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Starting Up from Science: The Case of a University-Organised Commercialisation Project

Malena Ingemansson Havenvid

6.1 Transforming Science into Business: What Are the Challenges?

Today, the conventional view of the university is not just that of an independent research and educational institution but also as a direct source of new business ventures and innovation (e.g., Meyer, 2003; Rider, 2009). Although universities have historically been expected to contribute to society in various ways (Widmalm, 2008), the contemporary role of the university is to have a more or less *direct* impact on economic growth by providing 'productified' research results ready to become embedded in a business setting (Ingemansson, 2010). The role of creating an *indirect* economic impact, by producing new knowledge and educated people that eventually create benefits for society, is now widely regarded as

M. I. Havenvid (✉)
Department of Industrial Economics and Technology Management,
Norwegian University of Science and Technology, Trondheim, Norway

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outdated and a more 'networked' view of how universities are supposed to contribute is taking over. This point of view is illustrated by the following quotation from the Lisbon Strategy, which was created as a guide for the European Union (EU) to develop into a 'knowledge-based economy':

> In the past, universities would develop new knowledge and, when it was mature, it might be picked up by business for commercial application. Far too much knowledge remains locked up in universities and the development of new knowledge takes too little account of the needs of business. This innovation model is out of date. Today, innovation is built around knowledge networks which, by sharing, developing and accumulating knowledge, facilitate a rapid development of products and services out of new ideas. (EU Communication from the Commission to the European Council, 2006, pp. 4–5)

The basic idea is that, in a knowledge-based economy, achieving innovation—new products and services—greatly depends on the development and sharing of new knowledge. From this perspective, scientific academic knowledge, and especially cutting-edge science, is given a special role as it in many ways represents the 'knowledge frontier' and therefore potentially holds a great value in spawning new business ideas. A key barrier to achieving such innovation, therefore, is when this type of knowledge remains purely 'scientific' and is not related to business needs in an effective way. Based on this assumption, policy makers have directed substantial resources to the support of academic entrepreneurship and technology transfer (Siegel, Waldman, & Link, 2003)—not least in relation to licensing and start ups (Bower, 2003). This support does not just come in the form of financial resources or legal and patenting consultancy for the researchers, but government is now also encouraging universities to take on a proactive role in the commercialisation of research (ibid.). Through the forming of innovation-facilitating organisations (holding companies, technology transfer office (TTOs), incubators, etc.), universities participate actively in selecting, developing, commercialising and exiting science-based commercialisation ventures (e.g., Baraldi & Havenvid, 2015; Baraldi & Waluszewski, 2011). Since the mid-1990s, this development has greatly affected the engagement of Swedish universities in the issue of commercialisation, and prominent examples of innovation-facilitating systems can be found at Uppsala University, Karolinska Institutet, Lund University and Chalmers University of Technology (Styhre & Lind, 2010).

University initiatives that commercialise research induce a number of questions regarding the requirements for successful commercialisation, as well as the particular conditions for creating businesses on the basis of scientific discoveries (e.g., Baraldi, Ingemansson, & Launberg, 2014). These initiatives have also spawned a wide range of studies investigating policies and commercialisation initiatives in a field now referred to as *university entrepreneurship* (Rothaermel, Agung, & Jiang, 2007). Focusing on how to best nurture scientific knowledge development from a business standpoint, the literature in this field includes investigations of associated features of the universities that commercialise its research, of their internal innovation-facilitating systems, of the commercialisation projects and start ups that are created, of different innovation-promoting policies as well as of the potential 'receiving' industries. The factors that in turn are identified as impacting the success rate of commercialisation are intimately related to the features of the nurturing environment in which business-directed scientific knowledge is supposed to be produced. For instance, access to financial and human resources (e.g., Jones-Evans & Klofsten, 1999), availability of business knowledge (e.g., Locket, Siegle, Wright, & Ensley, 2005), and certain features of the university environment that have a potential impact on the commercialisation projects (e.g., Gregorio Di & Shane, 2003) are all interpreted as key factors.

As this literature assumes a direct link between scientific knowledge development and innovation, focus for how to promote innovation is on how to foster this knowledge development; if the right conditions are in place as this knowledge is being developed, the greater the chances for commercial success. It also follows that the main determinant of whether universities or other public institutions are successful in commercialising research is the quantity of patents, licences or spin-offs that are created. Regardless if the patents or licences are being used for commercial purposes, or the spin-offs are selling products, the scientific knowledge is then perceived as having taken on a commercial form, which is regarded as one of the main challenges. However, in this chapter, it will be argued that the achievement of innovation—the widespread use of any new solution—is not facilitated by changing the conditions for knowledge development. Rather this process is dependent on how *the new*—be it knowledge or a physical solution—can be combined with existing resources in several different settings (Håkansson & Waluszewski, 2007). The context in which the new solution is developed—the *developing setting*—is merely one of three empirical settings that need to be able to combine the solution with their existing resources in a beneficial way in order for it to become an innovation. To enjoy widespread use, the solution needs not only be developed but also manufactured in a *producing setting* consisting of production facilities and business relationships. In addition, it needs to be purchased and utilised by a number of different customers, which means that it has to be combined with resource structures within a *using setting*. Represented by an industrial network perspective (Håkansson et al., 2009), this view holds that both the development and implementation of knowledge is context-dependent. As such, the value of any new piece of knowledge can only be understood in terms of how it relates to specific contexts, that is, the specific resource structures in which it is implemented. Therefore, in order to understand how the work of universities to commercialise scientific research relates to innovation, the relationship between individual, science-based solutions and their developing, producing and using settings must be included in the analysis.

From this standpoint, the purpose of this chapter is to discuss some of the challenges involved in attempting to commercialise science within the context of university initiatives for commercialisation. Using a case study of a commercialisation project initiated and run by a governmentally owned holding company run by Uppsala University in Sweden, the discussion focuses on the individual contributions of the developing, producing and using settings, as well as how these settings needed to relate to each other. Before learning more about the case, we will have a further look at how some of the issues of commercialising science-based solutions are described in the university entrepreneurship literature, and subsequently, at how such a challenge is understood from an industrial network approach.

6.2 Different Interpretations of Commercialising Science

6.2.1 Interpreting the Lack of Internal Resources as the Main Challenge for Science-Based Ventures

While being an obstacle in general for start ups, the lack of internal resources for the project or the start up business is portrayed particularly significant for projects and ventures originating in academic research. As touched upon in the introduction, one such resource is relevant knowledge, and particularly how to develop it from a business standpoint. Referring to new ventures in the interface between public and private, Locket et al. (2005) identify the 'knowledge gaps' that these ventures face at different stages of the spin-off process as a key area for further research. They see knowledge and organisational learning as crucial to investigate further in terms of the business skill sets and capabilities that might be missing at different stages of the new venture. Numerous other studies focus on the need for such knowledge at several organisational levels: the level of the individual academic (Locket et al., 2005; Meyer, 2003), the level of the start up team and management (e.g., Rothaermel & Thursby, 2005) and the level of the innovation-facilitating units (i.e., TTOs, incubators, innovation offices, etc.) (e.g., Siegel et al., 2003; Moray & Clarysse, 2005).

Regarding the individual academic level, it is often believed that academic researchers do not possess the required business knowledge for starting and running a spin-off company and therefore should leave business-specific tasks to business people. However, the inventor should be involved in the new venture in terms of the technical aspects of the invention (Locket et al., 2005). At the level of the start up team, it has been suggested that university spin-offs often consist of teams with insufficient business capabilities, and that the composition of the management teams needs further attention (Rothaermel & Thursby, 2005). At the level of the innovation-facilitating units, it has been proposed that, as the proper transfer of knowledge between the unit and the new venture is so important, the knowledge and skill set of the unit also becomes a crucial resource for successful commercialisation. Thus, the knowledge and skill sets that are relevant for the venture are, first, being able to operate from a commercial standpoint and, second, having an understanding of the specific industry, its customers and the appropriate usages of the technology (e.g., Bower, 2003; Colombo & Grilli, 2010; Feeser & Willard, 1990).

Another crucial resource that is often mentioned is capital. The access to venture capital has been highlighted as having a positive correlation to firm growth, measured as the number of employees of the venture. According to Hellman and Puri (2002), venture capitalists also provide professionalisation of start ups by assigning CEOs and filling other key positions in the company. Further, Colombo and Grilli (2010) distinguish between companies with different levels of industry-specific knowledge, and state that the involvement of venture capital is more valuable to start ups with a lack of this type of knowledge. They conclude that *The entrepreneurship literature generally agrees that human capital of founders and access to venture capital (VC) are two key drivers of the success of new technology-based firms* (Colombo & Grilli, 2010, p. 610).

The general perspective of this literature is that, if the appropriate skills are in place, a new venture should have a better opportunity of surviving and growing. However, while these skills should be industry-specific, address customer needs and technology usage, they are residing within the boundaries of the start up, or at most within the innovation-facilitating context that surrounds it (for instance, the incubator environment). Innovation-facilitating units at universities are viewed, then, as important facilitators of obtaining and transferring such knowledge to the project or venture. While this research has merit, it pays little attention to the need for interaction with the contexts involved in producing and using new products or services. Instead, these contexts are seen as separate in terms of it being possible to have knowledge regarding their requirements without specific interaction. In the next section, I present the industrial network perspective, which holds that interaction is an essential part of innovation processes, and consequently of the development of new ventures.

6.2.2 An Industrial Network Perspective on Science-Based Ventures: The Challenge of Relating the Developing, Producing and Using Settings

The Different Logics of Developing, Producing and Using

From an industrial network perspective, any new solution developed through science, or through any other activity, needs to fit into a socio-material world consisting of investment and other activities if it is to become an innovation. A number of industrial network studies have shown how the value of new technology in this sense is relative and relational (e.g., Ingemansson, 2010; La Rocca & Snehota, 2014; Linné, 2012; Shih, 2009). The relative value refers to how it can be combined with existing solutions in implementing contexts, and the relational value refers to how its benefits depend on the interaction processes between producers and users. This shifts the focus from the internal conditions of the new venture to the inter-organisational context in which it needs to become embedded; it also shifts the focus from the new solution the venture represents to how it fits into resources and can create benefits for others.

Ingemansson & Waluszewski, 2009 and Waluszewski (2007) identify three empirical settings, into which any attempted innovation needs to fit in order to become a widely used solution. These are referred to as the *developing*, *producing* and *using settings*. The developing setting represents resources adapted to the processes of research and development (e.g., Håkansson et al., 2009; Rosenberg, 1994; Van de Ven, Polley, Garud, & Venkataraman, 1999). Typically, these processes take place within environments that deal with explorative activities on a permanent or temporary basis, for example, public research environments, R&D departments or short-term development projects. In the development setting, the solution can remain 'open' in the sense that several directions and options are pursued simultaneously. In the producing setting, on the other hand, the new solution will need to be compatible with physical production facilities, supporting technologies and suppliers of materials and services. In this setting, standardising at least some features of the solution in relation to these production resources is therefore necessary (Dosi, 1982; Håkansson

& Waluszewski, 2007). For individual customers to take the new solution into use, they need to be able to combine it with their existing resources from a using point of view. Customers might represent various types of user environments that all need to gain some value from implementing the solution in combination with a number of other solutions. It might be a solution intended for use within hospital departments specialising in cardiovascular surgery, or for farmers involved in corn production. Either way, each using setting needs to combine the new solution with its specific resources and activities in order to benefit from its use. It is from the combined effects of these uses that the producing setting, in turn, needs to be able to create a positive economic outcome. Thus, the way the various customers purchase and use the solution over time is essential to how the producing structure can create economic benefits from engaging in its production (e.g., Rosenberg, 1982; von Hippel, 1988).

These empirical settings thus represent three distinctly different contexts, into which any new solution needs to fit in order to become an innovation. In addition, in any specific case, the producing and using settings consist of specific resource structures of knowledge, particular technologies, technical components and the suppliers of those technologies and components. Also, the *way* the new solution fits, or does not fit, into each of these three respective settings will affect the other settings. In this way, the settings are also interrelated, which is the main challenge for the development of new innovations. The settings individually relate to the new solution in different ways, whether from a developing, producing or using standpoint. However, the way the settings are interrelated implies that how these different 'logics' work together will significantly affect the innovation process. The different logics, in turn, are a matter of the specific resource structures in these settings. Furthermore, the interaction processes among them will affect how each setting can merge the new solution into its resource structure.

The Importance of Resource Structures

As has been argued, from an industrial network perspective the outcome of innovation processes is to a large degree directed by how the solution can be combined with the existing resource structures that the new solution is to fit into, rather than the qualities of the solution itself. Also influential in the success of innovation processes is how these structures function together as part of developing, producing and using logics. Furthermore, the actors might have different interests and objectives when engaging in such a process. In a study of the semiconductor and biotechnology industries in Taiwan, Shih (2009, p.199) states that the outcome of innovation processes is related to how the involved settings each manage to take advantage of existing resource structures, despite their different interests in doing so: *[…]producing, using and developing interfaces[…] can be characterized by close interaction or be very distant from each other. But irrespective whether the structures are close or not, they all have to take advantage of existing material and immaterial resources […]. This means that the settings will be interdependent at the same time as they have partly conflicting interests.*

In a study of an inter-organisational biotech project involving both academic and business actors, Lind (2015) also addresses the issue of different interests and goals. The project involved actors representing a developing setting (developing the scientific base of the project) as well as potential producers and users. Among these actors and settings, there were different goals that were primarily related to their respective sets of resources. Through a 'goal—and resource-matching' process, some of the goals eventually intersected by the actors identifying resource combinations as 'mutual resources', while others did not. This illustrates that, in the development of new solutions, the interests and objectives of the involved actors will relate to the resource structures in which they operate and how they can utilise them in relation to the new solution; this has been identified as a possibly even greater challenge for science-based ventures than for other ventures (e.g., Ingemansson, 2010; Ingemansson & Waluszewski, 2009). While the developing setting is involved primarily in academic knowledge production, both the producing and using settings represent different value-creating logics and objectives. In turn, this can make the identification of mutual resources difficult.

It also suggests that the outcome of developing new solutions and forming new ventures is not determined by any one actor or any one particular resource. Rather, it is dependent on how *the new* is combined with a number of different resources within different settings, and how the actors in those settings can create beneficial resource combinations in relation to each other. Along these lines, Ciabuschi , Perna, and Snehota (2012), p. 228 propose that new business formation needs to be considered as a collective rather than an individual act: *Given this collective nature of new business formation, how a venture will develop is difficult to foresee and also prevents any single actor driving and directing a new venture autonomously.*

Next, we will investigate a commercialisation project run by the governmentally owned holding company at Uppsala University that involved both academic researchers and business actors. By engaging in a joint collaboration for a new type of battery solution, the aim was to direct and speed up the commercialisation process towards industrial production and use, by gathering together the necessary actors. However, first we will look into the method used to engage in a case study of this project.

6.3 A Note on Method

This chapter details a case study of a commercialisation project that ran from late 2010 to early 2014. The case study approach is often chosen when the focus lies on analysing the role of the context (e.g., Dubois & Gadde, 2002) and the fundamental reasons for particular events (Dubois & Araujo, 2004). It is thus a matter of going in-depth into specific processes and investigating the reasons why they have unfolded in specific ways (Flyvbjerg, 2006). In this study, this was done by investigating the settings of development, production and use in terms of the actors involved in each setting and the main resources related to the processes of the project. For this purpose, *resources interaction* (Håkansson & Waluszewski, 2007) was used as a central concept to identify and analyse the technical (products and facilities) and organisational (organisational units and relationships) resources surrounding the new solution in the respective settings. By making the new solution the focus of study, and examining how it interacted with the surrounding resources in these settings, the purpose was to gain insight into the ways in which science-based solutions need to relate to established business networks, and what role innovation 'intermediaries' or facilitating actors can play in that process.

What should constitute the 'boundaries' of a case study is a widely debated issue with little consensus (Ragin & Becker, 1992). Here, the events that are described and analysed are confined to the time period during which the project was funded (2010–2014). The analytical focus was on tracing the resources of the three described settings that affected the development of the new solution in various ways. With this focus, the study is based on interviews with and observations of the central actors involved in the project as it progressed. The interviews were done over the period 2010–2014 with the academic researchers, the commercial partners and the holding company—in total, 15 interviews. Participating observations were made during two meetings involving the project members in 2010 and in 2012. All the commercial sites of the actors involved were also visited: F.O.V in Borås, Sweden; ETC in Gothenburg, Sweden; and FMC Biopolymers in Ewing, New Jersey, USA. Written sources such as project descriptions and scientific publications related to the project were also used. In addition, three bachelor theses investigating the industrial networks of the project's commercial partners (suppliers and customers) were completed in 2011. The overarching purpose of these theses was to investigate the commercial potential of the new technology in terms of how the partners could engage in the commercialisation project using their respective business networks.

6.4 The Case of the Salt and Paper Battery Project: Developing, Producing and Using Settings Involved in an Attempt to Commercialise Science

6.4.1 The Initial Scientific Research and Development: The Idea for a New Battery Takes Shape

During the 1990s, a research group at the *Department of Nanotechnology and Functional Materials* at the *Ångström Laboratory* at *Uppsala University* started to do research on the cellulose of a particular type of alga—*Cladophora*. The research work, which was led by an associate researcher specialised in nanotechnology and a PhD student with a degree in pharmacy, was based on developing knowledge about the particular features of its surface area, and how this could potentially be used for biomedical and pharmaceutical purposes. It was concluded that this cellulose had a very high surface area (~100 m^2/g), had a high crystallinity[1] and could be dispersed in water. As a result, it had superior qualities compared to the cellulose traditionally used in pharmaceuticals (tablets). In the late 1990s, this discovery created an interest at the *FMC Corporation*—a global supplier of chemicals for agriculture, food industry and pharmaceuticals. FMC was also the only supplier in the world of this particular type of alga cellulose and was therefore a potentially very beneficial collaborator from the research group's point of view. This resulted in what would become a longstanding collaboration between one of FMC's divisions, FMC Biopolymer (now FMC Health and Nutrition) and the research group.

During the first years of the collaboration, the work mainly concerned potential applications for pharmaceuticals. This resulted in the research group discovering several new qualities of the material that were useful for tablets, some of which proved valuable for FMC. The research at Ångström continued, and the idea that the material could also be used for conductive purposes started to form. The question they asked themselves was, what would happen if we could make a material with this high surface area to conduct electricity? Cellulose is however not a conductive material, rather it is used as an isolator of electricity. However, due to the high surface area of the alga it had great potential of interacting with the surrounding environment and with other materials, and therefore also had the potential of interacting with and containing a great deal of ions. For this purpose, the cellulose was coated with a conductive type of plastic (polypyrrole) which made it 'electroactive'. By placing this joint material in a fluid and bringing on a voltage, ions could be 'forced' into the material from the surrounding fluid. The idea was that this material could be used for biotechnical and biomedical purposes as a way to filter both desirable and unwanted protein from different types of solutions. However, in this process, it was discovered that the material could hold a lot more ions than expected. As the basic idea of a battery is that it

[1] This means that the material is organised in a particular structure (compared to an *amorf* material which is organised in a random structure).

should contain as much ions as possible to get a high-energy density, the idea that it could be used as a battery was born. In a publication of these results in the scientific journal *Nano Letters* (Nyström et al., 2009), in which the material was shown to efficiently charge and discharge (thus functioning as a superconductor), it was stated that *we introduce a novel nanostructured high-surface area electrode material for energy storage applications composed of cellulose fibers of algal origin individually coated with a 50 nm thin layer of polypyrrole. Our results show the hitherto highest reported charge capacities and charging rates for an all polymer paper-based battery* (ibid.). This became one of the most read articles of the journal the same year it was published, 2009. It was these initial and encouraging results that were the foundation of starting an academia–industry collaboration led by Uppsala University Holding AB (UUAB) Holding—the holding company managed by Uppsala University and owned by the Swedish government—in the pursuit of commercialising a new type of battery.

6.4.2 A Joint Academia–Industry Commercialisation Project: The Producing and Using Settings Get Involved

In December 2010, the start up meeting of the commercialisation project around the new potential battery was held at Arlanda Airport in Stockholm. It had by then been named the *Salt and Paper Battery Project* (S&PB project) as these were the basic components of the battery—cellulose and a saline solution. The project group attending the meeting consisted of both Swedish and foreign company representatives, a Finnish research institute and the academic researchers from Uppsala. The agenda for the day was to discuss how to proceed in the technical development as well as commercialisation of the new material that could be used for a new type of battery solution. The group, led by the holding company at Uppsala University, UUAB, had just received financing for the next three years from the Nordic Innovations Centre (NICE)[2] for academia–industry collaboration. The goal of these

[2] NICE is a cross-border organisation under the Nordic Council of Ministers for the promotion of economic growth and competitiveness in the Nordic countries. For further information: www.nordicinnovation.org.

three years was to bring forward a prototype that would be ready for commercialisation, that is, industrial applications. A criterion for receiving funds from NICE was that several Nordic countries had to be represented in the group, which, of course, affected which members were selected. However, UUAB's idea for how the group should be formed also specified that the members should represent knowledge and experience of (1) how to further develop the material from a scientific and/or technical standpoint, (2) how to identify appropriate uses and products for the new battery and (3) how to manufacture it in an economically viable and environmentally friendly way. Therefore, the members represented scientific and expert knowledge (the research group at the Ångström Laboratory and the Research Institute of Finland, VTT), a potential industrial user (F.O.V Fabrics in Borås, with its connections to the car manufacturing industry) and production skills with FMC Corporation—a global producer of cellulose and speciality chemicals. The group also had members with product development skills in how to design batteries, namely the battery-testing and development company, E.T.C Battery and FuelCells Sweden AB in Gothenburg, Sweden. This company was also working closely with the car manufacturing industry and had experience of setting up pilot production lines for batteries.

The project leader, UUAB, would coordinate the members of the project, facilitate communication within the group and pursue suitable industrial partners. All members of the group, both commercial and academic, were subsidising the commercialisation project so that they would function as *active* members, actively contributing to the commercialisation process from the standpoint of their respective businesses and ongoing activities.

6.4.3 The Interpretation of Production and Use: The Roles of the Industrial Partners

For UUAB, there were a number of options in relation to an attempt to commercialise the potential battery. One of them was to form a start up, but, as the research was still in its infancy, it was not considered the optimal course forward at that point. Also, from earlier experience of start ups, UUAB believed that this option would take too much focus away from the technical development and the search for appropriate usages of the battery. Instead, it wanted to try a different direction. By forming a group consisting of actors from both academic research and relevant industrial environments, UUAB's idea was to work with several aspects of the commercialisation concurrently, so that the process of finding a use for the new product would be sped up. Whether or not this would lead to the forming of a start up later on was considered a future issue. It had the intention of coordinating scientific research, marketing of the project and the product, as well as setting up a pilot production of the new product more or less simultaneously; as these aspects would be dealt with in parallel, the commercialisation process would also be accelerated. In this coordinating role, the first and main task of UUAB was to identify at least one application for the technology, so that the technical development, marketing and production could advance with the help of an industrial partner, whether within the project group or an 'external' partner. The ambition of facilitating the transition of the new battery from science to industry by handling several issues in parallel shaped the constellation of the project group and the roles of the different actors. Next, follows a presentation of the industrial partners of the project and what their intended roles were.

FMC Biopolymers

FMC Biopolymers—a division of the global corporation FMC Corporation—was involved through its units in Philadelphia, USA, and in Trondheim, Norway. The work of trying to incorporate the *Cladophora* alga in cellulose production was mainly done in Philadelphia. The work in relation to the project of developing and commercialising a new battery technology was focused on scaling up the production of the alga cellulose from laboratory to pilot scale. The task of the group at FMC was to supply the S&PB project with cellulose that could be used for research and development purposes, either by the researchers at Ångström and VTT or the other commercial partners, ETC and F.O.V. Therefore, it was important that the cellulose it supplied to the project was of optimal quality for the particular purpose of developing a material with high-energy density and thus had a high surface area. This demanded that the process development group at FMC needed to start at laboratory scale in its investigation of what types of equipment and chemicals could be used, and then scale up this process. As such, it was about starting from scratch, attempting to build a production process around the *Cladophora* alga.

ETC Battery and FuelCells

As a development company involved in battery testing, ETC Battery and FuelCells in Gothenburg was considered by UUAB a useful partner in testing and developing the new material as part of a commercial battery. ETC was a small non-profit organisation that would act as a link between academia and industry. Its members represented several Swedish universities (among them Uppsala university), private companies (Vattenfall and Göteborgs Energi) and the municipality. ETC owns and/or collaborates with a number of companies, such as the spin-off company, Alelion, which produces lithium-based batteries and of which ETC still owns about 10 %. There are also collaborations and joint projects with, for instance, SAAB and Volvo. ETC's role in the S&PB project was design and laboratory-scale production of battery cells, electrical testing, suggestions for potential applications and suggestions for how to set up a pilot production of battery cells. It was also to work together with Motorola in developing a prototype for a remote control based on the new battery technology. In direct connection to the S&PB project, the battery-testing facility expanded in terms of testing equipment, and a new manager was hired to handle both the testing activities and the communication with the rest of the project group.

F.O.V Fabrics

F.O.V Fabrics is situated in the heart of textile production in Sweden (Borås) and has a vertically integrated production of clothing and technical textiles (for instance, for the car industry, the military etc.). With about 100 employees, it manages to produce about eight million square metres of advanced fabric per year, with the European market as its prime target. The most famous product developed by F.O.V is the airbag, which was launched during the early 1990s. The two current owners of the company, who bought it in 2008, have the ambition of continuing the development of technical textiles. One specific product area they have identified as potentially profitable in the future is that of so-called smart textiles, in which conductive fabrics is one trend. Therefore, when the research results became known to them, the owners of F.O.V approached the research group at Ångström. A dialogue was initiated and, when the opportunity of financing from NICE appeared, F.O.V joined the S&PB project. Its role in the project was dual: to assist in the development of suitable fabric material that could be used as a component in the battery, and identify potential application areas for the battery in terms of technical textiles and clothing. For this purpose, F.O.V hired an electro engineer who was to work with the technical aspects of different fabrics, both in relation to using it as a component in the battery and as an application. Demands from the research group at Ångström related to required qualities of the fabric material was the trigger for the search for fabric suppliers within their established supply network, as well as from 'outside'. Another issue was which type of fabric coating could be used for attaching electrodes, and this was investigated in collaboration with the Swedish School of Textiles. One central issue, apart from the technical development aspects of the battery and how it could be made to function in a textile product, was the identification of customers for such products. Smart textiles and conductive textiles were, and still are, very new product areas and there was no existing supplier to learn from.

6.4.4 The Outcome of the Three-Year Funded Project

The foundation for the commercialisation project was the research results made at Ångström that related to how a particular material with a high surface area (algal cellulose coated with polypyrrole) could carry electrical charge. While the results had shown that it was possible to charge and discharge this material, there was a lot more to find out about *how* this charging and discharging was taking place, so that this process could be controlled and optimised for different purposes. To coordinate this continuing research effort, and to create a distinct link between the academic research and the commercialisation project, the Department of Nanotechnology and Function Materials hired an assistant researcher specialised in electron transport. The objective was to do academic research relevant to industrial applications.

However, an unanticipated discovery put the focus of finding industrial uses for the battery on hold; there was a problem with actually getting the material to hold the charge, and instead it discharged quite quickly. How and why this was happening was far from obvious. The initial hypothesis was that it was related to how the materials were combined in the battery (how the solids reacted with the fluid etc.) and that the solution to the problem, therefore, was to change how the combination was set up. However, further research showed that it was an integral quality of the conducting polymer itself (the polypyrrole); the material degraded as it was being charged, which eventually made it discharge. In 2013, and thus by the end of the three-year, NICE-funded S&PB project, the research group had reached two important understandings in relation to this issue: *how* the material was degrading, and that it was possible to charge the material without degrading it. However, there was still no conclusion in regard to how this could be done within the framework of a battery. In the research process of reaching these two conclusions, the research group stopped using cellulose from alga, as this particular type of cellulose only added to the complexity of trying to learn what was happening with the polypyrrole material and why. Also, in the effort of reaching enough charge of the battery, there were difficulties with completely excluding metal components, which was the initial goal.

During the three years of the commercialisation project, the research generated several PhD projects and publications, and it became the single largest research programme in the department in terms of staff and funding. For the purpose of doing further research on the basic features of the material, the research group obtained funding through a five-year research grant from the *Swedish Foundation for Strategic Research*. During the time of the grant, the group also established an important relationship with the Finnish research institute, VTT, which supplied it with essential knowledge of the properties of the material as well as craftsmanship in handling it in experiments. This cooperation has led to several co-publications of Ångström and VTT, as well as subsequent joint research projects supported by EU funding.

For the commercial partners, the S&PB project was not as significant in relation to the creation of the new battery. In relation to the research that was and is going on at the Ångström Laboratory—which at one point excluded the *Cladophora* alga—FMC Biopolymers is no longer a key partner. However, FMC has, as a result of the project, developed a pilot-scale production (from harvesting to production) of this particular alga cellulose that preserves as much surface area as possible; currently, this is mainly related to the production of their existing products. ETC is also presently no longer involved in the research taking place at Ångström; its collaboration with Motorola is also dormant, as the S&PB has not proven itself as a functional battery technology yet. In addition, when the funding of the project ended (and as ETC is a non-profit organisation dependent on external funding), the company needed to search for other projects in which to become involved. Even though F.O.V Fabrics took the initiative to become involved in the project, hiring new personnel to develop suitable fabrics and tried to identify both suppliers and customers for conductive textiles, it did not engage any suppliers or customers in the project, nor did it engage its own production facilities. In its judgement, these activities were not something it could proceed with until the new technology was further developed and it could determine what type of production adaptations would be necessary. It is, however, still collaborating with the research department at Ångström.

By the end of the project, UUAB had changed its strategy from trying to identify at least one application for the Salt and Paper Battery to a wider approach of marketing the technology as a platform for developing and commercialising different energy storage solutions. The project thus changed its name to *Energy Scandinavia* (ENESCA) and, in the pursuit of industrial partners, it now attends international industrial conferences with central researchers in the Ångström research group, marketing the project through, for instance, crowd sourcing for further ideas of how to implement the new technology.

6.5 Discussion

UUAB's effort to industrialise the production of the new battery technology was unsuccessful within the framework of the NICE-funded project. Speeding up the commercialisation process by involving commercial partners at an early stage and, in this way, trying to shape both the research and commercialisation process in particular directions, did not work—at least not within the set timeframe of the project. To discuss the challenges of engaging in such a project, this section analyses the actors involved in the project from the standpoint of the resources they brought to it, as well as the larger resource structures they represented.

From the logics of development, production and use stated earlier (Håkansson & Waluszewski, 2007), we can conclude that these settings each have a particular way of engaging in the innovation process. In any particular case, there are also specific actors and resources that represent these settings; this has several important implications, for example, while a general logic can be applied to these respective settings, any particular case must be understood from the standpoint of the specific actors and resources involved. This also means that the outcome of the innovation process is a result of these specific actors and resources and, consequently, the specific interaction processes they engage in, both in relation to the innovation process and to all the other activities in which they are involved (e.g., Van de Ven et al., 1999). A second implication is that the existing resources of these actors—with which the potential innovation is to combine—such as knowledge, production facilities and business relationships, are in turn related and adapted to a larger resource structure *unrelated* to the potential innovation. In the case of university-organised commercialisation projects, this means that the outcome will be the result of interaction processes involving different settings conditioned by different logics. More specifically, these settings involve actors with specific sets of resources, and thus each project needs to be understood in the context of how the new solution can be combined with these resources that relate to larger structures 'outside' the project.

In the case presented in this chapter, there was an overarching common objective of the project members to try to develop the battery towards industrial production and use. However, in this pursuit, each member organisation needed to find individual ways to combine the solution with their existing resource structure. In turn, this resulted in different ways of trying to benefit from and engaging in the project. Part of the *developing setting*—the research group at Ångström Laboratory and VTT—mainly engaged in testing materials in terms of learning about their basic qualities and features. Being involved in basic and applied research, these actors engaged a set of resources that were suited for exploring the components of the potential battery on a fundamental level. While there was a clear interest in identifying commercial uses for this potential battery solution, these actors could also benefit in other ways from the ongoing research process. Therefore, the quite unpredictable development process of the potential battery was actually creating a number of unforeseen benefits. The research group at the Ångström Laboratory produced several publications and PhD projects, engaged in further research collaboration with VTT and received further funding from different sources. Thus, from an academic point of view, the way in which the battery remained a 'research puzzle' was in this way positive; in fact, it grew to become the largest project at the department.

As the research needed to gain more knowledge about the energy-storing material (polypyrrole), the development process took a particular direction. This in turn had direct consequences for FMC Biopolymer. Involved in both developing a pilot production line and producing large quantities of the specific alga needed for the project, FMC was part of the *producing setting* for a main component of the battery. During the project, it managed to develop and scale up the whole process, from harvesting to supplying the alga. However, as an effect of the research process in the developing setting, the alga was eventually removed from the research process and consequently the project, which meant that the resource structure of FMC was no longer of any benefit to the developing setting or to the project at large. However, for FMC, this was not a purely negative development, as its larger resource structure of earlier investments, products, production facilities and business relationships was mainly related to algae and not to batteries. Therefore, its main interest was in pursuing more knowledge and developing more efficient ways of handling this specific alga in relation to the products it was already involved in, such as pharmaceuticals and foodstuffs. This meant that the resource adaptations performed by FMC were still creating benefits for it, but not in the way originally intended. Thus, while FMC appeared to represent highly relevant business knowledge at the onset of the project, and even engaged in the production of a main component, the way the commercialisation process evolved due to the developing setting completely changed its role. This complicates the idea portrayed by some of the university entrepreneurship literature that the appropriate knowledge and skill sets should be in place for a more successful commercialisation project (e.g., Locket et al., 2005; Rothaermel & Thursby, 2005). Evidently, the knowledge and skill sets that are needed can change quite drastically as an effect of the interaction of resources, both within and between settings.

For the potential users—F.O.V and Motorola—the ever-evolving nature of the research process and solution made any investments or adaptations in their resource structures inconceivable. Before the basic features of the potential battery technology were established (such as the components and their conductive abilities), it was difficult for them to relate it to their existing products, production facilities, suppliers and customers. Thus, the *using setting* of the potential battery was finding it impossible to justify the engagement of any resources in relation to an unfinished technology. F.O.V was a potential user of the battery in terms of incorporating it into textiles and it represented knowledge of large-scale production, but only in relation to fabrics and textiles. Therefore, it first needed a functioning battery in order to justify adapting its production processes to the new technology. The same applies for Motorola; in order to start incorporating the battery into its products, it would have to be clear how it would interact with the other components of its products and production processes. This shows that, while the idea of engaging potential users in the project was a way of trying to speed up the commercialisation process, the processes needed for a 'true' identification of use to happen require embedding the new solution within specific user environments. As a first step, this demanded that some features of the solution remained constant. As shown by Ingemansson (2010), the overall effects of such embedding processes take time to appear and it is only through these that the 'true' user pattern and buying behaviour is revealed. Again, this complicates the picture of having knowledge of the appropriate usages of new science-based technology ex ante (e.g., Bower, 2003; Colombo & Grilli, 2010; Feeser & Willard, 1990).

Lastly, ETC was also involved as part of the developing setting in creating a pilot production line for a complete battery solution. However, due to the insufficient knowledge and financial and production resources that ETC involved in the project, it would not have itself been able to become a producing unit for the new battery. Its knowledge and technical resources were thus connected to developing batteries, not producing them. This means that there was no 'full' producing structure around the potential battery technology. Thus, the producing setting, represented only by FMC Biopolymer, could not engage in establishing a production process that could assemble or produce the battery as a whole. While there surely would have been some challenging adaptation processes had such an actor been involved, there were no resources that could have been used as a standpoint for such a process.

This analysis shows that the potential battery solution, that was originally supposed to be a 'mutual resource' (Lind, 2015) from which all the project members could create various benefits, primarily remained a resource to the academic researchers in the developing setting. The producing setting managed to use the development of the solution in a beneficial way only in relation to one of its components, the alga, to which its resource structure was already adapted. For the using setting, it was hard to provide guidance on how to further develop the solution, as it could not relate it to its existing resources. This also made it difficult to create any benefits from a using point of view. The role of the innovation-supporting holding company, UUAB, was to facilitate and coordinate the commercialisation project. However, as the analysis of the settings of development, production and use has shown, the influence of such support was very limited, as the process depended on the interaction between settings that needed to create their own benefits in relation to their specific resource structures. These existing structures were not something that UUAB could have had any real influence on. Therefore, it was ultimately about how the potential battery solution could be combined with these structures and which adaptations could be made on this basis. In this combining process, the actors that benefitted did so not necessarily in relation to the goal of the project, but primarily in relation to their own existing resources and ongoing activities.

6.6 Conclusions

The nowadays 'networked' policy view of universities suggests that they are (or should be) part of knowledge networks that ultimately facilitate and speed up the development of new products and services. One approach that has been observed at several prestigious Swedish universities is to organise commercialisation projects based on new research to identify commercial applications that might otherwise have remained 'undiscovered'. From this view, the main problem of commercialising science is that the knowledge being produced at universities traditionally is 'locked up' rather than being more openly revealed to various commercial actors. Making universities and researchers part of networks that include business and investment actors is therefore seen as an essential part of the solution to this problem. Focus is placed on the *availability* of scientific knowledge, which, once accessed, can be applied in a business environment, with the right skills.

The university entrepreneurship literature (e.g., Rothaermel et al., 2007) investigates a number of factors that appear to affect how well science-based ventures succeed. In essence, these factors relate to the resources available for the individual venture to exploit, for instance in terms of relevant knowledge as well as financing. Here, the focus is instead placed on the individual venture, project or start up, in terms of how it needs to build a base of human and financial capital to make sense of relevant markets. This type of 'inside-out' perspective of the firm presupposes that the knowledge needed for the new venture to develop as a business can be identified ex ante, that is, before the involvement of relevant production partners and users. Although some type of market analysis and forecasting is necessary for new ventures without established producing or using structures (existing suppliers and customers), this assumption is problematic. Firstly, it is far from evident which type of customers is actually relevant and, secondly, it is largely unknown if and how they will use the new products or services (e.g., Ingemansson, 2010; Waluszewski, Håkansson, & Ingemansson, 2014).

In the case presented in this chapter, it was shown that, while business actors were involved in the project, the way their knowledge could be applied was largely dependent on how they could engage their existing resources in the project and which benefits that could be created from doing so. Thus, in order to engage in the production and use of any new solution and provide specific knowledge of how to do so, it needs to become related to the resource structures to which it is supposed to contribute. Therefore, 'general' business knowledge is insufficient and, even when specific actors interested in commercialisation are involved, the main challenge remains how to engage in the innovation process in a beneficial way from the different logics of development, production and use and in relation to specific resource structures. Furthermore, from the perspective that knowledge is context-dependent, the assumption that scientific knowledge development can be shaped by the facilitation of innovation becomes 'backwards'. Rather, to serve a purpose, knowledge will mainly be related to its surrounding context, and therefore its actual usefulness always needs to be revealed over time through interaction processes. Thus, from an industrial network perspective, the ultimate challenge of starting up new ventures from science lies not in how to better 'reveal' new research results to commercial actors or how to gain access to human and financial capital. The main challenge is rather managing to combine the new solution created from these results into producing and using settings. This is part of a process that lies outside the influence of any individual actor (Ciabuschi et al., 2012), as it needs to involve multiple actors that need to be able to create their own respective benefits from engaging in either producing or using the new solution.

References

Baraldi, E., & Havenvid, M. I. (2015). Identifying new dimensions of business incubation: A multi-level analysis of Karolinska institute's incubation system. *Technovation, 50–51*, 53–68.

Baraldi, E., Ingemansson, M., & Launberg, A. (2014). Controlling the commercialisation of science across interorganisational borders. Four cases from two major Swedish universities. *Industrial Marketing Management, 43*(3), 382–391.

Baraldi, E., & Waluszewski, A. (2011). Betting on science or muddling through the network. Two universities and one innovation commission. *IMP Journal, 5*(3), 172–192.

Bower, J. (2003). Business model fashion and the academic spinout firm. *R&D Management, 33*(2), 97–106.

Ciabuschi, F., Perna, A., & Snehota, I. (2012). Assembling resources when forming new business ventures. *Journal of Business Research, 65*, 220–229.

Colombo, M. G., & Grilli, L. (2010). On growth drivers of high-tech start ups: Exploring the role of founders human capital and venture capital. *Journal of Business Venturing, 25*, 610–626.

Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy, 11*, 147–162.

Dubois, A., & Araujo, L. (2004). Research methods in industrial marketing studies. In H. Håkansson, D. Harrison, A. Waluszewski (Eds.),*Rethinking marketing: Developing a new understanding of markets*. Chichester: John Wiley & Sons.

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research, 55*(7), 553–560.

EU (2006). Communication from the Commission to the European Council, 589.

Feeser, H. R., & Willard, G. E. (1990). Founding strategy and performance: A comparison of high and low growth in high tech firms. *Strategic Management Journal, 11*, 87–98.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry, 12*, 219–245.

Gregorio Di, D., & Shane, S. (2003). Why do some universities generate more start ups than others? *Research Policy, 32*, 209–227.

Håkansson, H., & Waluszewski, A. (Eds.). (2007). *Knowledge and innovation in business and industry—The importance of using others*. London: Routledge.

Håkansson, H., Ford, D., Gadde, L-E., Snehota, I., and Waluszewski, A., (2009). *Business in Networks*, Sussex, UK: John Wiley and Sons.

Hellman, T., & Puri, M. (2002). Venture capital and the professionalization of start up firms: Empirical evidence. *The Journal of Finance, LVII, 1*, 169–197.

IngemanssonM. (2010). *Success as science but burden for business? On the difficult relationship between scientific advancement and innovation.* Dissertation, Uppsala University, Uppsala, Sweden.

Ingemansson, M., & Waluszewski, A. (2009). Success in science and burden in business. On the difficult relationship between science as a developing setting and business as a producer-user setting. *IMP Journal, 3*(2), 20–56.

Jones-Evans, D., & Klofsten, M. (1999). Creating a bridge between university and industry in small European countries: The role of the industrial liaison office. *R&D Management, 29*(1), 47–56.

La Rocca, A., & Snehota, I. (2014). Relating in business networks: Innovation in practice. *Industrial Marketing Management, 43*, 441–447.

Lind, F. (2015). Goal diversity and resource development in an inter-organisational project. *Journal of Business & Industrial Marketing, 30*(3-4), 259–268.

Linné, Å. (2012). *China's creation of biopharmaceutical drugs: combining political steering, military research, and transnational networking,* doctoral thesis, Department of Business Studies, Uppsala University, Uppsala.

Locket, A., Siegle, D., Wright, M., & Ensley, M. D. (2005). The creation of spin-off firms at public research institutions. Managerial and policy implications. *Research Policy, 34*, 981–993.

Meyer, M. (2003). Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanisms. *R&D Management, 33*(2), 107–115.

Moray, N., & Clarysse, B. (2005). Institutional change and research endowments to science-based entrepreneurial firms, *Research Policy*, *34*(7), 1010–1027.

Nyström, G., Razaq, A., Strømme, M., Nyholm, L., & Mihranyan, A. (2009). Ultrafast all-polymer paper-based batteries, *Nano Letters*, *9*(10), 3635–3639.

Ragin, C., & Becker, H. S. (1992). *What is a case? Exploring the foundations of social inquiry*. Cambridge: Cambridge University Press.

Rider, S. (2009). The future of the European university: Liberal democracy or authoritarian capitalism? *Culture Unbound: Journal of Current Cultural Research, 1*, 83–104.

Rosenberg, N. (1982). *Inside the black box: Technology and economics*. Cambridge, UK: Cambridge University Press.

Rosenberg, N. (1994). *Exploring the black box—Technology, economics, and history*. Cambridge, UK: Cambridge University Press.

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change, 16*(4), 691–791.

Rothaermel, F. T., & Thursby, M. (2005). Incubator firm failure or graduation?: The role of university linkages. *Research Policy, 34*(7), 1076–1090.

Shih, T. (2009). *Scrutinizing a Policy Ambition to Make Business Out of Science – Lessons From Taiwan,* doctoral thesis, Department of Business Studies, Uppsala University, Uppsala.

Siegel, D. S., Waldman, D., & Link, A. N. (2003). Assessing the impact of organizational practices on the productivity of university technology transfer offices: An exploratory study. *Research Policy, 32*(1), 27–48.

Styhre, A., & Lind, F. (2010). The softening bureaucracy: Accommodating new research opportunities in the entrepreneurial university. *Scandinavian Journal of Management, 26*(2), 107–120.

Van de Ven, A., Polley, D., Garud, R., & Venkataraman, S. (1999). *The innovation journey*. New York: Oxford University Press.

Von Hippel, E. (1988). *The sources of innovation*. New York: Oxford University Press.

Waluszewski, A., Håkansson, H., & Ingemansson, M. (2014). Innovation forecasts—Unavoidable and context dependent. *Industrial Marketing Management, 43*(6), 1045–1052.

Widmalm, S. (2008). Forskning och industri under andra världskriget. In Widmalm, S., ed. (2008) *Vetenskapens Sociala Strukturer. Sju historiska fallstudier om konflikt, samverkan och makt*, Lund: Nordic Academic Press.