Paper submitted to IMP 2014

UNIVERSITY SPIN-OFFS AND THEIR ROLES IN BUSINESS NETWORKS

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ABSTRACT

This paper explores university spin-offs and their roles in business networks. It does so through mapping how university spin-offs establish themselves in a network to enable commercialization of their ideas. The theoretical frame of reference is rooted in the IMP-literature and focuses on roles, ways of approaching networks and resource development. The research is based on a multiple case study approach of five cases that have spun off from universities in Sweden and in Taiwan. Findings point to three different roles: intermediation, technology diversification and technology renewal. These roles are relative established actors in the network and hence indicate how the spin-off becomes part of such structures. The paper contributes to previous research through illustrating the process of finding a role, and through describing how a spin-off may choose different strategies, while still being dependent on established structures. By providing empirical evidence in this area, the paper aims to contribute to the IMP as well as the entrepreneurship literature.

Keywords: start-ups, spin-offs, networks, roles, university entrepreneurship

INTRODUCTION

In recent decades, the role of the university has expanded to include increased collaboration with industry (Gibbons et al., 1994; Etzkowitz and Leydesdorff, 2000). With regards to the so-called entrepreneurial university, there is a strong emphasis on academic knowledge to be used more effectively as a source of innovation and renewal in industry. One concrete example of stimulating university entrepreneurship is the attempts made by universities, incubators, policymakers and funding agencies to support and promote spin-offs from university research. Such university spin-offs (USOs) are defined as firms founded by university researchers based on academic knowledge (cf. Mustar et al., 2006). The USOs are a unique group of firms within the sphere of new-technology-based firms (NTBFs) and start-ups. Closely related to the USOs are corporate spin-offs and indirect university spin-offs. As the name implies the corporate spin-offs are spun out of existing companies, while the indirect university spin-offs are firms where the idea is originally from the university but the founder has worked within industry before founding the firm (Lindholm Dahlstrand, 2007).

The different types of spin-offs have different conditions and are therefore compared in literature. In comparisons (e.g., Lindelöf and Löfsten, 2006; Lindholm Dahlstrand, 2007) USOs display the lowest growth rates. Similarly, Wennberg et al. (2011) found that USOs tend to be riskier with higher failure rates and lower growth prospects than corporate spin-offs. Hence, from a practical point of view, it is important to study specifically how USOs may become more robust and viable. From a policy perspective, these studies are also important since large amounts of governmental funding are used to fuel the growth of USOs.

This model of creating USOs is encouraged by current policy but extremely difficult to manage and practice. A reason is that the research ideas that are the basis for the USOs are often radical or disruptive, including research discoveries, patents and related ideas for product development (Almus and Nerlinger, 1999). Moreover, USOs usually do not have established relationships to market actors, which in conjunction with their embryonic ideas imply that they do not easily fit into present structures (Chandy and Tellis, 1998). In order to commercialize research, the USOs need to face and sometimes challenge present business structures. Facing this, there are different actors belonging to different systems, or networks that need to be interacted with in various ways. Networks refer to how companies interact for business purposes (cf. Håkansson et al., 2009). Previous studies of USOs in networks have tended to focus on how a network can provide access to necessary resources for the USO (e.g. Hite, 2005), how the USO should create a customer portfolio that ensures high performance (e.g. Ozcan and Eisenhardt, 2009), clusters (e.g. Asheim and Coenen, 2005), network content and network structure (Hoang and Antoncic, 2003).

So far in the literature, relatively little attention has been paid to *how* USOs emerge and become part of established networks (La Rocca and Snehota, 2014; Anderson et al., 2010). Recently, IMP (Industrial Marketing and Purchasing)-based studies have focused on USOs in networks (Snehota 2011; La Rocca and Snehota, 2014; La Rocca et al., 2013; Aaboen, Dubois and Lind, 2011; 2013; Öberg and Shih, 2014; Laage-Hellman, 2012). Those studies pinpoint the importance of the initial business relationships (Aaboen et al., 2011; La Rocca et al., 2013; Öberg, 2010) and what can be learnt through the relationships and how individual relationships can function as motors in the USOs commercialization processes. Expectedly though, the USO can take on different roles in present network structures.

This paper focuses how USOs establish themselves in a network to enable commercialization of their ideas. Specifically, we study network roles of USOs. The purpose of the paper is *to explore USOs and their roles in business networks*. To accomplish this, we build on multiple cases of USOs and their development. The paper contributes to the study of how USOs get established in networks. The cases in the present paper illustrate a variety of roles and this observed variety of roles is to contribute to the relatively scarce literature on USOs establishment in business networks (La Rocca and Snehota, 2014; Anderson et al., 2010).

The structure of the paper is as follows. Next the theoretical frame of reference is presented, followed by the method section. Then five cases are presented and shortly commented on. The paper ends with a discussion and some concluding remarks.

THEORETICAL FRAME OF REFERENCE

This paper takes a network perspective on university entrepreneurship and a USOs role in a network. To be able to capture USOs development the paper departs from the IMP approach to business markets that enable us to study changes in networks. The IMP research tradition emphasizes interaction and networking over time between companies as a source of value creation (Håkansson et al., 2009). Our starting point is that interaction in inter-organizational relationships is crucial for USOs' development and commercialization endeavors (Baraldi et al., 2014). An USO would not have those necessary relationships from start (something that also separates the USO from other types of spin-offs), and hence needs to find ways to approach the network. This, and how such ways can be thought of as roles in the network frames this paper theoretically.

Ways of approaching the network

Literature on how companies strategize in network indicates how a firm can either conform or confront to other parties (Håkansson and Ford, 2002). If transferring this to how a USO creates a position in the network, the former suggests how the USO adjusts to fit with incumbent businesses and their established network structures, and would thereby presumably require that the idea becomes less disruptive/radical. Such adjustments include how design aspects and solutions take into account customers' present ways of using products and their investments in current systems. It would mean that the USO tries to establish itself in a network without changing current companies' and customers' ways of interacting. Resource configuration would be unilateral. Confronting the network, means that other parties need to change, or that additionally new parties need to establish themselves in the network, would include competing with incumbent firms, challenging established business relationships and at large: redrawing the contours of industries/markets. While confrontation may imply that the USO performs its strategy without considering other players, or in opposition to their intentions, confrontation may also be the case when established parties aim for new solutions, but do not know how to solve them. The configuration of resources would hence be reciprocal. The conforming and confronting occur also on the 'mental' level, meaning that present institutional logic of actors (Öberg and Shih, 2014; Lind et al., 2013) is challenged, adopted or adjusted. This hence implies not only taking into account tangible assets (such as resources of firms), but also how companies think about and have preferences for certain ways of acting.

While conform and confront (Håkansson and Ford, 2002) indicate two main routes to take in strategizing, also other approaches may be considered, and Chou et al., 2014 point to different ways of strategizing in the network with conforming and confronting as polar points.

Positions in networks

A USOs position in a network consists of the relationships that the USO intends to have with other actors. A position is the result of previous interactions (Gadde et al., 2010) and a current position also determines the opportunities for change that a firm is able to discover (Easton, 1992). When the USO approaches the network, its position is something that needs to be established, which could be seen as a transition from the position as research results or incubators, to business partners. In one sense, the position is a structural and rather static concept. However, over time it is a dynamic concept since the position of the USO is constantly evolving as a consequence of linked episodes, taking place in the interactions, based on perceptions of the history and projections of the future.

A position would be described vis-à-vis other parties. This means that fundamentally, the position that an USO establishes itself on complement or resembles positions of already present actors. Related to a supply-chain thought, positions would include how the firm places itself up- or down-stream to other actors. Additionally, though, position would also include the strength of the actors vis-à-vis other parties, whether it, as suggested by the discussion on conforming and confronting, it enables to change or only adjust to current structures.

Roles in networks

Roles refer to a function performed by someone or a description of what someone does (Parsons, 1951; Gross, 1958; Levinson, 1959; Williams, 1969; Turner, 1985). The one party holding a role does so relative others (Anderson et al., 1998; Chreim et al., 2007; Levinson, 1959; Turner, 1985). Literature on roles has referred to them as either semi-permanent or transitory. This indicates that a party may hold a role, as a USO for instance, or that it is defined by the way it acts. In this paper, we take this latter standpoint and hence explore USOs by their ways of acting relative established parties in the network. This points to roles as manifested through activities rather than predefined arrangements (Gross, 1958; Williams, 1969; Goffman, 1983; Laverie et al., 2002).

In IMP-related research Anderson et al. (1998) used roles to discuss what companies actually do in the network, and distinguish it from position, in terms of who they are. This in turn implies a dynamic and situation-specific perspective on roles, as it includes how a firm may take on changes or adjust with changes. If thinking of the present network as a structure with companies holding different positions therein, a USO would need to find a ‘space’ to establish itself there, relative those other parties. The idea of conforming or confronting, points to how it to various extents tries to melt into present structures or break them. The role vis-à-vis those other parties would though indicate how the USO acts relative them and in their possible absorption of research ideas.

Resource development

To explore the roles of USOs, we draw inspiration from a framework developed by Håkansson and Waluszewski (2002) on interactive resource development. This framework was also used in a similar way in the same context by Aaboen et al. (2011) focusing on how resources are developed through interaction for start-ups. The resource interaction occurs between and within the resource categories of business units (here the USO in focus and its network contacts), business relationships, products and facilities. Building on this framework

enable analysis of: (i) the resources that are exchanged, formed and developed between the USOs and its network parties; (ii) how original resources are changed, combined and recombined, and (iii) how resources impact one another, and are accepted or not as new resource combinations in broader network. This approach makes our analysis different from for instance Olsson et al. (2013) that explored the changing roles of middlemen using the activities, actors, resources framework. Figure 1 outlines our theoretical framework.

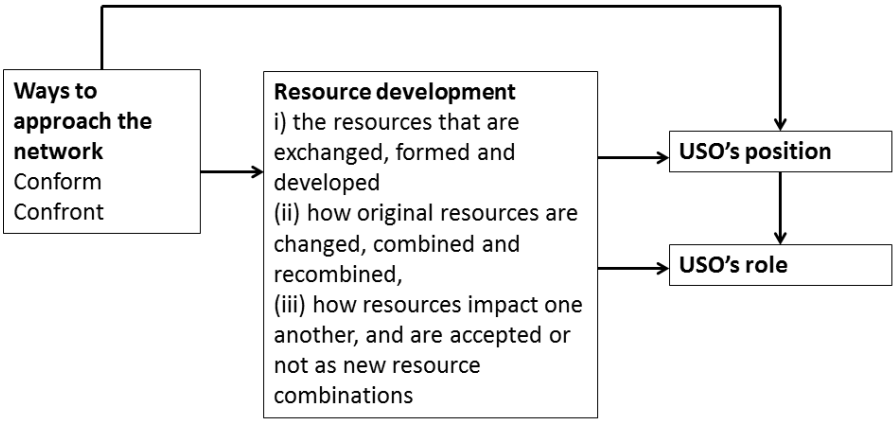

Figure 1: Analytical framework

METHOD

A case study approach

The empirical part of this paper is built on multiple case studies (cf. Eisenhardt, 1989). The reason for choosing a case study approach was to explore the phenomenon of USO's roles related to their context and enable the capturing of details. The multiple-case study design enabled us to compare among cases and also explore how USOs may take various roles in the network. The cases have all been conducted as part of ongoing or completed research projects.. Observing variety with regard to roles in business networks was the most important criterion for selecting cases, where we also wanted to include cases from different geographical areas, universities, maturity of USOs, and research disciplines. This poling of cases meant that results to wider extends would be valid beyond the specific cases studied, than had they been very similar (Eisenhardt and Graebner, 2007). The case studies have enabled us to capture the USOs during different stages of their development, present and past networks of such USOs, and how the network and idea have been affected by the USO and research idea.

The cases were based on interviews as main data source, complemented with secondary sources such as press releases and annual reports. Interviewees included representatives of the USOs and different network parties. While data has been collected for the initial research projects (and thereby somewhat different purposes), the interviews have been informal or semi-structured (McCracken, 1988) and allowed for in-depth understanding of the USOs and their developments. Each case builds on up to ten interviews. The interviews have mainly regarded the background of the USO, its initial development, key customers and/or other relationships that have been important to the USO, funding and plans forward for the coming two to five years. Secondary data sources aimed to provide facts on financial performance, check for accuracy of events and timelines, and also enabled the capturing of activities at their

time of occurrence (Huber and Power, 1985). All cases have been made anonymous using fictive firm names in this paper. .

Analytical procedure

As pointed out above, the cases were all conducted as part of completed or ongoing projects and selected based on their variety. In making the comparisons, the variety has also been challenging since the types of information have been differing between the cases. No authors have been involved in all cases. Still by working with case descriptions, we have spread the understanding of the different cases in the group and interacted around them to gain an understanding, identify the important dimensions to compare them on and in the end identify the roles. The analysis procedure entailed a comparison and separation of cases and in that sense the analysis of the cases started already during selection of cases to include in the paper. The analysis was directed at the individual cases, involved the synthesizing of interview transcripts, notes and secondary data sources, and captured the USO, network and role consequences. For each of the cases, preliminary case presentations were drafted and then addressed with questions concerning the USO and its role. This was done iteratively and separately by the authors.

Following the production of case descriptions, USO roles for each case were depicted. This included asking the case material about resource development, etc. Following iterative descriptions of various roles in the cases, the cases were then compared, with clarifications from the author that had collected the data from the specific case. The iterative roles were compared among the cases so as to find similarities and differences. This resulted in a description of different roles and their functions in the network. While the number of cases is limited to five, the final categorization managed to develop three main categories.

CASE STUDIES

This section presents five cases, which illustrate how USOs establish themselves in a network to enable commercialization of their ideas through exploring different roles of USOs in the network.

Biosurface

Biosurface is a biomaterial firm that commercializes a new type of implant surface and a new formula for synthetic bone. The firm is a spin-off from Chalmers University of Technology and is located in the incubator run by Chalmers Innovation. Biosurface is the first in the world to produce the bioactive substance hydroxyapatite (HA) with a shape, structure and chemistry that mimic natural human bone.[1] Among different possible applications in the medical field it can be used as a method for modification of implant surfaces. This is currently the main focus of the USO. It is now in the process of introducing this product in the market. The potential customers consist of implant manufacturers including those working with metals, ceramics as well as polymers. Synthetic bone used to help orthopedic fractures to heal is another application area. The current main owners are the two founders from Chalmers and two venture capital companies: Karolinska Development and Almi Invest. Other owners are Chalmers Innovation, Innovationsbron, business angels and employees.

[1] Hydroxyapatite is the main component of the body's hard structures (bone and teeth).

While implant surfaces is the main market currently targeted by Biosurface, it has already one product on the market. It is a HA-coated biosensor that can be used for studying the interaction between molecules and bone. The product was developed in collaboration with Q-Sense. This is another USO from Chalmers that has commercialized a novel technique for surface analysis.

In 2010, Biosurface had revenues amounting to SEK 300,000 (biosensor application) and seven fulltime employees (four of which have a PhD degree from Chalmers). The firm has not yet reached the market in its main field (implants). However, it is expected that the first product coated with the HA^{NANO} Surface will be launched with the help of a customer. Moreover, another indicator of progress is that Biosurface has successfully attracted interest among investors and from media. In 2011, for example, Biosurface was identified by *Ny Teknik* (a weekly technical news magazine) as one of the 33 most promising technology-based companies in Sweden.

Both Nobel Biocare and Astra Tech showed interest when Biosurface went out and started to search for a potential customer to collaborate with. But it was the former, which became the first partner. It had started an internal product development project where Biosurface's surface-coating method seemed to offer an interesting solution. Astra Tech on the other hand had just introduced a new surface based on an internally developed technology, where it had already invested considerable resources. Therefore, Astra Tech did not have the same incentive as Nobel Biocare to embark on a new project. It cannot be excluded that Astra Tech at some time in the future, when it is prepared to take a new development leap, will become afresh interested in Biosurface's technology.

As stated, Biosurface is a USO that has not yet reached the market, and this is despite that the USO is ten years old. Again, this illustrates that it often takes long time for a medicine-technology invention to be transformed into innovation and growth. It remains to be seen, though, whether Biosurface is going to be a commercial success or not. Without doubt this will be affected by how successful it is in its present networking with potential customers, primarily in the orthopedic field. This case illustrates how a medtech USO may need to involve other medicine-technology companies in its innovation process. As we can see, successful networking also with this type of counterpart is associated with certain challenges.

The case also illustrates how a USO can easily become single-sided dependent on large firms that it collaborates with. For example, Nobel Biocare's decision to discontinue the project was made outside the control of Biosurface, but had serious consequences. While the networking with users has become crucial for Biosurface's development, the relationship to the research environment from which Biosurface was once spun off has lost much of its initial importance. The responsibility for developing the technology has been taken over by the firm and it is no longer dependent on Chalmers for its competence development. This does not exclude, however, that at some future date useful new knowledge may come out of the continued research at Chalmers. As a final comment it is worth highlighting that Biosurface has fruitfully used the existing biomaterial cluster that it had become part of.

Airplane

The original idea of Airplane was to purchase 300 light jets and start a taxi firm with them where taxi pilots could rent the planes. The light jets were a new kind of airplanes that were planned to enter the market "soon" at that time. Rumor said that these planes were going to be priced at about a quarter of the price of a similar airplane and be very efficient to fly with. In

order to keep track of all the taxi-planes some kind of computer software would be needed. Some friends of the originator of the idea were students at the school of entrepreneurship at a technical university and decided to develop the idea further and a USO was started in 2002. In contrast to the originator of the idea the students did not have any experience at all from the aviation business.

The firm that was supposed to produce the light jets became more and more delayed in getting the light jets to market and in the end it went bankrupt. However, the USO had started to explore an alternative path in the current market of private jets while waiting for the light jets to materialize. The founders of Airplane went on tour in Europe with a power point presentation. A narrative from this time that they like to tell is how they had a car parked at the airport in Frankfurt with the keys on the wheel and took turns in driving it around for a week each. During this time they visited all major aviation companies in Europe trying out their software idea and trying to get the companies to sign up for their software for coordinating private jets. Competitors that most likely would sign up were an important sales argument. The USO soon realized that the most efficient way of selling the software solution was to let the customer try it for free at first with clear communication that it would cost more further on. The customers that try the software solution almost always continue to use it and they pay a fixed membership fee that they pay for 6 or 12 months at a time. Unless the customer actively ends the subscription it is prolonged. In 2012 the USO had more than 1000 paying customers for their software. The software allows companies to book private jets from aviation companies that are using the software through the membership fees. The advantage for the aviation companies listed in the system is that then it is more likely that they can avoid flying with an empty airplane or get long waiting times. Previously the only way of booking private jets was to flip through catalogues and then place an order. It was then likely that the companies that had the airport in question as home base would get the order rather than the firm that had an airplane at that airport that particular day.

Eight years after Airplane was initiated it already had 70 employees and the yearly turnover was approaching EUR 5,000,000. The USO is still expanding their customer network. The expansion especially takes place in Asia and Africa since it is already established in Europe, North America and the Middle East. The expansion is made in the same way as originally by first offering the system for free and then charging a monthly fee. In order to increase the customers satisfaction of being part of the system the USO tries to increase their number of flights for them by marketing private jets as a convenient way to travel to several destinations during one trip to attract customers' customers that previously thought that it only had to do with caviar and champagne. The USO does this for instance by writing feature articles for magazines. Airplane also tries to improve the quality of the booking service by for instance adding other parameters than price. Through acquisition a firm specializing in safety auditing is now part of the USO and through collaboration with airline authorities the USO tries to detect the illegal pilots and companies.

Since the USO already has 90% of the European market it is also trying to increase the value created in each customer relationship by offering additional services. The USO tries to come up with ideas and try them out in discussions with customers in the same way as originally. For instance, the USO figured that most of the inquiries to their customers were generated through their system, so why not offer their customers an easy way of giving and handling tenders. Similarly, the customers may be interested in incorporating certain elements from the system on their webpage to improve their sales. These extra-services increase the membership fees of the customers.

When the network grew Airplane realized that the networks use of the software generated a lot of business intelligence about the private jet business. Many customers used to ask the USO questions when there was something they were wondering about and the USO could easily find the answers by looking in their excel-sheets. The USO therefore decided to make this service more professional by investing in improving their system towards this type of function and hire an additional employee dedicated to the task of business intelligence only. This employee can generate reports on specific issues as well as write analyses of developments in certain markets etc. as well as writing articles based on their data for magazines like Financial Times and aviation magazines. This new service is expanding quickly and creates value for the USO both by sales of business intelligence and by creating credibility to the USO in the industry.

Biotech

Biotech was founded in 1997 and focuses on drug delivery, as a USO from National Taiwan University. Biotech‘s main technology platform is in new drug administration, through coating of active drug ingredients with liposomes. Today the USO’s headquarters is located in the Nangang district of Taipei. There are currently roughly 50 employees. The product line of Biotech consists currently of generic drugs externally acquired. The USO has also initiated the development of new drug formulations, based on a drug delivery platform.

At the time of the founding, the Taiwanese biotechnology industry was in a state of active government promotion. The considerable government support that initiated in the mid-1990s had created a number of biotechnology firms in various areas. This policy driven push of technology and entrepreneurship, however, had by the mid-2000s created few firms that had truly innovative products and ideas for the market. While institutional and private investors, in the beginning had shown some interest the lack of positive economic results eventually led to a credit crunch in the mid-2000s, leading to firms, government, and investors repositioning their ideas towards biotechnology investment and business.

Biotech’s founder came directly from an American university to take a position as a principal investigator at National Taiwan University. The founder had a well-developed academic network, involving research units at the forefront of liposome research in the United States and was now active at Taiwan’s top research university. The founder was involved in several attempts at commercializing liposome research in the United States, which led him to pursue the commercialization of some of his liposome patents in Taiwan. Biotech was formed as a vehicle to handle the commercialization of a generic drug coated with a liposome formulation. Initially the USO, worked from the laboratories of the universities, and relationships were formed with the university hospital where initial clinical trials were performed. Two local pharmaceutical companies were interested in investing in Biotech after the clinical trials had been finalized. This allowed the firm to scale its production, and also access the Taiwanese market. By early 2000 a venture capital firm had also invested. The infusion of capital allowed Biotech to develop new biopharmaceutical projects based on an internally developed drug formulations.

These projects were based on a drug delivery technology, and applying the technology firstly on generic drugs. These drugs are to be developed for the Taiwanese market, where connections to the generic drug manufacturers, allows for a streamlined, pharmaceutical production, clinical trial process, and re-imbursement from the health care system. This business model has been used by several Taiwanese biotechnology firms as it allows the firms

to gain short-term revenues, the innovativeness however is low and the price pressure pushes the profit margins low. To develop more innovative drugs, Biotech strengthened relationships with research universities in the United States and also establishing a subsidiary, taking care of the clinical development in the United States.

Material
Material develops a material that functions as a barrier against oxygen, grease and aroma and can thus protect sensitive foods, such as pet food or grease products. The barrier is environmentally friendly since it builds on the reuse of shell and waste from the agricultural setting. It can in particular be described as renewable if compared against the main solutions of today, that is, aluminum or oil based plastics. The barrier is manufactured in such a way that the shell and agricultural waste is dried to a powder and mixed with some other additives. This fluid is then wiped onto a cellulose material to give it the needed barrier properties.

The USO was founded in 2004 and builds on research performed at Chalmers University of Technology. Material has during the years attracted more and more venture capital. An important reason for bringing in venture capital a few years ago was that it has built a pilot plant for producing its material as well as optimizing that process to ensure the quality and supply of the material. Until now the material has only been produced in smaller volumes.

Today Material works with potential customers in different projects to test the material for various applications. These customers are large cardboard and paper manufacturers who are international by nature. When adjusting the material to the customers' facilities, Material works in a three steps model: First, lab-tests are conducted when tests are done with the material on a piece of paper, so called, substrate in their lab and therein test the barrier properties in relation to a certain material. This is part of its selling process and accordingly the USO covers the cost during that phase. In total, the USO has tested sheets for 30-50 customers, where there could be around five sheets for one single customer.

If the lab-tests turn out well, they continue with pilot-tests, which often are performed at a minor paper machine in terms of a role of 50-60 meter breadth at the customers' facilities. Although the smaller size of the pilot-tests, it is possible to run at full speed, that is, 5-600 meters per second. Material has performed pilot-tests with a few companies and they have learned several things concerning how the product works with the customers' manufacturing equipment, i.e. regarding the specific preconditions in the manufacturing, such as the importance and difficulties involved in cleaning the machines. The third step is to perform full scale trials at a paper mill. In those setting the costs are enormous with machines running paper of seven meter breadth and 500 meters per minute that have to be taken out of the normal production during the time the test lasts. No full scale tests have been done yet.

The potential customers are all in the pulp and paper industry, and Material considers the chain of companies involved to be: cardboard and paper manufacturers, converters, fillers and brand owners, distributors, retailers and consumers. A converter is a firm that purchases e.g. paper, cardboard, color, plastic and aluminum and processes them into ready-made packs that are sold to the fillers. Material mainly directs its efforts towards paper and cardboard manufacturers, who sell cardboards or papers without any barrier functions. It means that the material can add features to their products. The material is coated onto paper based on a dispersion technique and this technique is a necessary condition in order to make the coating fit into the existing processes of the cardboard and paper manufacturers. Another possibility for the USO is to direct their offerings towards converters that have these dispersion facilities.

The ongoing pilot tests are made together with some converters and some cardboard and paper manufacturers.

In addition, the USO has a dialogue with fillers in order to understand their demands on the barrier function. The USO is looking at the opportunity of finding a small brand owner to be able to show that they have a real product. Finding a small brand owner is important since today the USO does not have the capacity, being a seven people firm, for a larger customer. An interest for renewable materials among the retailers and consumers has led to an increasing interest among the companies in the pulp and paper industry.

Automotive Sensor

Automotive Sensor started off through the collaboration between a university researcher and an industry representative in the automotive sector. The firm spun-off from research on sensor technology. The individuals had collaborated together since before, and while the firm can be characterized as a USO, it was really spun-off from a firm they had ownership interest in. The USO resulted from two patents that Automotive Sensor was to develop further.

In its early development of ideas, Automotive Sensor received financial support from an industry venture capitalist associated with the automotive sector. This in turn resulted from previous collaborations between the innovators and the venture capitalists. It had as a consequence that solutions were promptly focused to the automotive sector, while it did not entail any bridging to customers. For the automotive sector, sensor technology built into software was at the time a radical innovation, similar solutions as the targeted one were generally mechanic ones.

Additionally venture firms also entered as owners, all of which declared their temporal engagement with Automotive Sensor. In addition to the venture firms, Automotive Sensor managed to start collaborations with some suppliers to the automotive sector. These suppliers place minor development projects at the USO based on their technological expertise. These suppliers to large extent drove the technological development in the automotive sector at the point in time and based on how automotive companies had often outsourced their production to a far end. For the USO, the relationship with the suppliers was important since the solution needed to be fitted into hardware produced by them. The collaborations however took different formats and the USO acted more as a sub-supplier to the suppliers than as a co-inventor. Hence, while relationships were established, they did not specifically focus on the software of the USO or its development.

Automotive Sensor had as its goal to become self-supporting and develop customer relationships on its own. The original venture firms also marked how they wished for an exit which stressed this issue further. The USO came to use many of its established contacts to try to establish itself in the network. These included the mentioned suppliers and also consultants related to the automotive sector. A consultant helped them to enter into fairs for the automotive sector and thereby potentially find business partners. While the USO appeared on such events, the USO was still considered as an odd bird, which attracted attention, but no real customer contacts. Automotive companies saw the financial weakness of the USO and remained hesitative. The USO therefore soon realized that it needed to take a different avenue in its attempt to become as self-supporting USO. It was acquired.

The acquisition made by a major firm in the automotive sector meant that the USO could engage with a complete different set of resources than before. It however also marked the end

of many of the relationships that Automotive Sensor had established from before. There was a power-struggle between suppliers and manufacturers that meant that the suppliers disengaged from the USO. Also competition among automotive companies made it less likely that any type of collaboration would continue with these. If they still had any interest in the solution, they now waited for the new owner to develop it into completion and further needed to address questions regarding whether the USO would be allowed to continue to work with them long-term. Suppliers started to consider competing solutions to the one developed by Automotive Sensor.

This case points to how the USO had problems to find a position that fitted its business. Ongoing restructuring among automotive companies and their suppliers made attempts to establish relationships increasingly troublesome. The USO, with its new technology, ended up in a position between present network actors, while still heavily dependent on them.

ANALYSIS

Table 1 summarizes our cases using the theoretical framework that investigates how the USOs approached the network, the different positions they held and the roles that they assumed in relation to different actors when they had these positions.

Table 1: Case summary and analysis

	Approaching the network	Position	Roles
Biosurface	Conforming. Development of applications with potential customers, which gain access to a new surface technology.	Development of collaborative relationships with potential customers (large med-tech firms) in different application fields.	*Technological diversification.* Sub-supplier (of surface) to implant manufacturers (which constitute a link to the end-users in healthcare).
Airplane	Conforming. Had an idea on how to position itself between actors on the market that were competitors and connect buyers and sellers.	Position as spider in the web among customers. Increased network of customers. Increased knowledge of customer needs.	*Intermediary*. Service-provider. Knowledge provider.
Biotech	Confronting. Applied drug delivery technology to generic drugs and supplied a new kind of pharmaceutical drug to established networks.	Position among university actors. Part of Taiwanese market because of relationships with two local pharmaceutical companies. Additional relationships within the industry and universities.	*Intermediary.* Start-up biotech firm with growth potential. Taiwanese biotech firm. Streamlined producer of drugs with low innovativeness. Innovative drug developer.
Material	Conforming. Idea of how the product will	Performing pilot-tests together with potential	*Technological diversification.* Potential

	fit in production processes of customers and value chain.	customers. Dialogues with other members of the value chain.	growth firm. Partner for exploring new technologies for established companies.
Automotive Sensor	Confronting. Two patents.	Relationships to suppliers enabled technological development. No customers found while venture capitalists wanted to exit. USO acquired and suppliers exited their relationships.	*Technological renewal in network.* Potential growth firm. Innovative firm. Odd bird. Acquired.

As stated in the introduction of the paper, governments have increasingly encouraged universities to collaborate with industrial actors. Current research policy has actively promoted academic knowledge as a source of innovation and renewal in the industry. In this context, USOs in particular are important vehicles for transferring knowledge between universities and industry. From the understanding, it is expected that USOs would lead to new structures, requirements for additionally new actors, etc. However, and as illustrated by our cases, an USO also needs to take present structures into consideration. This would mean that the USOs would change the network or adjust to it along the continuum of conforming and confronting strategies.

Looking at the cases, Biosurface, Material and Automotive Sensor are examples of how an USO can be a vehicle for new technology development and demonstrates the viability of a new technology and how it can force other actors to. Biosurface's technology is now part of a product on the market and was part of a collaboration with a large firm, which has been influential in its network. The technology of Material serves as an alternative to the older technologies on the market. The technology of Automotive Sensor is now acquired by another firm after forcing other actors in the market to start developing competing solutions. From the case description it appears as if the three USOs were more successful as vehicles for technology diversification then as growth firms since none of them were able to form relationships with paying customers for their main product.

Airplane and Biotech are in contrast examples of USOs acting as intermediaries and taking on the role as a bridge between various network parties. This means that the USO creates a new network position while it to a limited extent impacts the other parties. Airplane connects the providers of private jets with the customers that needs to book private jets and in the end also connects them with the actors interested in the private jet market. Biotech serves as an intermediary between developers of generic drugs and pharmaceutical firms through their drug delivery system and also serves as an intermediary between research institutes, pharmaceutical producers and potential customers during the development of new drugs.

USOs serving as vehicles for technology diversification and USO serving as vehicles for intermediation display differences in their development processes. For example, the technology diversification USO lets the technology remain constant during the development , while the intermediary USO continues to develop its idea to seize opportunities that are discovered when the positions and roles change. A clear example is that of Biosurface that developed a product based on its technology, which was not the intended product. Paradoxically the firm continues to try to find customers for the intended product instead of

developing further based on the "unintended" product. Conversely Airplane as an intermediate constantly looks for opportunities to improve its' offering among their customers and based on their customer network.

For technology diversification, USOs to become technology renewal USOs they need to be able to form customer relationships. In contrast, the intermediary USOs is able to form customer relationships but conforms to the customers that their resource structures are relatively unaffected. In order for the intermediary USO to become technology renewal USOs, the intermediary USOs would need a more radical technology or influence the network into a more radical organization. Then whether the technology renewal USOs are a more developed form of the diversification and/or the intermediary USOs, that is, a third type of USO with a different development process we leave for future studies to investigate.

The above case descriptions show how different roles USOs may take in networks. The Biosurface and Material cases to some extent tell similar stories. Those USOs have been around for some years but paying customers and profits are still distant. Their current aspirations for roles in their networks are focused at being suppliers of established firms. To obtain this type of role needs long-term interaction with prospective customers. The technologies are promising but to integrate the technologies in their customers' resource structures is a tricky issue. To have the established firms adapt their resources to new resources has proven to be difficult. Both cases contain elements of (aspirations for) technology renewal in the customers' processes. This is particularly evident in the Material case in terms of using a sustainable production method in contrast to existing methods. However, in order to become suppliers to the established firms implies conforming to the established logics of the networks. The two cases also show dimensions of technology diversification in terms of if the customers start to use those new technologies that might have a changing factor in the networks, for example, if the new material is to be used, new sources of supply will be necessary.

The case of Automotive Sensor has been acquired at this point in time. Still the case shows similarities with the Biosurface and Material cases in terms of seeking a role as a supplier to established firms and conforming to the established resource constellations of the networks. The Automotive Sensor case had clear dimensions of technology renewal in that it offered new sensor technology built into software, which at that time was regarded as novel solutions. It might be that those aspirations can further develop within this larger firm.

Biotech active in the medical biotechnology sector has taken an interesting role. The role that the USO takes in networks is the role of an intermediary. This is done by developing pharmaceutical products by applying a drug delivery technology. Here the firm, uses generic drugs, and combines these with the internally developed drug delivery system. The marketing of the drugs is done in collaboration with local Taiwanese pharmaceutical firms that involves in the clinical trial process, and sales of the drug to hospitals. The firm also develops novel drug products, by serving as the intermediary in a network of research institutes, pharmaceutical producers, and potential customers.

The Airplane case also illustrates the role of intermediating among actors that previously were not connected. Coordinating private jets and making them visible for the end customers through the use of software has proven to be a fruitful role with a customer base that is still growing. This intermediation role can contribute to renewal in an industry that previously has been driven by a more fragmented logic with a number of individual brokers. In this sense,

this new role resulted in that the former brokers became unnecessary, implying a confrontation in the network.

CONCLUSIONS

With basis in the five case studies we suggest a typology of USOs' roles in business networks.

- The USO as an intermediary: the USO functions as a bridge between various network parties (that are either directly or indirectly connected to the USO). This would mean that the USO creates a new network position (a space in the network not previously held by any actor), while it to limited extends impact other parties. Resources would be combined and adjusted to established parties. This is what we see in the *Airplane* case and in the *Biotech* case.

- The USO as a vehicle of technology diversification: the USO offers typically established companies a channel through which they can diversify. Large companies tend to avoid disruptive innovation, and divert research findings to new corporate entities, as the innovation does not fit into the established companies' institutional logic, nor easily follow from their resource interaction. Here network changes would follow since the USOs would change also the resources of the established parties. This is what we see efforts for by the *Biosurface* case, and *Material* case.

- The USO as a vehicle for (technology) renewal. The USO as a way to renew stagnating businesses and rigid networks. Here the very aim would be to change the network and allow for new parties to establish themselves as producers and customers. Resources would be configured with the USO driving these changes, as would logic. This is what we see in the *Automotive* case.

This paper makes the following contributions: A first contribution is in relation to the discussion on university entrepreneurship and how universities commercialize their research through USOs. On the one hand, USOs can be seen as reflecting a linear technology spin-out funnel (Clarysse et al., 2005): looking for ideas with commercial potential, validation, patenting, searching for financing, establishing a firm (Baraldi and Waluszewski, 2011). On the other hand, more interactive commercialization mechanisms are identified, such as cooperation platforms including different types of inter-organizational interactions (Baraldi et al., 2014; Nilsson et al., 2011). We seek to use case studies to deepen the understanding of university entrepreneurship through highlighting links between activities, underlying thoughts and logic, and contextual influences between items such as USOs and established networks. This paper of USOs makes a contribution by showing the complex process of how they get into the established network structures. It further links this to ideas on underlying institutional logic and thereby connects goals/motives of parties with actual interaction patterns, alignment/misalignment of goals and their influences on the network and chosen paths (conforming or confronting of networks).

The second contribution lies in the intersection between entrepreneurship, innovation and business network studies. In the past years, innovation, entrepreneurship and business network studies have approached shared interests, but there are still many unresolved

questions in the intersection of the fields. Innovation studies have focused on open innovations, crowdsourcing, and co-innovation to mark how different companies co-produce innovations. Often in such studies, a single firm is considered as being able to *manage* the network (Bessant et al., 2012), and network consequences are thereby rarely considered. Entrepreneurship studies increasingly acknowledge networks and seeing a relational practice (Anderson et al., 2010; Lechner and Dowling, 2003), but mainly considered individual ties for the entrepreneur (actor ties) to for instance venture capitalists with limited attention to the network level (company-to-company and the inclusion of several parties and their interdependence) of analysis. For example, individual relationships between universities and spin-offs have been investigated (Wang and Shapira, 2009), leaving room to building further on the understanding of interaction in networks. Business network studies have increasingly focused on innovations, start-ups and new ventures (Snehota, 2011; La Rocca et al., 2013; Aaboen et al., 2013) but USOs are still rather rare study objects and capturing the views of other parties in the network is even rarer. The starting point for studies of innovations in industrial networks is the established relationships between firms (Håkansson, 1989; Laage-Hellman, 1997), and most innovations are incremental as a consequence (Story et al., 2009): ideas are generated as improvements as part of present interactions in established structures. The establishment of new firms in a network and disruptive/radical innovations made by such firms as USOs makes a contribution to the literature.

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