stand-alone laboratory grows to become a Silicon Valley-type firm. In other words it offers a further step in Teece’s analysis of firm organisational structures, with a specific orientation in the context of ASOs.

Figure 4: Knowledge governance evolution in Emilia Romagna ASOs life cycle



The next section will repeat the same analysis to the Greater Manchester region of England in order to understand the similarities and differences between the two contexts, and to put forth some policy implications.

Greater Manchester

There are four universities in Greater Manchester: University of Manchester, Manchester Metropolitan University, University of Bolton and University of Salford. According to the HEFCE (Higher Education Funding Council for England) survey (2009), these four universities produced in total 146 ASO firm that were active in 2008. Of these 146 ASOs, 29 were spurred from the University of Salford while the other 115 were from the University of Manchester. Therefore, this clearly represents the main source of ASO in the region. The University of Manchester currently own 233 active patents (HEFCE 2009).

Although the number of active ASOs in the Greater Manchester region is known, there is not, to our knowledge, a regional monitoring tool that allows the names of all the regional ASOs to be known⁸. Internet research led to the acknowledgement of 56 created ASOs, of which just two come from the University of Salford. About twenty per cent of them were no longer active in late 2009. All the other ASOs were contacted by e-mail and telephone. Ten of them accepted to be interviewed, all from the University of Manchester. The indicators described above, and in particular the number of patents and ASOs from the University of Manchester and the universities in Emilia Romagna, seem to indicate that we are comparing two similar contexts.

In terms of policies few main tools provide support for ASO firm creation and development. First of all, at a national level, the “University Challenge Seed Fund” acted from 1999 to 2004 to provide funding rounds to business ideas that were still at such an early stage of development that common investors would not have been interested. Another very influential national initiative was the “Science Enterprise Centres”, aimed at funding the construction of 12 centres specialised in the commercialisation activities of the annexed university. Both programmes flowed into the main national third mission activities supporting tool, the HEIF (Higher Education Investment Fund). The fund is directed at universities and other higher education institutions that will autonomously manage it. A decentralised approach is notable

⁸ Nor there is, in our knowledge, a monitoring tool at the North West regional level

where universities are the main actors implementing the policies (Charles 2003). From a regional perspective, other supporting tools are present at NUTS I level. In particular, the NWDA (North West Development Agency) is the institution that manages the ERDF (European Regional Development Fund) in order to boost innovative and technology transfer activities. The salient character of these policies is once again found in the decentralisation of the designing and implementation of the projects to the Higher Education Institutions, that is universities. To this regard, the main tool that supports the University of Manchester ASO formation and development is the Umip Limited (University of Manchester Intellectual Property). Umip is a private company entirely owned by the University of Manchester with the aim of managing the university IP and providing management supporting tools for ideas of business. Umip also has a VC that funds selected projects. But the main supporting tool of this private TTO is represented by the usual involvement of one figure, always with an industrial background, into the valuable ideas of business. When academic staff wants to investigate the possibility of commercialising some research outputs, Umip is contacted and a person is designated to evaluate the project. By positively evaluating the project, the Umip representative takes part in the company's shares and therefore takes an active managerial role that is also motivated by direct incentives.

Our empirical analysis of the Greater Manchester region should have been based on interviews directed to both the University of Manchester and University of Salford ASOs. Unfortunately, the only respondents to our calls were ASOs from the University of Manchester, that is by far the most representative university of the region. Our Greater Manchester ASO population can be therefore considered a self contained population, because all our interviews come from the same environment. Let us now move to the brief descriptions of the ten Mancunian ASOs.

Firms development description

Firm α

Firm α is active in the building services sector and currently especially concerned with energy issues. The firm has two main activities: software production and provision of consultancy services.

Time T_0 . In 2001, the founder started a postgraduate course in physics. During his master's he developed a new and interesting software package. He then enrolled on a second master's course in 2003 on building and running businesses. During this second year of postgraduate studies the feasibility of the technology was tested and an academic professor took part in the team. The ASO was established in 2004 with public grants being raised, with the help of the academic figure involved, in order to further develop the technology and to further test the commercial value of this new product. The founder was the only person involved in developing the product at this stage, although his scientific background, and especially the physics department, considerably influenced the early development of the technology (internal productive processes and intermediate R&D). The professor took an active part in this phase because his role was fundamental in order to obtain the grant (factor indicating commercial function based on internal knowledge) and to find the first appointed figure (training of employees based on external knowledge), a part-time sales director. Taking part in some exhibitions also developed the commercial side of the firm. In particular, the first exhibition was in 2004 and ended with a year of orders (factor indicating commercial function based on external knowledge). As a result, the two factors 'cancel each other out' and we recognise an intermediate level of knowledge to carry out this function). The IP issues were managed through consulting services (IP issues based on external knowledge). Copyright was the most important issue for the ASO as software is not patentable in UK.

Time T_1 . The first flow of orders produced a considerable amount of revenue for business growth. A reorganisation of the firm took place at this point. The current sales and marketing director moved to the position of managing director (internal knowledge

of productive processes), and a new sales and marketing director was hired from the industrial world (external knowledge for the commercial function). A new chairman of the business was appointed, whose background was in a VC company, because the ASO needed a figure who could drive the growth of the firm. The former chairman (the academic professor) moved back to his academic role as he was not able to carry out both positions at the same time. Two software developers were also appointed (these two figures represent external knowledge of ASO R&D function, which combined with the internal knowledge from the founder, leads to the acknowledgement of an intermediate degree of internal knowledge for this function). The people appointed in this phase partly came from the previous network assets of the founder and partly from standard recruitment procedures (intermediate knowledge of the training of employees activity).

Time T₂. The ASO saw a gap in the market created by a new law approved in the UK and decided to move in that direction by developing an extension of the product they were already producing. Basically, in order to show that a building complies with UK law, an energy certificate has to be produced. This certificate can only be released by accredited software and firm α was the first company in UK to be awarded accreditation for this software. The temporary monopoly lasted six weeks, in which firm α was the only company able to release this certification and this ended in significant revenues and leadership in the field. Moreover, an institutional body, still in late 2007, asked the ASO to offer training related to this software. Many engineers were trained by the ASO, and this led to the development of a consultancy service *per se* inside the ASO, which now involves more than half of the company staff and produces the lion's share of the profits. The consultancy service function also gave feedback to the R&D and productive department of the firm. Moreover, a new VC fund was secured by the sales and marketing director in 2009, in order to direct the R&D towards the development of a further extension of the core-product (commercial function to be considered based on an intermediate degree of knowledge, because of the combination of the internal knowledge given by the sales and marketing director and the external flows of knowledge coming into the firm from the consulting services; similarly the productive processes are considered based on intermediate knowledge because of the combination of the new consultancy services external knowledge with the knowledge provided by

the already present engineering team producing the software; training is considered external; R&D becomes based on internal knowledge as no new figures or events had a significant impact on it).

Firm β

Company that produces software to manage the various stages of course assessment in universities, schools, and all other professional educational bodies.

Time T_0 . A research project started in the computer science department in 2000 with the aim of investigating software technology to electronically manage course marking and assessment procedures. In 2004, the academic team ran out of funds to further develop the technology and went to the Umip offices to find out how to obtain funding by commercialising the idea. As standard practice, Umip assigned someone to evaluate the project. The outcome was positive and the conclusion was that the best way of going to market was to create a venture in order to further develop the product/technology, which was still at an early stage. The ASO took place in 2004. At that time, the university team saw the commercial potentiality just as a way of getting further funding to continue the research project that had begun several years earlier. The company therefore took place with considerable assistance from the Umip figure taking care of the marketing side of the product. The company was formed by two scientists and the Umip representative (training of employees based on external knowledge). The Umip representative was immediately able to raise a small amount of money, thank to his personal networking assets, in order to test the market potentiality of the product (commercial function internal). This initial market investigation determined the direction the firm should focus the product development. The firm was still carrying out the research and productive processes at the university laboratories (R&D and productive processes based on external knowledge). IP issues were investigated through external consulting (external knowledge). Software cannot be patented in UK and protection is mainly based on secrets and copyright.

Time T_1 . An important investment fund (from a private investor who resembled a business angel) was raised quite early on, thanks to the Umip figure. Some Ph.D fellows

were given funding (R&D intermediate because of the combination of the external knowledge from the Ph.D students and the internal knowledge from the two senior academics); the firm is still run inside the university premises (computer science laboratories) and two developers from the parent organisation were hired by the company (productive processes tending to be based on external knowledge because of the location in the computer science laboratories; training based on external knowledge). A huge telemarketing research project was financed with this funding to understand who the potential customers could be and to receive feedback in terms of product development. This was also a difficult process in terms of understanding who should be referred to inside universities or large educational bodies and how to establish which steps were need for the product to be approved, which is usually a complex path due to the rigid organisation of state bodies (intermediate commercial function because of external knowledge provided by market research and because of internal knowledge provided by Umip figure). This research was outsourced to two external companies that were easy to find in the market place (generalised complementary assets; strength of the external character of knowledge for productive processes). Consequently, the ASO selected 50 to 70 organisations that had explored the prototype of the technology more deeply and that gave various feedback in order to decide how to further direct the R&D team in the technology development. Finally seven trials were planned for late 2009, early 2010. Now the mission is to continue the growth path but to remain a small firm, which will sell the licence once the market is ready to be mass customised by big companies. IP issues are now becoming more important, but, like before, mainly managed by consultants (IP externally managed): the firm is filing software patents in EU and US, where possible.

Firm γ

Firm γ works in hardware supports, in particular concerned with the designing process of microchips to manage very complex data.

Time T_0 . Firm γ can be traced back to a public research grant that a professor of the computer science department started in the late nineties. The company was formed in

2000. The catalyst of the formation of the company was a contact the professor had with an old friend working in a VC. This friend (from now on referred to as H.) decided to invest half a million pounds in a very blue-sky research project, not through the VC he was managing that would not have been interested in investing technology at such an early stage, but from a personal investment fund. The person interviewed – the founder professor– affirmed that the company was formed specifically to take H.’s money and use it to provide additional funding for research while setting up a vehicle that the IP could own and manage. There was no short-time commercial perspective at the time and the company is still not trading today. The ASO never hired any employees and still run in the parent organisation premises. Another figure plays an important role in the company: it is the University of Manchester representative that has been “dragged into” the company due to his friendship with the founder (external training of employees; commercial function based on internal knowledge, due to the presence of this figure in the team before the ASO constitution). The role of this figure has been mainly about dealing with H. for additional money and to keep the IP protection moving. The company raised other four rounds of investment of approximately the same amount. The R&D, and to a lesser extent the productive processes, are therefore supported by the financing of Ph.D and post-doctoral fellowships operating in the department rooms (R&D based on external knowledge). In order to move the research on, patent issues are very important. The company is able to use patents of other companies because they are used inside universities and are only for research purposes. The companies that own the patents represent the complementary assets owners, which we can consider to be at least specialised because the process of negotiation with them is complicated in order to obtain access to the patents. The patents of the ASO are filled with the help of external consultants (IP managed externally; productive processes based on external knowledge because the presence of the university representative dealing with the IP moving function that is one of the main mission of the ASO as a company, and because of the specialised complementary assets owners that provide access to compulsory knowledge).When the company becomes commercial, it will need to renegotiate all the license agreements with those companies complementary assets owners.

Firm δ

The firm concentrates on developing and designing software for chip complexity management. The technology provides size and cost reductions in electronic systems.

Time T_0 . A group of researchers at the Computer Science department of the University of Manchester developed an innovative technology to manage chip complexity in a long path started in the nineties. In early 2000 a group of young members of the research group were very keen to start-up a company to exploit the research output and they were confident in the potential value of the innovative technology. This group, led by one figure that will be the CTO, concentrated on the procedures to set up an ASO in 2001, when they were still working as researchers at the university. The ASO was formed in 2003 to develop the technology and make it marketable. It was formed by five members of the research group and the professor leading the group at the department. Initially, the business ran from inside the university (external R&D and productive processes; we can consider the training of employees external as the company was set up by a considerable number of former department staff). The commercial function was not taken into high consideration at this stage and was mainly based on the previous network of the professor involved in the business, who at this stage set the basis that would lead the company to get an important investment fund from a VC in the next phase (commercial function based on internal knowledge). IP issues were investigated by external consultants who concluded that there were no possibilities of patenting software and the *industrial secrets* representing the main protection mechanism. The IP will mainly concern copyright issues and will continue to be managed through consultancy services.

Time T_1 . A big investment from a VC was reached a few months after the formation of the firm, thank to the previous network of the professor involved. The first step involved the hiring of a CEO through executive recruitment (intermediate commercial function from the external knowledge brought in by the CEO and the internal networking assets that led to obtainment of VC fund). The new CEO was located in US and a second division of the company, the downstream side, took place in US. A few engineering graduates were also hired but it was a secondary labour force compared to team that was already established (training of employees and productive processes within the firm). The firm moves from the university premises and the CTO of the ASO

is still the same (R&D based on internal knowledge). The product development took longer than expected and the first product needed more than two years to get into the market place. Complementary assets owners of the specialised type are present. They are big semiconductor companies owning the standard on which the technology need to be built. It is therefore essential for the ASO negotiating with them to work on those standards, in order to be to embed the ASO-core-technology in them (strength in the external character of the productive processes).

Time T₂. The first product generated the first revenues, but the technology was still not highly profitable. The growth path continued and in 2008 the firm staff reached 25. The R&D team continued to be directed by the same CTO (R&D based on internal knowledge). A new tournament of appointments was experienced in this third phase, where the company tried to assume a more structured character. A sales and marketing director was hired in US and some more experienced engineers were hired in UK where the technology development base was set (training and commercial function based on external knowledge; productive processes based on internal knowledge for the former team and on some external knowledge brought in by the new experienced engineers). The complementary assets owner issues were always present (productive processes mainly considered external because of the complementary assets owners element).

Firm ϵ

The core technology of the firm is a mathematical algorithm for process control, and the core product is software for monitoring applications and control systems

Time T₀. In the eighties an Electronic Engineering professor developed a mathematical algorithm for process control and a new venture was created (from now on referred to as P.) at the time in order to apply the technique to industry. The technology was working well and in the mid-nineties the business was sold to a big industrial automation company (from now on referred to as I.). The research group continued working on next generation software in partnership with I. for some years. However, in 2001 I. was no longer interested in supporting the collaboration because of some strategic change. A new venture was therefore created in 2002 by two academic professors of the research

group and a person coming from I. as managing director, who was not happy with the new strategic approach of I.. They had enough industrial support in terms of jobs and feedback from external companies, provided by the managing director and academic network, in order to keep the company alive while finalising development of the software (internal commercial function from previous network of founders). The company was run from university premises. It was formed, concerning the R&D and productive processes, by the academics, and four other people, two post-doctoral students from the research group and two engineers from I.. The two post-doctoral researchers were financed by a national grant. These four people spent much of the time onsite at external partner companies in order to test the product (R&D and productive processes based on external knowledge as they were carried out in the university room, influenced by 20-30 years research at the School, and conducted in strong collaboration with external companies; external training of employees as new employees from the research group department or from I.). A less important patenting activity was carried out through external consultancy (IP issues based on external knowledge) because algorithms are not effectively protectable.

Time T₁. One of the professors, in the role of chairman and also a founder of P., left the ASO in 2004 and a new chairman was appointed. This new figure was known both by the professors and by the manager coming from I. but was found through executive recruitment. Initially, the company thought it would produce and sell software as the core activity, but during this phase the team realised the importance of developing a side service-consultancy business, in order to get more feedback from the industrial world. The consultants hired were mainly from the School of academics (training based on external knowledge). Most of the company revenue and new orders came from the new consultancy services (factor representing external knowledge for the commercial function). The need to grow moved the company to find a new and bigger investment tournament. An internal human resource was the main vehicle in order to get VC investment in 2005 (internal commercial function: an intermediate commercial function is acknowledged in this phase because of the combination of this element and the previous one). The VC investment was directed towards the expansion strategy. A software developer that used to work for P. was appointed: the aim was to put a person who knew about the history of the technology in the R&D department (R&D based on

external knowledge; productive processes based on external knowledge because they were significantly influenced by the consultancy services).

Time T₂. In approximately 2005-2006 the ASO was awarded another regional initiative grant. This grant was used to expand the business in terms of products. One of the partners of the ASO was also a pharmaceutical company and the ASO followed the idea of applying the technology to the pharmaceutical sector. In order to move in this direction, a large amount of research was carried out, and the research group at the School was the main driver behind this research for the first couple of years. Then, once the new technology application was developed in the early stages, the R&D function returned to the company (R&D intermediate). Long acceptance processes were needed by the pharmaceutical sector to be affected by new techniques of process control and lots of work in conjunction with the pharmaceutical partners was needed to develop a suitable product (these companies represent complementary assets owners and give a first external character to the productive processes). Concerning the other activities, the company was organised as it had been previously, therefore an active commercial role continued in the consulting services (external commercial function) and the already established R&D and productive processes were established as before (productive processes based on intermediate degrees of internal knowledge, given by the sum of the internal character of the consultants and engineers with the external influence of the pharmaceutical companies complementary assets owners). Also the training of employees function did not change (external) as the main source of new human resources was the academic research group, that was often putting in contact the ASO with the best students coming out from the teaching side of the School.

Firm ζ

Molecular diagnostics concerned with respiratory fungal infection.

Time T₀. The idea of creating a business did not directly result from academic research, but from the acknowledgment of a clinical need. A professor at the Medical School recognised the possibility of a better and quicker diagnostic of fungal infections. Umip was part of the company when it was created, but its involvement at this initial stage

was quite marginal. The academic professor and the Umip representative had some contacts in order to raise some initial money to make a business plan and to set up the firm (internal network that is based on internal knowledge of commercial function). The professor had already been part of a new venture creation in the past (internal entrepreneurial skills). The company was established in 2006 and initially operated from the university labs (R&D externally managed because it is within university). The firm was supported by an IP and a technical consultant right from the start (IP issues based on external knowledge; productive processes were partly based on external knowledge imported by the consulting technician and partly based on internal knowledge regarding the entrepreneurial skills already available within the team: productive processes based on intermediate level of internal knowledge). There was no training of employees at this stage. Already in the initial phase the ASO was able to secure a VC type of investment fund from a big pharmaceutical company. Consequently, the networking assets of the professor acted as a main driver for the investment obtainment (strength of the internal character knowledge in the commercial function).

Time T₁. With the investment , the company moved from the university laboratories . Some people were hired and different divisions within the firm were set up in less than two years, which included: R&D, development, manufacturing processes, clinical trials and marketing & finance. In 2008 and 2009, two more investment tournaments were raised but they were not as important as the previous one. Up to this point, three products have been produced, but revenues were not enough to finance the company and to continue in the research and development. New investments appear to be needed. Now the company employs approximately 20 staff. All the employees found by national recruitment practices and they all already had some work experience when appointed (training of employees based on intermediate knowledge). The R&D was conducted mainly inside the firm locals (7 people involved in this function inside the ASO), although the company also collaborates with some universities (not specifically University of Manchester) (R&D considered to be based on external knowledge because new people were involved in this function and because of considerable collaboration with various university departments); the manufacturing function was conducted by five people in the company with the support of several partners, mainly found through

advertising (productive processes based on external knowledge). In the marketing function there were three to four people coordinated by a sales manager, who was hired in the first half of 2008. The ASO also organises several activities like focus groups and other events (commercial function based on external knowledge). Patenting activities were always performed through consultants (IP issues based on external knowledge).

Firm η

Design and production of breakthrough printing technology

Time T_0 . In early 2000 a British company funded a research project on a new printing technology, to a professor and his research group. In 2004 the company reorganised the business and decided not to remain in the electronic market any longer. The University of Manchester, represented by Umip, evaluated the project and decided to buy from the company the patents and IP rights developed during the collaboration between the research group and the company. Additionally, they decided to support the creation of an ASO with the aim of further developing and commercialising the technology. Umip participation led to some funds being raised to write a business plan and set up the ASO (commercial function based on internal knowledge). The company initially was run from the university lab (R&D based on external knowledge). The business took place in June 2006 and concentrated on the R&D functions with no operative activities. The company was only comprised of the professor and the Umip representative with the role of business manager. In early 2007, the Manchester Technology Fund and a private investor joined the ASO shareholders with an initial investment. MTF and the investor were found due to connections the professor and Umip representative already had (confirming the internal character of the commercial function). The initial funding tournament led to the operation activities taking place. Some people in the professor's research group were financed and, at that time, the business was still running from inside the research group laboratories (productive processes based on external knowledge). The employed staff were all from the professor's research group (training based on external knowledge). The IP issues were external because they were managed by external consultancy services.

Time T₁. In early 2008 the ASO expanded the commercial team and recruited an expert CEO (commercial function based on external knowledge). His role was to build a commercial strategy that could sustain the company through further investment rounds and realise an exit for investors. By mid 2008, another investment fund was reached from the same private investor and Umip. The company left the professor's laboratories and got a room in the Incubator of University of Manchester. More people were appointed: six technicians were operating in the company at that time and in early 2009 an expert managing director was appointed (productive processes based on external knowledge). However, the R&D function continued to be based inside the university research group due to the funding of four research assistants and two post-doctoral students (R&D based on external knowledge). The commercial function was increased not only due to the appointment of the CEO, but also due to the organisation of regular national and international conferences and events (commercial function based on external knowledge). Almost all the new people appointed in the R&D and in operational functions were coming from the professor's research group (externally trained employees) and IP continued to be based on external consulting.

Firm θ

Business psychology company producing specific software and offering consultancy services

Time T₀. The university mentality in favour of third mission activities was influential and two psychology professors had the idea of starting a company (in approximately 1997) before knowing exactly what the core-business activities would be. Nevertheless, the idea of producing some product packages had always been in the mind of the founders. The ASO took place in 1999, with the aim of conducting consultancy services for a few years while understanding what to focus the business on and to decide what the core business should be. The previous network of the two professors would have guaranteed some jobs to keep the company alive (commercial function based on internal knowledge). Umip made a small investment at the very beginning in exchange for company shares. This investment led to the appointment of a managing director and two

psychologists (productive processes based on external knowledge). All of them came from the research group of the two academics involved in the business (training of employees based on external knowledge). The R&D bringing to the business idea was the one the two professors had been doing for many years in the university (R&D based on external knowledge). The IP issues at this stage were mostly related to copyright and were managed externally.

Time T₁. In 2002 a product developer was appointed and in 2002-2003 a new investment fund from the MTF was secured with the mission of expanding the business. This figure firstly led the company to buy software that already existed and then to a collaboration with an external company for the development of an innovative learning package (productive processes based on external knowledge as the product developer is the main vehicle to the partnership; moreover the production processes were carried out in partnership with external companies). A third professor was contacted in London through advertising procedures and he became part of the company in order to develop the consultancy services in the London area. The consultancy services at this stage were still done in order to increase cash flows, but mainly in order to produce feedback to the IT product developer team, which was still made up of only one person (another factor of external productive processes; the feedback influences represents external knowledge for the commercial function). An exhibition was also organised to received more feedback in terms of market needs (commercial function based on external knowledge as feedback came from both the consultancy services and the exhibition). The R&D remained based on the research done in the university, mostly, but not only, by one of the professors (R&D based on external knowledge). Training became less related to the academics research group and moved towards more advertising practices (intermediate level of knowledge in training of employees). IP managed externally with the software partner companies.

Time T₂. Although up to this point revenues had increased as expected, this did not happen in 2004. Moreover, at this time the company still lacked a clear aim because the positive stream of revenues dilated this focusing process. The unexpected fall in profits of 2004 therefore caused the business to be reorganised. This benefited from the learning acquired in the previous years of activities. A core business activity was

defined and the growth of the firm should have followed that path. The managing director, the same from the beginning, decided to leave the role and moved to the head of the consultancy team in Manchester. The newly appointed managing director was an internal resource: one of the two academics, not yet deeply involved in the ASO activities (productive processes based on internal knowledge). Moreover the IT section of the firm increased and was driven by the same product developer. Some new software products were developed internally (again productive processes based on internal knowledge). The R&D is now concerned with both IT and psychology. The IT is internally managed but derived from the external academic knowledge for psychology (R&D therefore based on an intermediate level of knowledge). Training and IP issues did not change (even though IP was not shared with other companies at that time, they were nevertheless managed externally). The commercial functions continued to grow and events, conferences and other initiatives multiplied; research and marketing optimisation tools were put in place, like the creation of a network of people and organisations that currently represents the main channel for new customers (commercial function based on external knowledge).

Firm 1

Drug development company that produces small molecule aggregation inhibitors especially for Alzheimer's.

Time T_0 . A professor (from now on referred to as D.) of the University of Manchester had been studying inhibitor molecules since his Ph.D at Stanford University. He moved to University of Manchester in the early nineties. At the time he was undertaking some pure research with any application in mind. However, some years later he arrived at the point that the technology he was developing could have important implications for Alzheimer's. In 1997 he published a paper on his research findings. This paper was influential and led to some research grants that allowed the funding for a Ph.D student to work on it. In approximately 2000, two more papers on the topic were published by the research group and they were noticed by a chemist (from now on referred to as Dr T.) who was working for a big pharmaceutical company. Dr T. put himself in contact

with professor D. saying he had arrived at the same research findings and he was going to patent the further development of the results. Dr T. invited professor D. to join him and form a company. The professor agreed on the project and the two started a University of Manchester ASO in 2001. The two set up the company together. Dr T. had the entrepreneurial and management skills, while professor D. already had two Ph.D students working on the R&D side of the product (R&D based on external knowledge, in the university laboratories). For the first two years the firm was run from the professor laboratories (productive processes intermediate, given by the external knowledge for the university as the company was run from within it, and the internal management and entrepreneurial skills from Dr T.). Through Umip contacts, the ASO secured its first big investment from a big VC company (internal network, so commercial function based on internal knowledge). There was no training of employees at this stage. IP issues were very important and managed externally.

Time T₁. The first fund led to the growth of the company and gave it some structure. Dr T. was the first employee of the company. The company transferred from the university and two researchers were hired through normal advertising procedures (training based on internal knowledge, up to this point). The R&D was still greatly influenced by professor D.'s research group (external knowledge influencing R&D). Drug discovery needed several phases of tests and all these out-of-the-core activities were outsourced (productive processes based on external knowledge). A director was appointed from the industrial world (again confirmation of externally based productive processes), and he was found by the VC network assets (training of employees based on external knowledge in this case, that led to an intermediate level of knowledge for training employees). Another round of investments was secured in 2004-2005. Again the internal networking assets were the main determiners of this (commercial function based on internal knowledge) and its objective was to keep the patenting and trials activities moving until the technology was further developed, to the point that it could be sold to a large pharmaceutical company.

Firm κ

Designing and production of monitoring systems for water utility and waste management companies

Time T₀. In early 2000, a water utility company granted a research project to the School of Chemical Engineering to develop a cost-saving monitoring system. The partnership between the company and the research group ended in the first half of 2000s and the professor leading the research group saw the possibility to commercialise the technology. He went to Umip and in 2006 the ASO took place as a virtual company because only the professor and the Umip representative were part of it. The technology was not ready to be commercialised with a license and a new venture creation way of exploitation was chosen. The company is currently still running in the professor laboratories and the R&D that led to the technology development was the output of 20 years of research (R&D based on external knowledge). The product value added was in the assembling procedures of different hardware devices that already existed on the market and the supporting software that makes the hardware assemble work. Concerning the productive processes many prototypes and tests were done in the development phases of the product. At the very beginning, before the company was set up, the assembling was done inside the professor laboratories. Very soon, roughly at the ASO generation moment, an external company took care of all the assembling procedures, leaving the testing phases to the professor. It is a complementary asset owner that took care of all the out-of-the-core procedures. Recently, also some testing phases were moved to the complementary company, while the interpretation of the testing results remained in the ASO as they represented analysis that depended on the 20 years' know how (productive processes based on external knowledge). There are no employees at this stage, although there is the plan to hire three full time employees after the first investment, which is due in early 2010. The ASO already has customers: mainly water companies but also other organisations that need special monitoring systems, for example, systems to reduce fuel waste. The commercial function is conducted by the Umip representative that has participated in to several conferences and, also by web advertising, has found some partners and customers. From these connections, important feedback has lead to new development paths being faced. The previous professor network is still important in this commercial phase (commercial function intermediate). IP issues have been externally managed. Technology is not

easily patentable and the secret and the tacit component appear to be the main protection mechanisms. Copyright has been secured.

Findings

In the first phase of the ASO life cycle we notice five different configurations. All of them are mainly carried out by relying on external knowledge, and, similarly to the Italian scenario, the commercial function is the only function at this time that is never based on external knowledge. In eight firms out of ten, the commercial function is based on the knowledge of some internal resource, usually on the Umip figure or on the previous academic network. Conversely, in nine out of ten firms, the R&D function is carried out through knowledge that is external to the firm. Similarly IP management is always based on external knowledge.

Table 5: Governance of knowledge in ASO firms at time T_0 , Greater Manchester

	$t_{0,1}$	$t_{0,2}$	$t_{0,3}$	$t_{0,4}$
R&D	I	L	L	L
Prod.	H	L	I	L
Comm.	I	H	H	I
Training	L	L	x	x
IP	L	L	L	L
Gover.	L	L	L	L
Firms n.	1	6	2	1

Out of the ten firms taken into consideration at time T_0 , eight pass to the next phase. Two firms of the initial population are still in the first phase. One of them (firm κ , configuration $t_{0,4}$) was established in 2006 and is waiting for initial investor funding at the beginning of 2010 that will lead to the employment of three full time individuals and will give it the opportunity to grow, while the other one (firm γ , configuration $t_{0,2}$) started in the early 2000s but was mainly generated as a vehicle to invest in a blue-sky

research project and signs of commercialisation are still far off. In this last case, the ASO represents a tool that is able to flexibly secure private investments and manage IP rights in the long run.

Out of the eight firms we notice six different configurations at time T_1 . Only one firm (firm δ , configuration $t_{1,7}$) relies mainly on internal skills to carry out the identified functions. However, following the next evolution of this firm, it moves towards a more decentralised organisation in the third phase. All the other seven firms show a decentralised mode of organisation of knowledge. This means that although there are differences in the governance of knowledge of the different functions, a closer route of evolution of the Mancunian ASOs is noted compared to the Italian ASOs. In other words, if we look at each business activity individually, we would argue that the ASO approach to the selected function is highly variable in the studied population (except the IP issue function). Conversely, if we look at the overall knowledge governance approach, we notice that at stage T_1 the organisation of knowledge is externally based for all firms but one. The decentralised knowledge governance tendency is very evident. Two firms approach all the functions externally (firms ϵ and η , configuration $t_{1,8}$) and two firms only approach one function not externally, which remains based on an intermediate level of internal knowledge (firms ζ and θ , configuration $t_{1,9}$).

Table 6: Governance of knowledge in ASO firms at time T_1 , Greater Manchester

	$t_{1,5}$	$t_{1,6}$	$t_{1,7}$	$t_{1,8}$	$t_{1,9}$	$t_{1,10}$
R&D	I	I	H	L	L	L
Prod.	H	L	H	L	L	L
Comm.	L	I	I	L	L	H
Training	I	L	H	L	I	I
IP	L	L	L	L	L	L
Gover.	L	L	H	L	L	L
Firms n.	1	1	1	2	2	1

Moving to the last phase of development, a selection process takes place and four firms gets to time T_2 . Three of these four firms (firms α , δ and ϵ) show a decentralised knowledge governance, while one (firm θ) shows an intermediate configuration ($t_{2,14}$).

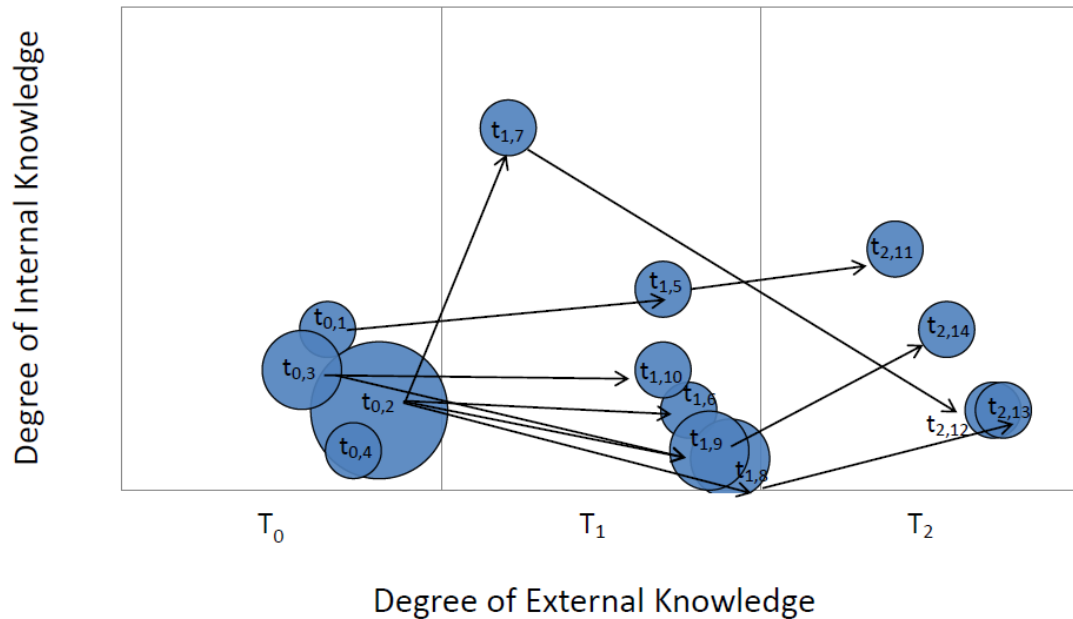
In this final phase, we notice some common approaches not only in the overall governance of knowledge, but also intra-function. In particular, similarly to the Italian scenario, the tendency in to move towards internal management of the R&D function, which is less and less based on the edge research of the university, and to move towards external knowledge influence to carry out the commercial function.

Table 7: Governance of knowledge in ASO firms at time T₂, Greater Manchester

	t _{2,11}	t _{2,12}	t _{2,13}	t _{2,14}
R&D	H	H	I	I
Prod.	I	L	I	H
Comm.	I	L	L	L
Training	L	L	L	H
IP	L	L	L	L
Gover.	L	L	L	I
Firms n.	1	1	1	1

However, some differences between the two contexts are notable regarding the upstream functions, represented by R&D and productive processes. While in the Italian scenario R&D and productive processes tended to move towards a centralised knowledge governance approach from time T₀ to time T₂ in almost all firms, in the Greater Manchester scenario this trend is much less evident. Our analysis showed that productive processes in particular, appear to be approached by English firms at time T₂ much more on external knowledge compared to Italian firms.

Figure 5: Knowledge governance evolution in Greater Manchester ASOs life cycle



Summing up, on one hand the Greater Manchester analysis confirms our conjecture, and on the other it reveals a more standardised approach to the evolution of ASO firms, if compared to the Italian scenario. It is therefore possible to argue that the routes followed by different ideas of business to get to a venture established in the market appear to show a significant rate of variety that led to the acknowledgement of the limits of the shared in the literature assumption that the transformation path is unique. However a common approach to decentralised modes of knowledge governance is acknowledgeable in each stage of these ASOs life cycle.

Conclusions

As mentioned above, the Mancunian context reveals less variety of paths if compared with the Italian situation. It could be asserted that Mancunian ASOs follow a more standardised development route than the Italian counterpart population. It is arguable that the initial and the final configuration of the two populations are quite similar, while

significant differences are present in the middle stage of development. Let us now face the comparison in more detail.

The similarities between the two contexts are especially present in the first phase of development, when the ASOs have just been created and resemble the stand-alone laboratory type of firm. The firms are highly decentralised especially for what concerns the upstream functions and are somewhat based on internal knowledge in undertaking the commercial function. In the third and last phase, in which firms should be like the Silicon Valley-type of firm, the two populations appear to be structured quite similarly, although the Italian group relies more on internal capabilities than the English counterpart, which continue to organise themselves in an organisation that is slightly more based on external knowledge. How can these differences be explained? A possible answer to this question is the different approach to the ASO business in Italy and in UK. While Italian ASOs are often created in order to form a durable and probably family-style business, the English ones are created in order to make money and with the clear objective of selling the business to a big company in the near future. This was revealed in the conducted interviews. While only one Italian ASO talked about merger or acquisition for the future (but not of selling the business), all but one English ASO expect to sell the business to a big multiproduct company. It is not by chance that the only English firm to not put forth this idea is the configuration $t_{2,14}$, the firm with the most internal knowledge based configuration of the four firms reaching the last phase of development. In other words, if the idea of business in the future is to maintain the ASO on the market place, the development of some internal capabilities could represent a requirement for the growth perspective, while if the mission is to get to a profitable license as soon as possible, it may not be worth investing in the development of such internal capabilities.

The main differences in the two contexts, as anticipated before, are encountered in the middle phase, which means that the main differences between the two populations are acknowledged in the ways of developing a business idea to an almost established firm. In this phase we notice a high variety of different combinations of external and internal knowledge for the firms to carry out the functions in the Italian context, while with the English firms we notice a prevalence of approaches based on external to the firm's

knowledge. If we look at the intra-function differences it is arguable that both contexts show a significant variety of paths, while looking at the overall combination of external and internal knowledge the Mancunian ASOs appear to remain based on high levels of external knowledge throughout their life. Again the expectations of the future of the business could represent a possible answer to these differences. Italian ASOs make trials to understand the best way of approaching a business, while English ASOs just need to develop the technology up to the certain point in order to be bought by a big company, therefore relying on external knowledge as much as they can and investing as little as possible in building capabilities, which is recognised as a slow path (Henderson 1994). Another possible answer to this question could be represented by the past experience of the two contexts in dealing with the ASO phenomenon. It is acknowledged in academic literature that Anglo-Saxon countries started to pay attention to the ASO phenomenon in earlier stages than other European country. The greater experience of the English context, compared to the Italian one, in dealing with the ASO practice led to a more standardised way of developing the business ideas into commercial products, which is reflected in more similar paths of development.

The analysis also led to some policy implication considerations:

- Acknowledging the existence of different stages of development can lead policies to focus not only on providing determinant factors, but also to focus on the different needs relating to various stages of ASOs life cycle. For example, firms that reach the third phase always show a commercial function that is based on external knowledge. Acknowledging the need for firms to develop a commercial function based on external knowledge in the second phase of development, could help ASOs reach the third phase.
- The comparative analysis shows that different contexts illustrate different paths of ASOs evolution. This leads to the acknowledgment of the importance of a specific context when designing innovation policies. For example understanding and then taking the long-run goal of Italian ASOs founders into account could represent an important advantage for policy makers in designing specific regional policies and in trying to identify the possible hidden needs of some distinctive ASOs.

This related work to the topic of academic spin-off firms, showed that the process of firm development is usually not considered by economics and management literature. This work sought to move a step in this direction. Moreover, it is also essential to overcome the static and incomplete character of the main firm theories adopted by the literature. This occurs by concentrating on knowledge flows taking place both within and across the firm in various stages of development. The analysis showed that taking into consideration the development process of firms, leads also to grasp some limits of the average policy. These limits are related to the static nature of policies usually aimed at providing a context with some predefined factors and to the absence of the context specificities consideration.

Conclusions

The emergence and diffusion of Academic Spin-offs (ASOs) has been rather common across most Western economies over the last three decades. This is a testimony to how the boundaries and the content of business organization have changed under the pressure of global competition and, in turn, as a response to the need to develop ever-more specialized knowledge assets. From a policy perspective the existence of ASO firms bears upon the process of local economic development via a multiplicity of mechanisms such as the transfer of knowledge from university to the market, positive localized externalities, and, related to the former, the provision of stimuli that enable or facilitate innovative and entrepreneurial potential locally (Etzkowitz 2001).

This thesis has sought to analyse the development paths followed by ASO firms throughout their life-cycle and to compare two different samples of ASOs in their development. It has been noted that on the one hand the ASO's organizational structure in an early stage of the cycle resembles the stand-alone laboratory of Teece's (1996) taxonomy; on the other hand the description provided by academic literature refers to a Silicon Valley-type of firm. Our research, in line with the work by Vohora et al (2004), has sought to fill the gap between these two extremes and to describe the paths that an ASO follows from one archetype to the other. We investigated the issue by finding out whether some basic functions were conducted mainly internally or externally to the firm; in other words we tried to capture the prevalence of internal versus external modes of knowledge governance adopted by a firm to undertake some fundamental business activities at different stage of the ASO firm development, with the two extremes being the stand alone laboratory versus the Silicon Valley-type of firm.

The empirical analysis had two main outcomes: first of all our main conjecture that the process of ASO development is not unique or does not follow a dominant route has been confirmed and secondly different trends have been observed in the various contexts investigated. Regarding the former, the analysis indicates a variety of different paths in terms of organizational structure, that is in terms of knowledge governance, that the ASOs have followed throughout their life cycle. The empirical work conducted rejects the notion that the transformation of a stand-alone laboratory into a Silicon Valley-type of firm follows a dominant, or unique, route. Rather, the factor bias of each firm shapes a specific path of growth and development. The various paths are likely to be different for the entire population and at times will overlap. Finally and most importantly, not all firms reach a mature stage in their life cycle; for those that do, we observe a reduction in the variety of organizational structures. It appears that ASOs undergo certain selection processes.

In other words, both the beginning and the end of the stylised life cycle therefore feature a relatively lower variety of organizational knowledge and of governance structures: the same Penrosian resources at the two points in time, differently combined in terms of internal versus external knowledge, entail different organizational structures. Our work therefore adds to the framework elaborated by Vohora et al. (2004) on the development paths of ASOs: by proposing a richer articulation of the development paths that are possible in the life cycle of the firm.

The work has also referred to the knowledge governance modes in place in different points in time of the ASOs development path. To this regard it has been noted that at an early stage a new firm needs to be closely connected to the environment in order to be able to coordinate the knowledge useful for the business activity. While upstream linkages with the parent organization are strong at the beginning, downstream linkages need to be developed during the life cycle. These linkages are very important because of the knowledge tacitness the ASO firms typically try to exploit. The tacit character, in turn, reduces appropriability and requires the development of entrepreneurial capabilities in order to be transferred. Therefore the academic entrepreneur is an intermediary in scenario with high transaction and interaction costs. In some of the firms studied horizontal complementary assets were also needed, and when specialized

or co-specialized, other agency issues had to be addressed. The development of downstream and horizontal linkages is crucial in the development of the ASO firm and sometimes some of these activities are internalized by firms. The Silicon Valley-type of firm prototype is reached again by a small number of firms of both populations at the end of the life-cycle. These firms, particularly in the Italian scenario, show a low variety of structures, basing their activities mainly on an intermediate combination of internal and external knowledge governance, therefore showing some level of integration and hierarchy, but maintaining high flexibility at the same time.

In this regard, and referring to the second point above, the two contexts proved to have some differences. The two contexts have not been deeply analysed in terms of technological and geographical environmental influences and in our opinion this is the main limit of our work. However some conclusions referring to the contextual differences have been drawn. In particular concerning the differences related to the paths that firms undertook to get from an early stage to a Silicon Valley-type of firm.

The ASOs in Greater Manchester followed a much more decentralised path of development compared to those in Emilia Romagna. Two main reasons are put forth to explain these differences and both relate to contextual characteristics. The first one is the mission of the scientist-entrepreneur undertaking such a path of research result exploitation. The Emilia Romagna context is highly populated by family-based firms which, also due to a cultural bias, do not aim at the traditional Schumpeterian step towards expansion and rather prefer to operate in the context of family-based ownership and management. In this scenario the goal of the scientist-entrepreneur is not targeted so much on the development of a technology to be sold to big company as soon as possible. Instead of maximizing the profit from the technology developed in this way, it is more closely related to the growth of the firm and its suitable establishment in the market place. In this perspective, building internal capabilities represents a must to foster the establishment of the firm. The scientist-entrepreneur, as revealed by our interviews, often seeks to mature a stable occupation in the local market, without selling the technology developed or looking for this solution. Moreover, ASO firms are often service based, such as Kibs, and do not have a patented technology that is sellable. Their inclination towards acquiring a position in the regional or national market is even

more intense. Conversely English ASOs appear to remain particularly linked to external knowledge throughout the phases of their life cycle. As their first goal is to create a technology that will attract a big company, there are no worthy reasons to invest in the development of internal capabilities, a process that is acknowledged to be slow and difficult (Henderson 1994). It is not by chance that all firms except one of this sample had this goal for their ASO.

The second reason explaining the difference of behaviour between the two groups of ASOs concerns the extent to which universities are involved in local market needs. The ASO phenomenon in UK represents an answer to market needs. When technology requires further investment to be commercialised the ASO is a possible solution (Lambert Review 2003). It is acknowledged that Anglo-Saxon countries are more experienced in commercialising public research output, and are therefore more experienced in ASO generation and development. Being in a more mature phase of development concerning these kinds of practices leads to such phenomenon being approached in a more standardised way, which is reflected in more similar paths of development. Moreover this standardisation also means that contextual markets are often used to dealing with the needs of these kinds of firms, which is reflected in a more decentralised way of ASO development. In other words in Italy there is less need for ASOs as a solution to some technology development processes compared to the UK.

This research also leads to some policy implications. Our work gives evidence that the process of ASO development varies within the same context and across different contexts. This indicates that policies aimed at supplying some known determinant factors to a distinctive context do not provide a comprehensive response to the problem they aimed at. In other words acknowledging the variety of development processes and the differences between contexts, leads to the recognition of the need for policies to supply the hidden capabilities in various stages of the ASO life cycle. This means, policies should be elaborated in order to provide specific answers to specific problems arising at different stages in the development of the firm. Usually policies are directed to favour the replication of some recognized best practices. Acknowledging a high variety of paths means recognizing the need to take into account out-of-standard practices. This means policies should avoid leaving ASOs without support because they

are not following a predefined route of development. In other words policies should be open and adaptable, and should address the problem of providing some specific capabilities when needed.

Finally and conceptually the present work also discusses the theory of the firm by arguing that it is necessary but not sufficient to focus either on the transactions or on the resources. The integration of the two main strands of literature on the theory of the firm indicates that the adoption of a framework that uses knowledge governance as a unit of analysis is a fruitful line of investigation. If we recognise that the same blueprint applied to two different contexts (also different firms of the same local environment) leads to different outputs, it means the centrality of learning in the innovation processes should be acknowledged, and therefore it means implicitly recognizing that knowledge is a dynamic resource that changes as soon as it is applied to a specific context of use. If we further assume a dynamic perspective in order to understand the innovation processes, and therefore the drivers of economic growth and development, the governance of knowledge has to take first place in the analysis of the firm. This dissertation follows the steps indicated by Antonelli (2006, 2008) who stressed the importance of focusing on knowledge governance in order to appreciate the component processes of technological change. While previous theories of the firm concentrated on large-manufacturing corporations, this approach opens up more flexibility to include a broader range of organizations and firms, not least Kibs, and to contextualise them in their local environment.

We studied how knowledge is organized inside a particular type of firm at different stages of development. The same approach could be applied to different contexts and different types of firms, and could lead to a better understanding not of the boundaries of the firm, but of the knowledge organizational mechanisms undertaken by a firm.

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Appendix

QUESTIONNAIRE

HISTORY OF THE FIRM

Would you please describe all the events that took place, from the business idea to the current situation, during the constitution and development of the “spin off” concept?

Guiding lines:

1. From which research project did the business idea, further become the core activity of the spin off, arise?
 - a. Which were the main research project’s features?
2. How did the business idea change in the course of time?
 - a. How was scientific knowledge turned into a technological product?
3. Which were the reasons leading to choose the spin off as a exploitation mean?
 - a. Why was it preferred to other forms (i. e. license, consultancy, research contracts, etc)?
4. How did the national, regional and academic policies (if by any chance there are some) affect the spin off birth and evolution?
 - a. In particular: which policies (joined programmes’ and projects’ names)?
 - b. How they affected the spin off?
 - c. When (along the enterprise’s development)?
 - d. Which were the result(s)?
5. How is the enterprise organized?
 - a. How is it internally organized in terms of duties and roles?
 - b. How did the structure develop during the years?
6. How was the enterprise’s staff selected and organized? Which were the choosing criteria?
7. Did the enterprise experience any logistic changes?
 - a. If so, of which type?
 - b. If so, due to which reasons/events?

FIRM'S CHARACTERISTICS

Members	Number (how many public and non public employees) Trend Reasons and aims for hiring/employment (and for dismissal)
Turnover	Value Trend
Social Capital	Value Trend Sharers and their percentages
IP	Patent applications Assigned patents Other rights Protection's reasons Evaluation of the protection's practicality/functionality
Funding	Sources (percentages and source/provenance) When during the firm's development/life cycle? Submitted requests/applications
Product	What (product/service) Final costumer designed product or intermediate product Clients' localization (regional, national, European and non European percentage) Clients' sector (percentages and area percentages) Competitors' localization (sector and area percentages)
Public relations	description of the interactions with: other enterprises (from which sector and interaction's argument); TTO, Incubator, Scientific parks, university and research centre; banks and funding institutions; public management/administration