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The Governance of Knowledge in Academic Spin-Offs. The Case of Emilia-Romagna

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The governance of knowledge in academic spin-offs. The case of Emilia-Romagna.

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Abstract

The phenomenon of academic spin-offs (ASOs) has been widely studied in recent times. Scholars have mainly concentrated on identifying the factors that favours the phenomenon and the incentive alignments of the parties involved in the process. These works tend to remain static in nature by solely investigating the ex ante determinants of the process, that is the elements that favoured a context to be more profitable than others, usually in terms of the number of ASOs generated. More recently scholars have also acknowledged that ASOs are heterogeneous firms and have started investigating the development process of such firms. It has been highlighted that ASOs need to overcome certain defined stage of growth in order to become established firms in the market. Our work continues this line of investigation and aims to gives evidence that the paths of ASO development are heterogeneous themselves. We investigate the flows of knowledge taking place within and across the firm in a dynamic manner, at various stage of the development process of the firm: we study the governance of knowledge in a sub-population of ASOs and give evidence of the variety of possible ways the firm can develop.

Keywords: governance of knowledge, academic spin-off, theory of the firm, technology development

JEL codes: D21, D23, D83, L23, L26, O31, O32

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1 Introduction

Academic spin-off firms have received increasing attention both from scholars and policy makers. They represent a direct way of technology transfer from university to industry when the technology to be transferred reveals itself to be, at least in part, tacit, and needs further development in order to be accepted by the market place (see e.g. Fontes 2005, Shane 2002). The phenomenon has been widely studied, both quantitatively and qualitatively (Rothaermel et al. 2007). In particular scholars investigated the incentives lying under the phenomenon, the so called determinants. Some studies have also focused on the process development of these firms, more recently (Mustar et al. 2006): they mainly investigate the stages and obstacles such teams of inventors have to face in order to develop a research project that results in a commercial product.

In recent times literature has proven that there exists a heterogeneity of ASOs (Druilhe and Garnsey 2004, Mustar et al. 2006). They are new firms that operate in different types of business, such as services, physical products, licensing of intellectual property rights, or software. Each type of business is reflected in a different typology of firm's business model and often new ASOs move from one business model to another in relation to the different resources available and capability developments (Druilhe and Garnsey 2004).

Studies on heterogeneity of ASOs concentrated mainly on identifying different typologies of ASOs according to their resource base (Druilhe and Garnsey 2004), to the characteristics of the of organization they are spinned off (Audretsch and Lehmann 2005, Clarysse at al. 2005), the characteristics of ties with the parent organization or the supporting partner infrastructure, like differentiating from ASOs generated in partnership with an already established company and stand-alone ASOs (Wright et al. 2004).

The heterogeneity of the process development of such firms appears to be less explored: this study aims to explore this area of investigation. Our main conjecture is that the process development that leads an idea of business to become an established firm in the market does not follow a dominant route.

The predominant approaches to the ASO topic are the Resource Based View (RBV) and the Transaction Cost Economics (TCE). The former aims at understanding which are the determinant resources a scientist, an ASO, a university or a local area should arrange in order to stimulate the phenomenon in a best practices diffusion manner; the latter aims at identifying the informational barriers that hinder the success of the phenomenon. In other words RBV concentrates on the production processes, while TCE on the exchange processes: these works do not explore how production and exchange processes interweave in the development process of the firm.

These two approaches are static in nature, and therefore are not able to understand the process of evolution taking place that lead an idea of business to become an established firm. In order to overcome these limits, it is necessary to have a framework able to point to the interdependence between the exchange and production processes (Langlois and Foss 1997), that explains how the co-evolution of the two types of processes lead the development process of the firm. Following a methodological approach proposed by Antonelli (2008), based on the notion of localized

technological change (Atkinson and Stiglitz 1969), the present work aims at providing an initial step in filling this gap, by analysing how the knowledge is managed by the firm at different stages of development.
The localised technological change approach, recognizing the dispersion of knowledge among different agents, gives a primary role to external knowledge. Knowledge generation is no longer only the output of R&D and productive functions but emerges also as an output of the interaction processes (Metcalfe and Ramlogan 2005). The firms approach to the governance between internal and external knowledge becomes a source of firm competitive advantage. This means 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.
Our objective is to study the development process of a population of ASO firms. In order to do so we have investigated the combination of internal and external approaches of governance of knowledge a firm undertakes in its development process. The final objective is to provide evidence of the heterogeneity of processes of ASO firms development.

2 Literature review

The aim of the present section is to synthesise from the economic and management literature issues relevant to the organization of the production, exchange processes and their interdependences, in order to understand which is the ASO firm profile identified by scholars and what do we know about the process development that transforms an idea of business into a product. Two are the main interests of the literature: the determinants and the development process. An ASO firm profile will be then derived.

2.1 The determinants

The determinants mainly relate to the number of firms created (see e.g. Di Gregorio and Shane 2003, Shane 2001, Lockett and Wright 2005, Powers and McDougall 2005) or to their performance in terms of success (see e.g. Shane and Stuart 2002, Audretsch and Lehmann 2005). The determinants are important in our perspective because they highlight the ideal scenario where the likelihood to generate an ASO firm and/or for the firm to succeed is higher. The scrutiny of the determinants has been conducted from different perspectives. The focus has been on the university and Technology Transfer Office (TTO), on the individual, team or region.
Among these stimulating factors it is worth highlighting the presence of patents (Colyvas et al. 2002, Shane 2002, 2004), their scope (Shane 2001) and effectiveness (Shane 2002); the

entrepreneurial capabilities of the CEO2 and of the spin-off team (Chiesa and Piccaluga 2000, Clarysse and Moray 2004); the previous experience, either of the university or TTO in dealing with technology transfer activities (Friedman and Sielberman 2003) and in ASOs generation and development practices (Lockett and Wright 2005, Powers and McDougall 2005), or in having undertaken activities with the industrial world, both at the institutional level of university and TTO (Lockett and Wright 2005, Powers and McDougall 2005) and at the individual level of the researcher or team of the new venture (Landry et al. 2006, Krabel and Mueller 2009); the presence of supporting policies both at the national or regional level (Baldini et al. 2006) and at the institutional level of university (Friedman and Sielberman 2003, Chang et al. 2009); and finally venture capital (VC) availability (Chiesa and Piccaluga 2000, Powers and McDougall 2005, Henrekson and Rosenberg 2001). The availability of the latter is positively related to the generation of ASOs also because of the network assets it provides to the ASO firm: the higher ex ante the networking assets of the founders, of the university and of the TTO, the higher is the incentive for the formation and success of ASOs (Colyvas et al 2002, Friedman and Silberman 2003, Grandi and Grimaldi 2003, Zucker et al 1998, 2002, Krabel and Mueller 2009, Jain et al 2009).

2.2 The development process

The development process of ASOs seems to be less explored compared to the identification of the determinants. The seminal work by Roberts (1991) identifies three developmental stages, mainly related to the capacity of getting financial investment funds: start-up, initial growth and sustained growth. Some works recently investigated the issue with respect to ASOs (see e.g. Vohora et al. 2004, Clarsse and Moray 2004 and Shane 2004). Clarysse and Moray (2004) undertook an analysis of the Robertsian start-up stage which an ASO follows, by deeply examining a single case study. The authors indentified four stages a team needs to encompass in order to be able to carry a market efficient productive activity: idea, pre start-up, start-up and post start-up. The authors explore the evolution in the decision making process and in the human resources organization: their findings reveal that hierarchies are very flat until the third phase and a slow learning process leads to the institutionalization of the organizational structure of the firm which is required to get to the fourth phase. Moreover market preferences and external shocks appear to play a fundamental role in shaping the decision making process and its organization.

Using a different approach Vohora et al. (2004) propose a dynamic perspective on the processes of acquisition and building of capabilities during the ASO creation and development. By focusing on the importance of different sets of knowledge at different points in time during the ASO life, they identify five phases and four critical objectives, the so called junctures, to be reached for the firm to move to the next stage of development. The ASOs life cycle starts in academic research, and the recognition of a business opportunity is the critical step to take in order to get to the next phase, the so called opportunity framing. The first critical juncture is given by the acquisition of some

[2] Several works investigated 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 training the academic to be a CEO is probably the best choice because of recognition from the team and for technical reasons.

knowledge about the market characteristics in order to be able to recognize an opportunity for business. The second phase, the opportunity framing stage, consists of moulding the business idea into a more concrete business approach and, in order to get to the next phase, the ASO team needs to get an entrepreneurial commitment. There are two main routes to accomplish this task: hiring a surrogate entrepreneur or training the scientist with entrepreneurial competences. The third phase is called pre-organization and consists of the development of targeted strategies and their implementation. When they enter the pre-organisation ASOs are just constituted firms and completely operate in the market environment for the first time. They put their first product on the market and they obtain a first review of their for-profit mission. The critical step to overcome is called credibility and consists in the ability of raising funds in order to further develop the technology thanks to the market feedback received during the pre-organisation phase. The following phase of development is the re-orientation, that concerns the ability of continuously managing the identification, acquisition and adaptation of useful resources. The re-orientation phase is very important because it is in this phase that ASOs reach a core structure in order to operate in the market. The insights obtained by the market feedback of the pre-organisation has to be put in place in this stage and the firm define its strategies in order to dynamically operate in the market. When the ASO reaches a sustainable rate of growth, the last critical juncture is overcome and the ASO gets to the last phase of development, the 'sustainable return phase', where the firm is able to flexibly respond to market needs and changes in a Teece et al's (1997) dynamic capability perspective.

While Vohora et al. (2004) delineated the compulsory trajectory to accomplish in order to become an established firm in the market, Muller (2010) undertook a duration analysis and found that different firms proceed in the growing path with different speed. According to the resource base each firm owns and to the resources needed from the market, each ASO develops at a different pace. Our purpose is to enrich these insights on the life cycle of ASO firms3, by pointing to the different paths ASOs may undertake in order to develop from an idea of business to an established firm in the market.

2.3 The ASO firm profile

From the management literature it is also possible to derive some organisational characteristics that describe how an innovative firm organises itself. In particular Teece (1996), identifying some organizational factors such as hierarchies, integration, scope, changing culture and external linkages, distinguishes five typologies of archetypes of an innovative firm, according to different combinations of degrees of organizational factors. The archetypes range from the Multiproduct firm highly vertical, highly integrated, with a wide scope, low changing culture and low external linkages, to the stand-alone laboratory that is neither integrated nor hierarchical, point its success on the exploitation of a patented invention and on strong external linkages, and displays a narrow

[3] The life cycle adopted here is not related to some technological evolution as the traditional contextualization of life cycle (see e.g. Utterback and Abernathy 1975). The purpose is not to identify a dominant design or standard, but the attention is placed on the firm's evolution in terms of the capabilities it needs to build or acquire in order to proceed to the growth stages.

scope and a high changing culture.
When we compare ASO firm characteristics with the types of innovative firms identified by Teece (1996), it is possible to perceive an ASO as a middle ground-type of firm - in between the stand-alone laboratory and Silicon Valley-type of firm. More in particular, studies that investigated ASOs in their early stages of development referred to organisations similar to a stand-alone laboratory, while case studies on successful firms refer to Silicon Valley-type of firms. The difference between the two models of firms is mainly revealed in the level of hierarchies and of vertical integration a Silicon Valley-type of firm owns compared to the stand-alone laboratory.
In other words at the constitution ASO firms display the features of a stand alone laboratories (see e.g. the case-study explored in Clarysse and Moray 2004). The just created ASO firm shows very flat hierarchies, quite a specialized scope, low level of integration, and possibly a high changing culture and significant level of linkages with the external environment. Such external linkages will be particularly developed with the upstream parent organisation, and, probably, will still have to be developed with the downstream market place.
Conversely, successful ASO firms, usually used for case study researches, display the features of the Silicon Valley-type of firm: some level of integration and of hierarchies, still quite a specialised scope, and very developed external linkages. Such linkages will probably be less directed towards the upstream environment, but markedly orientated to the industrial world. Such linkages will therefore mainly be horizontal and downstream. These linkages are very important for a flexible organisation such as a Silicon Valley-type of firm. They allow not only to understand the market requirements in order to manage the product development, but also make the ASO aware about the availability of different resources in the environment, such as of complementary assets. Complementary assets owner (c.a.o.) can be general when easily available in the market or specialized and co-specialized when the interaction between the buyer and the seller is significant in order to positively conclude the transaction (Teece 1986, 1988).
In order to investigate the mechanisms that lead an idea of business to become a literature-style ASO that resembles a Silicon Valley-type of firm a methodological approach grounded on Antonelli (2008) will be used. This embraces the notion of localized technological change and puts the focus of the analysis on the knowledge governance mechanisms. We will therefore investigate the evolution of knowledge flows taking place within and across the firm during the main phases of development of the ASO firm.

3 Research design

The methodological approach of this work is the case study research, where a sub-population of regional ASOs is investigated. The region analysed is Emilia Romagna, in the North of Italy. The next section will provide a description of the regional features and give evidence of the self contained character of a sub-population of regional firms. Then the methodological approach to the

case study and the data set will be described.

3.1 The region

The Emilia Romagna region is shaped and characterised by certain factors meaning that the region can be considered as a self-contained economic system. Doloreux and Parto (2005) affirm that Emilia Romagna is one of only three regions that can be labelled a fully-fledged 'regional system of innovation'. 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 and behaviours 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 and 2006, while the second started in 2007 and will last until 2013.

3.2 Data

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-offs4, while a second choice was made from a sector type selection. The overall ASO database was first divided into four 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. Before each interview was conducted, background material from the firm website and from university's TTOs was collected. At least two firms per university were reached and directly interviewed using a semi-structured questionnaire. The average time of the interviews was one hour, ranging from 40 minutes to more than 2 hours. Each conversation investigated the historical development of the ASO firm from the idea of business generated inside the university locals to the firm in the market at the present state of the art. The purpose was to identify the governance of knowledge approach of each firm to a selected set of business activities in different points in time of the ASO life cycle.

Six business activities have been identified and studied: research and development (R&D), managerial activities, manufacturing and/or services provision activities, marketing activities, training of employees and intellectual property (IP) issues. Each activity has been defined and a finite set of possible approaches to its conduction identified ex post the interview. This classification procedure is useful in order to allow the replication logic mechanism (Eisenhardt 1989, Yin 1994). Finally, in order to provide triangulation we had a four hour interview with a the Spinner Programme director, that was at the same time also the university manager of the TTOs of one of the four university of the region. Such figure played a crucial role in all the selection process of Spinner ideas of business, and was deeply involved in the ASO processes taking place in the universities of the region.

Each approach observed has been classified as internal or external to the firm. An approach has been considered internal when the business activity of reference has been conducted on internal to the firm skills and competences; on the contrary an approach has been considered external when the skills and competences needed by the firm for its conduction were founded outside the firm. Finally, when business activities have been carried out by the conjunction of both internal and external approaches, an intermediate degree of governance of knowledge has been appreciated. Let us now explore in depth which approaches have been founded by the ASOs in order to carry out each business activity.

3.2.1 Research and Development

It represents the activity source of the new venture. The idea of business is, by definition, generated inside the university environment, that is to say from an R&D activity. The R&D activity is fundamental for the formation of the ASO firm, and usually, but not always, continue to represent

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

one of the sources of competitive advantage during the firm development process.
To our purpose it is important to understand in which ways the R&D activity is conducted by the ASO firm. In the first phase, in which the ASO firm is just an idea of business, the R&D is conducted, by definition, inside the university laboratories, and therefore labelled external, in terms of governance of knowledge approach, to the ASO firm. In the following phases, the R&D relevant to the ASO business activity, can still be mainly conducted within the parent department: the academics involved in the business still maintain their position in the university and carry out the needed R&D for the ASO firm, or via research contracts or fellowships the ASO sponsors to the parent department. Finally a third scenario, representing a situation of external approach of governance of knowledge, has been observed: the R&D is conducted by a partner company. This is the case where a new innovative product is developed in conjunction with other specialised firms. Alternatively, the R&D activity can be conducted within the ASO, and in this case the knowledge approach to this activity is internal.

3.2.2 Managerial activities

They represent the managerial skills and capabilities that initially lead the ASO to reach an entrepreneurial commitment and thereafter represent, basically, the source of the decision making processes.
It is perceived an external governance of knowledge approach to such activities when an external manager is appointed by the ASO: in the following stage the new staff will be an internal figure, and therefore, ceteris paribus, the activity will become internally approached. It is perceived an external governance of knowledge approach also when the scientist-entrepreneur is trained on purpose, for example via the Spinner Programme a regional policy aimed at supporting ASO firms in their early phases with consultancy services and provision of managerial courses. On the other side, managerial activities, are considered to be based on an internal governance of knowledge approach when the scientist-entrepreneurs already had industrial experience or if they do not do anything specific in this regard.

3.2.3 Manufacturing activities and/or service provision

They are formed by the manufacturing operations and/or the provision of services and represent all the non-R&D activities concerned with productive processes. When an ASO business is only concerned with the development of R&D projects, we consider R&D as the more basic research activities and the manufacturing and service provision as the more applied operations, related to the adaptation of the R&D outputs to the market/customers requirements.
The knowledge governance scenarios that refer to this business activity are multiple: an external approach is acknowledged when the activity is conducted inside the university laboratories, or when the activity is conducted in conjunction to specialized or co-specialized complementary asset owners or when new appointed staff have a significant influence on this activity. An example of the latter scenario is the following: an ASO is built on the idea of selling some innovative software running on already available pieces of hardware; in an advanced phase of development a related service division with a significant impact on the whole business is implemented: the new division

represents an external approach to the governance of knowledge of the business activity labelled 'manufacturing activities and/or service provision'. On the other side, when the operations regarding the manufacturing and service activities are conducted within the ASO or at most in conjunction with general complementary assets owners, an internal governance of knowledge approach is perceived.

3.2.4 Marketing

This business activity is fundamental when the business idea enters the market. It is acknowledged by the literature that building a market knowledge is one of the main obstacles of the ASO firms (van Geenhuizen and Soetano 2009). Basically, this activity concerns the network assets by which the firm reaches customers. We consider this activity to be based on internal knowledge when customers are reached via the previous academic's network, or via the personal founder's network. Otherwise the approach is considered external. There are several scenarios that could lead to the latter situation: when the marketing activities are based on the ASO's network, on exhibitions and conferences, on fund-raising activities, on the new staff's network, or when new staff is appointed in order to carry out the activity (for example the appointment of a sales and marketing director).

3.2.5 Training of employees

This activity represents the degree of training new staff receive when appointed by the ASO. New hired staff can be of two types: with significant experience or without. In the former case the new staff is hired in order to bring to the ASO some lacking capabilities, whilst in the latter the new staff is hired mainly to expand the workforce of the ASO. Moreover there are two acknowledged channels of recruitment: new staff are selected via normal recruitment procedures, such as job advertising and employment agencies, or from a known school, usually the parent university department, that tends to put the ASO in contact with the best students of the department. Therefore on the consideration that there are no new hired staff both expert and coming from a preferred school, three scenarios are possible. The first one, when the new staff are expert and recruited via job advertising, with the aim of providing some latent capabilities to the ASO firm: in this case we acknowledge an external approach to the governance of knowledge of the training of employees activity; the second when the new staff is non expert and recruited via job advertising: it is acknowledged an internal approach of governance of knowledge to this business activity; and finally we acknowledge an intermediate governance of knowledge approach when the new staff is coming from a selected school and, by definition, non-expert.

3.2.6 IP issues

Everything concerned with the management of intellectual property rights is part of this activity. Usually ASO firms, like other firms, tend to rely on external consultants in order to follow through these activities: in this case it is acknowledged an external approach to the governance of

knowledge of such activity. However, although an isolated case, an ASO built a major internal patents screening activity aimed at understanding the patent trends taking place worldwide around the technologies of interest. This latter case, per se, is an example of internal approach to the governance of knowledge of the IP issues activity.

3.3 The governance of knowledge in the ASO development process

This section provides the summary of the empirical analysis. Firs it will be reported a table reporting the history of each ASO firm of the sub-population and then each business activity will be investigated through the lens of the governance of knowledge approaches.

Table 1: The ASO firms stages and junctures

	Phases 1 and 2 Research and opportunity framing	Juncture Entrepreneurial commitment	Phase 3 Pre-organisation	Juncture Credibility threshold	Phase 4 Re-orientation	Juncture Sustainable returns	Phase 5 Sustainability
	Idea of business; Feasibility studies; Managerial and market knowledge acquisition.	Identification of entrepreneur; Firm takes place	Develop a first organisational structure to operate in the market	Capability of raising funds to continue in the product development	Develop the capability to respond to customer needs by productively governing market feedback	Responding to market preferences in a dynamic capability approach	Operating in a dynamic capability approach; Answering to customers' problem-solving needs
Firm a	The idea of the business takes place in a prestigious department, also thanks to the University. The idea is to set up a company able to conduct R&D projects for pharmaceutical and chemical companies in a time where R&D outsourcing was a growing practice.	The ASO takes place: the entrepreneur is a scientist that received management training (Spinner). The ASO starts working on some research contracts secured by the academics involved and on putting some promising patents on the market.	Some contracts are secured, mainly because the academics involved are influential; new innovative products and patents are produced, but the ASO is not able, with few exceptions, to find the right customers, that is companies outsourcing significant R&D.	The academic network customers are the main source of revenues. These revenues are re-invested in producing more innovative products. The business works, but not well enough: it does not take off as expected. Inability to secure VC funds.	Modification of the core business toward the cosmetics and wellbeing; the business changes substantially, and the new core business is experiencing a new pre-organization phase.	Not overcome	Not reached
Firm b	A team of post-doc students of the biology department, some of them with previous industrial experience, decide to create a business in order to offer the local territory services related to their academic background.	In the team of founders there also is a prestigious professor of the local system, able to secure several jobs for the ASO in the local area. The entrepreneurial commitment is given by the previous industrial experience of two of the founders.	The team operate in many complementary biological subsectors: environmental management, mollusc culture, aquaculture, flora-fauna monitoring and census, environmental management and restoration. The value added of the ASO is the ability of offering integrated services related-to-the-territory compared to other firms in the market.	The changing normative and the fame of the president of the ASO in the local area, lead the ASO to secure enough revenues to foster growth.	A new member enters the team of founders. The new member is specialised in another complementary subsector: agronomy. The services offered by the ASO reach now an even higher range of potential customers. The ASO also defines a core business and a path of specialization through which to grow. Although secondary to the business, a new technology starts to be developed with a complementary asset owner, that is a firm operating in the aquaculture technology sector.	Exporting the business in other areas: adapting the knowledge developed in the local area to other context specificities.	The firm nowadays operates at a nationwide level in Italy. Customers refer to the ASO not only for the service they usually offer, but also for specific problem solving situations.
Firm c	A professor of the Pharmaceutical department sees the lack of clinical research organisation (CRO) companies and people trained to work in CROs in the Italian territory. The idea is to implement a masters course through which to train students and create a spin-off acting as a CRO to hire the best students of the masters course.	The professor undertakes Spinner management training, and his network contacts in the industry help the ASO to get some first jobs.	The business does not take off because the market requires high profile CROs and the masters students are not experienced enough to make the CRO grow and become established in the market.	A new CEO is hired from the industry with experience both in other CROs and in big pharmaceutical companies. The new CEO has robust knowledge of both the problems of CROs and the requirements of pharmaceutical companies.	The new CEO changes the CROs mentality towards an high profile firm. The ASO core feature is to offer a high profile service. His network assets are very important and very soon he is able to secure important jobs firstly in the Italian market and then also abroad.	Important revenues. The ASO participates in important projects with international partners, giving prestige to the firm.	The ASO extended its competences: not only working as a mere CRO but also coordinating international projects as a project manager. The ASO did not grow so much in terms of people,. but of revenues. However it offers its partners an important value added.

Firm d	A group of graduate and post-doc students of the geology department have an idea of developing a new software technology, based on satellite image analysis. They aspire to build a business on the know how developed during their studies. The idea is to set up a company that offers the market a specialized set of services and in the meantime develop the innovative software.	Management training by the students (Spinner); first feasibility studies done with the help of Spinner; some contracts based on the service activities secured even before the formation of the ASO firm.	The new software technology reveals to be unfeasible and its development has to be abandoned. The ASO firm concentrates on the services activity.	The ASO is able to secure enough jobs in the local area and produce revenues to expand the team.	One of the founders leaves the firm. Two other members coming from the same department take his place. The business remains much the same. Some jobs are secured also outside the region, but the growth is not as fast or significant as wanted. There are not enough customers and revenues to expand the team and in order to consider the business sustainable.	Not overcome	Not reached
Firm e	During a thesis that a student of physics develops with his professor, an innovative technology that is complementary to the father's company core product. The initial aim is to set up a business developing upstream technologies (air quality monitoring instruments) for the father's company.	The ASO is generated: the technology ownership is transferred by the university to the ASO in exchange of capital shares. The student-entrepreneur and his father's company have invested capital in the company.	The technology is firstly implemented on a product that would have answered a father's company requirement. The first ASO product allows the father's company not only to operate with an ad-hoc product, but also to refer to the local market instead of going abroad.	The first product leads to initial and important revenues. A local bank invests capital in the business.	A second product is created thanks to the participation in a European commission project. This new product has to be sold not only to the father's company but also in the market place.	The ASO firm starts to find his own customers.	The ASO is closely linked to the parent company for which it continues to represent the upstream R&D function, but also works for other independent companies worldwide
Firm f	A team of scientists decide to exploit the know how of 20 years excellence in the electrical diagnosis technologies. The leading professor is world famous for his research.	The university pushes a spin-off creation from this team. Although the ASO is created without a specific idea of a business product, but only with a lot of problem-solving ideas, the leading professor of the department has wide experience in dealing with the industrial environment.	A first product is generated: it consists in an innovative software running on an assembled physical product. The firm maintains some activities inside the university laboratories. The chief of the department professor remains the main commercial vehicle for the firm.	The first product leads to important revenues and fame for the firm not only in Italy.	The ASO expanded greatly in terms of people. A famous manager coming from one of the biggest Italian multinational companies is appointed. A service department is created in order to manage the feedback from the clients. A manufacturing division is also created in order to develop physical devices ad hoc for the software that is the core product. A new generation of products is developed: there are several early customers that allow an efficient technology development.	The ASO firm starts to answer clients problem solving requests. The university withdraws its capital taking with it great revenues.	The firm is now composed by a holding and three associates and operates worldwide. Three products have been created so far. The team of directors is thinking of merger and acquisition practices.

Firm g	A big chemical corporation offers an important research contract to a research group in order to study an important number of molecules. This fund would have shifted the research group's attention towards the applied side of research. In the opinion of the head professor of the group, a team of researcher should conduct half time applied research and half time basic research: the research contract would have shifted such balance. The solution is to create an ASO that would have started its activity by securing that contract research. Two students (a post-doc and a recently graduated) decided to create a firm under the supervision of the research group professor.	Trained entrepreneur by Spinner, willingness by young researchers to set up a business, and a first important job already secured.	The firm still conducts some operations inside the university laboratories. The main job continues to be the initial research contract, but the first customers are found by the ASO thanks to the organisation of specialised workshops.	The ASO sets up a yearly organization of conferences in order to show the market the research evolution on the chemistry of the solid state drugs and to make companies aware of the presence of the ASO. The ASO also obtains a local bank loan.	The firm detaches from the university and expands in terms of people, also thanks to a local bank loan; the service offered enlarges to complementary products (complementary skills of new hired people).	The exhibition's organization appears to be very productive: the first two years is at the Italian level and then it expands to an international level. Customers increased exponentially.	The firm works mainly worldwide and answers to problem solving request by clients.
Firm h	An interdisciplinary research centre (human-machine interactions: union of department of mechanic engineering and communication science) receives several contract researches from private companies. These companies often ask the centre further services that extend the research contract. The decision to create an ASO is mainly due in order to better manage the private flows of income.	A big research contract leads to the decision of setting up an ASO on which to start this activity and develop new product technologies. Trained entrepreneur by Spinner.	The firm still works inside the research center laboratories and mainly on the first fund. The firm develops mainly software and product prototypes. Two divisions are set up.	The big company funding the first big product made the ASO reach a credibility point by giving it enough revenue and visibility in the market. Moreover a regional award is secured and leads to the development of a new product-technology.	The ASO re-organises in three divisions and a transversal fund-raising division. Also a sort of manufacturing process inside the firm takes place in order to develop a platform system.	The fund raising activity is very productive and leads to company growth.	At this point the ASO funds the entire research center activities, and operates worldwide in the market.
Firm i	A disabled student developed a technology for disabled people to easily use computers. He and his colleague decided, with Spinner help, to set up a company based on such technology.	Trained entrepreneur by Spinner, and willingness by young researcher to set up a business.	The firm is set up with the aim of further developing the technology and applying it to other products. The first product is put on the market: it has to be adapted to each disabled customer, so a service activity is done primarily by the disabled founder.	A further important regional award is secured, and leads to the development of the second product technology.	Two new products are placed in the market and the firm also starts acting as intermediary for other products already in the market.	Not overcome	Not reached

Firm j	An innovative technology for an acoustic simulation product is in development inside the department of engineering. The idea of a group of researchers (three between PhD and post-doc students and two research fellows) is to start a service activity via an ASO through which to fund the technology development.	Management training of two academics (Spinner) and appointment of a marketing director.	The innovative product needs time to be developed as requested by the market and the business is based on the service activity that produces the expected cash flows.	The innovative product, just developed at an early stage, is sold to a big company, and two of the founders leave the company. The revenues obtained by the service activities and by the technology sold are redirected towards the development of a new variant of the former technology.	The new technology product is in development and the ASO has already found some early buyers. However, this product, that should be the core product of the ASO, is re-experiencing a pre-organisational phase and the business still lives only on the service activities.	Not overcome	Not reached
Firm k	The idea of business is based on a new product to be developed in conjunction with a multimedia company. The idea of business is the commercialisation of featured contents able to be adapted to common use devices as mobile phones in points of interest (such as natural parks, museums, etc). The firm is also set up because of the willingness of some temporary researchers to start an own business.	Management training by academic (Spinner) and some research contracts (on the service activity) given by academic network assets means that the ASO is earning its first revenues.	The main product reveals to be unfeasible. The service activity proceeds but is not enough and it is enlarged to a seasonal activity in a natural park, thanks to a new member of capital.	Not overcome: firm not profitable enough yet.	Not reached	Not overcome	Not reached

3.3.1 Research and development

Table 2: Governance of knowledge in the R&D activity

	Phases 1 and 2 Research and opportunity framing	Phase 3 Pre-organisation	Phase 4 Re-orientation	Phase 5 Sustainability
Firm a	External: in the Uni lab	External: in the Uni lab	Intermediate: Uni lab + within ASO	x[b]
Firm b	External: in the Uni lab	-[a]	Intermediate: within ASO + partner company	Intermediate: within ASO + partner company
Firm c	External: in the Uni lab	-	-	-
Firm d	External: in the Uni lab	-	-	x
Firm e	External: in the Uni lab	Intermediate: Uni lab + within ASO	Internal: within ASO	Internal: within ASO
Firm f	External: in the Uni lab	External: in the Uni lab	Intermediate: Uni lab + within ASO	Internal: within ASO
Firm g	External: in the Uni lab	External: in the Uni lab	Internal: within ASO	Internal: within ASO
Firm h	External: in the Uni lab	External: in the Uni lab	Intermediate: Uni lab + within ASO	Intermediate: Uni lab + within ASO
Firm i	External: in the Uni lab	Internal: within ASO	Internal: within ASO	x
Firm j	External: in the Uni lab	Intermediate: Uni lab + within ASO	Intermediate: Uni lab + within ASO	x
Firm k	External: Uni lab + partner company	-	x	x

a: "-" means the activity is not carried out by the firm in that particular phase of development.
b: "x" means the ASO did not reach that phase of development.
These symbols are also used in the following tables and have the same meaning.

The R&D activities are externally approached during the first phases, before the firm is constituted. One of these firms, Firm k, developed the technology to be exploited with the help of an external company, while in all the other firms the technology is developed exclusively inside the university laboratories. In the following phases the R&D activities tend to be internalised in all ASOs, with different time lags. The use of university labs in advanced phases of the firm life cycle are most of all a characteristic of the firms that need expensive instruments in order to conduct the R&D function:

> Firm a – re-orientation.
> Nowadays the ASO is constituted by two research groups: one with mostly chemical and pharmaceutical competences that operate within the department units, and the other specialised in the cosmetics and wellbeing sector, that operate in the ASO labs. In the near future, for university law, we need to move the ASO activity out of the university labs and therefore the wellbeing part of business will maybe be the only one that will continue to operate. It is not possible to sustain the chemical and pharma activities for the huge costs of infrastructures. We could give it in outsourcing to the department. We still don't know what we're going to do and how.
>
> Firm f – re-orientation.
> After the first successful product there have been several evolutions of it and a new generation of products. The new products are now more the answer to market feedback than to research inputs. However their development represents a mix of the two factors. Thanks to the professor X. and to the ASO scientific board, the relation with the university department has always been strong and beneficial.

Of the six firms reaching the sustainability phase of development, meaning those that become established firms in the market, only Firm h keeps important links with the parent organization: this

ASO, with its funds, finances the whole activity of the research centre which spinned the ASO off:

> Firm h – sustainability.
> In 2001 an interdisciplinary research centre was created in order to develop research on the human-machine interaction. Such a research centre gave birth to an ASO. […] Now the ASO organises the research centre activities because it is the spin-off that manages all the research contracts and maintains all of the activities of the whole research centre .

Of the other five firms, three conduct the R&D activities entirely internally, while one conducts it in partnership with an external company. This is Firm b, a pure service company, that is developing, with a specialised c.a.o., new techniques of oysters acquaculture:

> Firm b – re-orientation and sustainability.
> Together with a fishing machinery company we patented a technology for the oyster acquaculture. We are further developing the product. It is a slow process that will take some time: we are testing it both in our sea, in Goro [in the North of Italy, in the Adriatic sea], and in the South [of Italy]. There are huge differences between the two waters and the instrument works differently in different types of water.

R&D activities show a common trend among all ASOs: initially they are conducted in partnership with the parent organisation, and with different time lags they become approached within the firm, or in partnership with external companies, going trough the stages of the life cycle. This trend highlights the evolution of the upstream external linkages: very strong in the beginning and less and less pronounced during the ASO development.

3.3.2 Manufacturing and/or service provision activities

Table 3: Governance of knowledge in the 'manufacturing and/or service provision' activities

	Phases 1 and 2 Research and opportunity framing	**Phase 3 Pre-organisation**	**Phase 4 Re-orientation**	**Phase 5 Sustainability**
Firm a	External: in the Uni lab	External: in the Uni lab	Intermediate: Uni lab + within ASO	x
Firm b	Intermediate: within ASO + Uni Lab	Internal: within ASO	Internal: within ASO	Internal: within ASO
Firm c	External, in the Uni lab	Internal: within ASO	External: new staff	Internal: within ASO
Firm d	Internal: within ASO	Internal: within ASO	Intermediate: within ASO + new staff	x
Firm e	Intermediate: Uni lab + within ASO	Internal: within ASO	Internal: within ASO	Internal: within ASO
Firm f	External: in the Uni lab	Internal: within ASO	Intermediate: within ASO + specialized c.a.o.	Intermediate: within ASO + specialized c.a.o.
Firm g	External: in the Uni lab	Intermediate: Uni lab + within ASO	Internal: within ASO	Internal: within ASO
Firm h	External: in the Uni lab	External: in the Uni lab	Intermediate: Uni lab + within ASO	Internal: within ASO
Firm i	Internal: within ASO	Internal: within ASO	Internal: within ASO	x
Firm j	External: in the Uni lab	Internal: within ASO	Internal: within ASO	x
Firm k	Internal: within ASO	Internal: within ASO	x	x

The manufacturing and service activities conducted by ASO firms represent the operational activities of the firm. In the early stages they tend to be externally approached, that is done within the university laboratories, although some ASO teams do it themselves, without any significant support from the parent organization. The internal approach to such activity in the research and opportunity framing stage is mainly represented by the provision of services:

> Firm d – research and opportunity framing
> We started with the Spinner supporting tool. While we were testing the feasibility of the main innovative product, we started working in the local area. We were asked to go out for simple consultancy services based on our background.

It is interesting to note how in the pre-organisation eight firms conduct the activity internally, while in the following re-orientation only five approach it internally. This is due to the strong re-organisation character of the re-orientation phase of development, where the firm's structure and strategies are significantly revisited. Two firms experienced an introduction of new staff that represented a source of external knowledge important for the re-organisation of the firm's business:

> Firm c – re-orientation
> The two founders lack managerial and entrepreneurial competences. They called me for this reason. Before I worked for the industrial world: I have been clinical monitor and resource associate both for other CROs and for a big pharmaceutical company. I knew the criticalities between the pharmaceutical companies and the average CRO. I therefore identified the problems and used my knowledge in order to make the ASO work as needed.
> Therefore the initial idea of business changed soon after my arrival. We did not have the time to train young clinical monitors and we needed to create a network of clinical monitors already experienced. We did that and the strategy had a positive result. Moreover we could offer something more: specific courses to our partner, yielded by the academic founders in the university.

Differently, Firm f developed an important hardware extension of the core product, and consequently went into the market place in order to find the right specialised complementary asset owners in order to properly build a hardware product:

> Firm f – pre-organisation, re-orientation and sustainability
> The idea has always been a product: the business was born on a set of new ideas condensed in the product, where the product value added was given by the good ideas, not by the hardware per se […] Further on we saw the possibility of increasing the efficiency of the good ideas by developing an ad-hoc hardware. That was the step towards the ex-novo design of the products. […] The hardware is made in outsourcing […] We had many trials before to find the right partners. We always stayed in the local area, because you need to be near your partner: you need to go there and discuss the product many times.

The manufacturing and/or service provision activities are differently approached by different firms in the early phases, while they tend to become governed internally to the firm moving on towards the advanced phases of development, in this similarly to the R&D activities.

3.3.3 Managerial activities

Table 4: Governance of knowledge in the managerial activities

	Phases 1 and 2 Research and opportunity framing	Phase 3 Pre-organisation	Phase 4 Re-orientation	Phase 5 Sustainability
Firm a	External: Spinner training	Internal: within ASO	Internal: within ASO	x
Firm b	Internal: within ASO	Internal: within ASO	Internal: within ASO	Internal: within ASO
Firm c	External: Spinner training	Internal: within ASO	External: new staff	Internal: within ASO
Firm d	External: Spinner training	Internal: within ASO	Intermediate: within ASO + new staff	x
Firm e	Internal: within ASO	Internal: within ASO	Internal: within ASO	Internal: within ASO
Firm f	Internal: within ASO	Internal: within ASO	External: new staff	Internal: within ASO
Firm g	External: Spinner training	Internal: within ASO	Internal: within ASO	Internal: within ASO
Firm h	External: Spinner training	Internal: within ASO	Internal: within ASO	Internal: within ASO
Firm i	External: Spinner training	Internal: within ASO	Internal: within ASO	x
Firm j	External: Spinner training	Internal: within ASO	Internal: within ASO	x
Firm k	External: Spinner training	Internal: within ASO	x	x

Few ASOs already displaced management skills, given by previous industrial experience, while all the other ASOs received the Spinner training. Spinner sought to give scientist entrepreneurs the basic foundation of the managerial capabilities required to conduct a business. In the pre-organisation phase, when the firm is just constituted, all the firms of the population rely on internal resources for the decision making procedures inside the ASO.

The re-orientation, differently, saw a significant number of firms referring to the external environment in order to acquire new needed managerial capabilities. Three ASOs revealed this need: two of them transferred the decision making process almost entirely to the new executive staff appointed:

> Firm f – re-orientation
> I brought into the company order and decisional rationality: what we shall do within the firm and what we get from outside, understanding when a prototype is ready, that is, when it is the case to go further in its development or to stop. […] Creativity is outstanding. Not a day goes by without somebody proposes a new idea. It is important to put them in a row, and understand whether they are part of the core business or not, and which ones are to be continued and which ones not.

In the other ASO the board conducting the firm's decision making process just expanded:

> Firm d – re-orientation
> In April 2008 two of the three founders left the company and two new entered. I still maintain the main coordinating role, but they brought new competences, new contacts and new jobs. For example one of them already worked with us: we knew him from before. He worked with us in some jobs where we needed some particular services.

Management skills, moreover, has also been found to represent one of the main obstacles for ASO firms to grow. In particular one scientist entrepreneur highlights the difficulties in developing the required managerial capabilities:

> Firm a – re-orientation
> We continue in developing beautiful and highly innovative ideas: companies remain astonished by our ideas, but it's not enough. We produce high technical contents, but companies look also for proof of feasibility, information about market potentialities, expected revenues and further development costs of the product. We should start from these steps even before starting the development of the research idea. We lack this phase. We are all scientists. I've really spent lots of effort in order to acquire managerial capabilities that I didn't have, but I still am a scientist! I still lack some tools.

Managerial skills need to be developed or acquired from the external environment by each firm during its development. Some firms already display these skills from the very beginning (Firms b and e). Some firms rely on the capabilities built in the research and opportunity framing during the whole life cycle (Firms g and h) and some others need to update them by going to the external environment also in the re-orientation phase (Firms c and f). All the firms going through the whole life cycle approach this activity internally in the sustainability phase. This point highlights the tendency of building some hierarchies within the ASO firm during its growth towards an established firm.

3.3.4 Marketing activities

Table 5: Governance of knowledge in the marketing activities

	Phases 1 and 2 Research and opportunity framing	**Phase 3 Pre-organisation**	**Phase 4 Re-orientation**	**Phase 5 Sustainability**
Firm a	Internal: academics' network	Internal: academics' network	Intermediate: academics' + ASO's network	x
Firm b	Internal: academics' network	Intermediate: academics' + ASO's network	Intermediate: academics' + ASO's network	External: ASO's network
Firm c	Internal: academics' network	Internal: academics' network	Intermediate: academics' + new staff's net.	External: ASO's network
Firm d	Internal: academics' network	Internal: academics' network	Intermediate: academics' + ASO's network	x
Firm e	Internal: academics' network	Internal: founders' network	Internal: founders' network	Intermediate: founders' + ASO's network
Firm f	Internal: academics' network	Internal: academics' network	External: ASO's network	External: ASO's network
Firm g	Internal: academics' network	Intermediate: ASO's network + exhibitions	External: exhibitions	External: exhibitions + ASO's network
Firm h	Internal: academics' network	Internal: academic's network	External: fund raising and ASO's network	External: fund raising and ASO's network
Firm i	Internal: academics' network	Internal: founders' network	Intermediate: founders' + ASO's network	x
Firm j	Intermediate: Academics' network + staff	Intermediate: Academics' network + staff	External: ASO's network + staff	x
Firm k	Internal: academic's network	Intermediate: academics' + new staff's net.	x	x

The marketing activities are very important for a new venture, especially when the market of reference is not particularly defined or even more, is non existent, that happens quite often with ASO firms. In the early phases the knowledge of the market comes from the academic environment: a department or a professor that is famous for his research can be very important for the early stages of an ASO in order to find customers:

> Firm f – research and opportunity framing and pre-organisation
> The fame of the professor X has played a fundamental role in the output of the initial commercial activities.

The evolution of such an activity is quite slow, changing slightly from a phase to the following one. It is acknowledged that acquiring a significant knowledge of the market is one of the main obstacles of an ASO firm (van Geenhuizen and Soetano 2009).

> Firm b – pre-organisation and re-orientation
> Everyone of us [founders] is a coordinator of a specific sector. The service provided requires team planning and execution, but the marketing activity is conducted singularly. For such specific and high-knowledge based services is not possible to hire a marketing figure that represents all the sector specialisations. Each one of us conducts the marketing function for its sector, and each one of us does it in his own way. From the point of view of the growth of the business we need to improve the marketing activity, but we still don't know how to do it.

Many are the ways in which ASOs acquired external knowledge of the market: new staff, exhibitions, fund raising and the prestigious of the ASO itself.

> Firm g – pre-organisation and re-orientation
> Every year we associated a workshop activity to the research and productive activities, in order to both disseminate our competences and make the Italian companies (now also international companies) aware of the scientific society's progress in the field of solid state drugs. […] This activity acted for us as a showcase. After the first workshop we activated two more pharmaceutical clients, that outsourced to us part of research studies they were conducting. Then we experienced an exponential growth: now we work for 25-30 companies, mostly pharmaceutical, a few in Emilia Romagna, 60-70% in Italy and the rest abroad.

Five of the six firms reaching the last phase of development show an external approach for the governance of knowledge of the marketing activities. In these firms the ASO's network become one of the main drivers for reaching new customers.

> Firm f – sustainability
> This particular product was one of our ideas. We patented it and then, for various reasons, we left it there in standby. After some months, an American company came here for a specific reason related to a particular product. They were very happy with us. During a tour of the company they saw this product and finally we sold them the exclusive right to sell it in US.

Firm e, instead, counts on an internal approach until the last phase of development, where the function is based on an intermediate approach. It is the only firm to conduct the marketing activity in a non external approach in the sustainability phase. The reason is due to the nature of the firm. Firm e was generated in a sort of joint venture with an established company, that is the ASO CEO father's company. The ASO mission was to develop a technology that would have first of all be implemented in the established company. The established company continued to represent an important source of contacts and potential customers for the ASO, although its products became in the last phase also requested by companies not in contact with the established company:

> Firm e – pre-organisation, re-orientation and sustainability
> Initially the firm was completely dependent from the network of contacts of O. [ASO CEO father's company]. The situation remained the same for a while. It took some years for our product to be sold to other customers. Recently we expanded our client basket. We now work only for a 50-60% of turnover for O.

As said before the knowledge of the market has to be acquired from outside the firm during its life cycle. In other words the knowledge of the market represents those downstream external linkages a new-firm needs to develop in order to become an established firm. All the businesses reaching the sustainability phase, in the end approach the activity externally.

3.3.5 Training of employees

Table 6: Governance of knowledge in the training of employees activity

	Phases 1 and 2 Research and opportunity framing	**Phase 3 Pre-organisation**	**Phase 4 Re-orientation**	**Phase 5 Sustainability**
Firm a	-	Intermediate: parent University provenience	Intermediate: parent University provenience	x
Firm b	-	Intermediate: parent University provenience	Intermediate: parent University provenience	Intermediate: parent University provenience
Firm c	-	Intermediate: parent University provenience	External: advertising + expert	Internal: advertising + non expert
Firm d	-	Intermediate: parent University provenience	Intermediate: parent University provenience	x
Firm e	-	Intermediate: parent University provenience	External: advertising + expert	Internal: advertising + non expert
Firm f	-	Intermediate: parent University provenience	Intermediate: parent University provenience	Internal: advertising + non expert
Firm g	-	Internal: advertising + non expert	Internal: advertising + non expert	Internal: advertising + non expert
Firm h	-	Intermediate: parent University provenience	Intermediate: parent University provenience	Intermediate: particular faculty
Firm i	-	-	-	x
Firm j	-	Intermediate: parent University provenience	Intermediate: parent University provenience	x
Firm k	-	-	x	x

The training of employees takes place from the pre-organisation phase, once the firm is constituted. As already noted, new hired personnel can come from a known school, such as the parent department, or can be appointed via recruitment procedures such as advertising. In this last case, new personnel can be expert or non expert. It is possible to note that initially the tendency of ASOs is to hire young researchers from the parent department, a practice that sometimes continues for the whole of the ASO life cycle:

> Firm a – pre-organisation and re-orientation
> Usually the department sends us students to do their internship or thesis. According to our needs we sometimes ask them to remain in the firm, initially with a temporary contract. We hired permanently four of them and there are three more in internship at the moment.

The tendency to hire staff from the parent department remains high also in the re-organisation phase:

> Firm f – pre-organisation and re-orientation
> We like young graduates coming from the department.

An interesting situation is described by Firm h, where initially they used to hire personnel coming from the two departments that gave birth to a research centre that spinned off the ASO, while in the later years they tended to rely on graduates of the mechatronic school, a particular school created in recent times to serve the requirement of a technological district nearby:

> Firm h – all phases
> Initially we used to rely only on engineering. In recent times, especially when we started making our prototypes entirely on our own, we started choosing mechatronic graduates. They have all the competences needed, of mechanics, electronics and informatics, and they are very flexible among the three domains, and therefore constitute a perfect mix of competences for our firm.

Only in the sustainability phase, ASOs are already established firms in the market and often prefer to hire selected young researchers and take care of their professional training internally:

> Firm g – all phases
> We tried to build complementary specialisation inside the firm in order to be able to offer a more complete service. Therefore we needed to hire people with different, although close, backgrounds. We need to spend some time with them in order to understand if they are the right people. It is a difficult choice and we need to know if we like them and if they like to work with us.

The training of employees has been approached very similarly in the pre-organisation phase and approached differently in the following phases. Each firm seems to rely on preferred methods of recruiting employees, not showing a common trend among ASOs.

3.3.6 IP issues

Table 7: Governance of knowledge in the IP issues activity

	Phases 1 and 2 Research and opportunity framing	**Phase 3 Pre-organisation**	**Phase 4 Re-orientation**	**Phase 5 Sustainability**
Firm a	External: Consultant	External: Consultant	External: Consultant	x
Firm b	External: Consultant	External: Consultant	External: Consultant	External: Consultant
Firm c	External: Consultant	-	-	-
Firm d	External: Consultant	-	-	x
Firm e	External: Consultant	External: Consultant	External: Consultant	External: Consultant
Firm f	External: Consultant	External: Consultant	External: consultant	External: Consultant
Firm g	External: Consultant	External: Consultant	External: consultant	External: Consultant
Firm h	External: Consultant	External: Consultant	Intermediate: Consultant + internal personnel	Intermediate: Consultant + internal personnel
Firm i	External: Consultant	External: Consultant	External: Consultant	x
Firm j	External: Consultant	External: Consultant	External: Consultant	x
Firm k	External: Consultant	External: Consultant	x	x

IP issues is the activity most externally approached by ASO firms: they regard patent applications and copyright and trade marks protections. In the research and opportunity framing phase all the

ASO conducted some related activities via external consultants. Often these external consultants were reached via the Spinner supporting tool and remained the same for the entire life of the ASO. Two pure service firms (Firms c and d) did not continue with the activity after the first stage.
Only one firm approached the business activity in a non external approach of knowledge governance: Firm h, in the re-orientation phase, decided to build an internal office of patents screening activity in order to be continuously updated with the related technology development:

> Firm h – re-orientation and sustainability
> It has also been put in place an internal procedure of patent scouting. When we have an interesting idea, the first thing we do is understand if and what has already been done on it.

IP issues are very similarly managed by ASO firms, that is externally. Apart from one case, all the firms rely on external consultants for such an activity both in the beginning and in the end of the development process.

3.4 General findings

The analysis of the governance of knowledge of the selected business activities leads to some patterns of the firm's development. Regarding the R&D business activity there is a tendency towards an internal approach of governance of knowledge: in the research and opportunity framing phase all the ASOs approach it externally, conducting it at the university laboratories; moving through the life cycle, there is a shift in its governance towards an internal approach. The university's influence on the technology development of the ASO core business become less and less relevant with the firm growth.
The governance of the management skills tends to be external in the first stage and becomes internal in the pre-organisation phase of development. This is an expression of the fact that usually scientists are trained to be entrepreneurs during the research and opportunity framing phase, and operate as entrepreneurs in the pre-organisation phase. In the following re-orientation phase they often realise that the managerial skills needed by the ASO firm need to be updated and often we register a new external contribution to the firm's knowledge for the decision making process of the ASO firm. The new staff internalised in the fourth phase becomes then an internal resource in the sustainability phase.
A similar scenario happens in the manufacturing and service provision activity: we note a significant recourse to external knowledge in the re-orientation phase, due to the improvement of the technology or product core business of the firm. The re-orientation confirms to represent a very important phase, where the business needs to be re-organised significantly in order to proceed in the development trajectory.
The marketing business activity behaves in an opposite way to the R&D: initially it is managed by means of internal resources, such as the networking assets of the department, of the academics involved or of the founders, while moving towards the following phases of development it is governed more and more externally. There are several ways to this approach: organisation of

exhibitions, implementing a fundraising division, new customers given by the reputation the ASO gained in the market place, or appointing devoted employers to a marketing function.
Finally the training of employees and the IP issues activities have been studied. These two activities follow common paths of evolution among all the firms. The former move from an intermediate approach of governance of knowledge towards an internal one. Differently, the IP issues are approached externally in all phases by all firms except one that builds a patent screening division within the firm.

3.5 The paths of ASO's growth

Let us now look at the analysis from the perspective of each firm, that is analysing how differently ASOs organised themselves in each stage of development. Each ASO displays a configuration, that is an organisational structure given by a combination of external and internal approaches for each business activity, in each phase of development. Some ASOs show exactly the same configuration. This is clearly highlighted in Table 8. Here the label 'I' means that the firm governs the business activity with an internal approach of governance of knowledge; 'M' means intermediate and 'E' means external. From the table it is possible to see that eleven firms organised themselves in six different configurations during the research and opportunity framing phase. In the following stages we note a multiplication of different configurations adopted by the population. The pre-organisation phase shows nine different configurations, where only two are identical for more than one firm. The re-orientation phase is characterised by the presence of only ten firms, and each firm shows its own configuration. Finally, of the six firms arriving at the sustainability phase of development, there are five configurations, where one is the same for two firms.

Table 8: The business activities governance of knowledge at different phase of development

a. Research and opportunity framing

Phase 1 and 2 - Research and opportunity framing						
Configurations' number	1	2	3	4	5	6
R&D	E	E	E	E	E	E
Management	E	I	I	M	E	E
Manufacturing/service	E	M	E	I	I	E
Marketing	I	I	I	I	I	M
Training employees	-	-	-	-	-	-
IP issues	E	E	E	E	E	E
Firms' name	a, c, g, h	b	d, i, k	e	f	j

b. Pre-organisation

Phase 3 - Pre-organisation									
Configurations' number	7	8	9	10	11	12	13	14	15
R&D	E	-	-	M	E	E	I	M	-
Management	E	I	I	I	I	M	I	I	I
Manufacturing/service	I	I	I	I	I	I	I	I	I

Marketing	I	M	I	I	I	M	I	M	M
Training employees	M	M	M	M	M	I	-	M	-
IP issues	E	E	-	E	E	E	E	E	E
Firms' name	a, h	b	c, d	e	f	g	i	j	k

c. Re-orientation

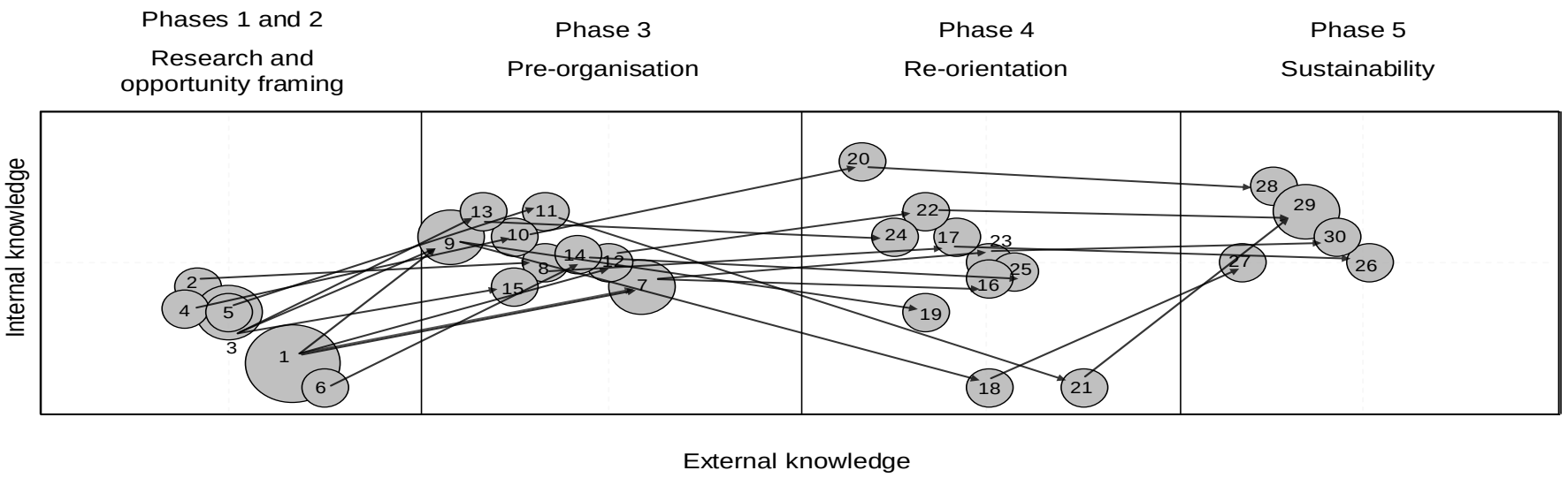
Phase 4 - Re-orientation										
Configurations' number	16	17	18	19	20	21	22	23	24	25
R&D	M	M	-	-	I	M	I	M	I	M
Management	M	I	E	M	I	M	I	M	I	I
Manufact./service	I	I	E	M	I	E	I	I	I	I
Marketing	M	M	M	M	I	E	E	E	M	E
Training empl.	M	M	E	M	E	M	I	M	-	M
IP issues	E	E	-	-	I	E	E	M	E	E
Firms' name	a	b	c	d	e	f	g	h	i	j

d. Sustainability

Phase 5 - Sustainability					
Configurations' name	26	27	28	29	30
R&D	M	-	I	I	M
Management	I	I	I	I	I
Manufact./service	I	I	I	I	I
Marketing	E	E	M	E	E
Training empl.	M	E	I	I	M
IP issues	E	-	E	E	M
Firms' name	b	c	e	f, g	h

This work first of all confirms our conjecture, that the route ASO undertake in order to transform an idea of business into a firm established in the market does not follow a dominant route but is multiple. The analysis also allows further considerations. Figure 1 – developed only for illustrative purposes – summarizes the concept and allows us to clearly observe the degree of internal versus external overall approaches to the governance of knowledge of the firm.

Fig. 1 The governance of knowledge of the ASOs of Emilia Romagna in their life cycle



The figure is an illustration of the configuration identified in Table 8: each ball represents a configuration and its area is proportional to the number of firms that adopted the same configuration. It compares the firm propensity to organise the business towards an external or an internal approach of governance of knowledge. This figure could represent a further step in the articulation of Vohora et al. (2004) argument and 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 of firm. It therefore also offers an elaboration of Teece's analysis of firm organizational structures, with a specific orientation in the context of ASOs.

The figure sheds light on some points. First of all it is arguable that in the research and opportunity framing phase ASOs are similarly structured towards an external overall approach of governance of knowledge. In the pre-organisation phase one notes a multiplication of organisational structures, that however are quite close to each other in an intermediate combination of external and internal approaches. Ten ASOs reach the re-orientation phase, the stage of development where firms need to re-organise significantly in order to proceed in the growth path. Here we note, as said before, a multiplication of configuration, but also a widening of such configuration towards the whole range of combination of external and internal approaches of governance of knowledge. Put it differently, the governance of knowledge approach of ASOs in this phase is highly variable: some firms organise themselves in a highly internal approach of governance of knowledge, while others in the opposite highly external approach. There isn't a best approach in order to move to the next stage: this is confirmed by the fact that highly external configurations 18 (Firm c) and 21 (Firm f) and highly internal configuration 20 (Firm e) go through the last stage of development. Of the ten firms that reached the re-orientation phase, six get through the last phase. The six firms that become Silicon Valley-types of firm, organise in five configurations very similar in terms of combination of external and internal approaches. They all are concentrated in between an intermediate and an internal level of governance of knowledge. This means they build some form of hierarchies on one hand, and develop external linkages with the market environment on the other.

The findings revealed by the analysis are mainly two: on one hand there is a variety of possible paths for an idea of business to become a firm established in the market. In terms of external versus internal governance of knowledge approaches, this is particularly evident in the re-orientation phase, that is in the stage of development where firms need to re-define a core business activity and in which they need to become able to organise resources in a dynamic capability manner. The second finding concerns the fact that in order for a stand-alone laboratory to become a Silicon Valley-type of firm, the firm must acquire and build external knowledge about the market (external approach for the marketing activities) and develop internal capabilities in order to govern the productive functions given by the R&D and manufacturing and/or service provision activities. This is also reflected in the evolution of external linkages: in the beginning they are particularly important in the upstream segment of the business, that is with the parent organisation, that is the technology source of business, while they become highly relevant in the downstream segment with the development of the firm, that is in the marketing activities.

4 Conclusions

This work has sought to analyze the development paths followed by ASO firms throughout their life-cycle. The work indicates a variety of different paths in terms of organizational structures, that is in terms of knowledge governance, that have been followed by the different ASOs over their life cycle. In other words the factor bias of each firm shapes a specific path of growth and development, and for the entire population these are likely to be different, at times overlapping, paths. Finally, not all firms reach a mature stage in the life cycle; for those that do we observe a reduction in the variety of organizational structures: it appears that ASOs undergo some kind of selection processes.

Both the beginning and the end of the stylised life cycle feature a relatively lower variety of organizational knowledge and of governance structures. In the early stage these are quite close in that they share decentralized modes of governance of knowledge, similar to the stand-alone laboratory. This resonates with the notion that a new ASO firm needs to be deeply connected to the technological environment in order to be able to coordinate the useful knowledge required for the product to be developed. 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 tacitness of the knowledge 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. The deeply connected environment of Emilia Romagna and the supporting tools provided by the region are conducive to the networking activities, both with the downstream market place and with the possible horizontal complementary asset owners. The Silicon Valley-type of firm's prototype is reached by roughly half of the firms of our population at the end of the life-cycle. These firms show less variety of structures compared to the intermediary phases of the life cycle, basing their activities mainly on an internal approach of knowledge governance, therefore showing some level of integration and hierarchy.

The work also leads to some policy implications. Our work gives evidence that the process of ASO development varies within the same context. Consequently, policies should be elaborated in order to provide specific answers to specific problems arising at different stages in the development of the firm. Policies directed towards the stimuli of the ASO phenomenon, and more in general towards new technology based firms, on the contrary, are usually static in nature: they aim at providing to that context some predefined factors found correlated with good results in other contexts. This work points to the need of designing open and adaptive policies. Open in order to operate at different stages of the firms development, and adaptive in order to solve some specific problems that arise only in a particular idiosyncratic route of the firms development.

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 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 (Antonelli 2008). 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 (Knowledge Intensive Business Services), 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 as aimed by TCE and RBV, but of the knowledge organizational mechanisms undertaken by a firm.

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