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## **SPINNING-OUT UNIVERSITY TECHNOLOGIES: A ROLE FOR STUDENTS IN THE COMMERCIALIZATION PROCESS**

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### **Abstract**

Universities engage in technology commercialization, based on different motivations including the goal of accomplishing sustainable innovation with economic and societal impact and diversifying income streams. The latter objectives are better realized from spinning out successful new companies, which compared to licensing create advantages both for the university and the academic inventor.

Although universities generally struggle to successfully commercialize research results as new firms, some universities are much better than others at spinning out companies. The research has not identified a singular formula to increase university spin-outs. A common theme in much of the empirical evidence is that academics/university researchers lack knowledge related to market development which must be supplemented for successful commercialization. This study analyses the role of non-research students in developing knowledge about markets to supplement the knowledge-gap among academics, which as far as we know have not been widely explored.

The analysis is based in the context of a technical university which provides a unique opportunity to explore how students working to fulfil academic requirements can create momentum around a technology to increase its spinout potential. The results show that students working with potential spin-out technologies as class projects are seen as nonthreatening which allow them to gather useful market information. This early information can stimulate interest leading to partnership development as well as help to identify advantages and challenges for different applications of a technology.

### **Keywords**

Technology commercialization, University Spin-outs, Researchers' knowledge gap, Student resources.

### **Introduction**

Research universities around the world have vastly increased their involvement in patenting activities and many have been the foundry of successful knowledge and technology-based companies. These activities have contributed to some universities developing a reputation as hotbeds for entrepreneurship while others aspire to achieve such a reputation by providing a campus infrastructure that support entrepreneurship among the university community. Common infrastructure for supporting entrepreneurship among university communities includes technology transfer offices (TTO), incubators and other programs to facilitate enterprise development.

Commercializing university created knowledge is done mostly through technology licensing and new spin-outs (Mosey et al., 2007; Lundqvist, 2014). Universities engage in new venture creation with many different motivations including the goal of accomplishing sustainable innovation with economic and societal impact and diversifying income streams through commercialization of knowledge. Compared to licensing, spinning out new companies create advantages both for the university and the academic inventor, as equity holders, which act as incentives to promote spin-out rates as a means of commercializing university research output. Some universities are quite effective at spinning out companies although the evidence suggests that most face significant challenges to commercialize research results as successful new firms and there is no systematic explanation for observed differences (Di Gregorio & Shane 2003). Due in part to disparate legal systems, European universities in general lag behind their US counterparts in spinning out researched-based firms (Rothaermel et al., 2007).

Research has not identified a winning formula for increasing university spin-outs and universities continue to explore different approaches and methods. Nerkar & Shane (2007) have shown how the ‘scope and pioneering nature’ of different technologies influence commercial outcome. In addition, university policies, intellectual eminence and commercially-oriented research have also been identified as factors that impact the spinning out of new companies based on research results (Di Gregorio & Shane 2003). Van Burg et al., (2008) and Jain & George (2007) have explored the role of the technology transfer units in providing access to resources and support services to influence spin-out activities. An important finding from the research is that academics (referring to professors and university researchers) lack key knowledge related to market development which must be supplemented for successful commercialization of research results (Vohora et al. 2004).

To help address this challenge, we explore whether non-research graduate students can gain important market insight and product development knowledge to supplement researchers’ knowledge gaps in the technology commercialization process, which as far as we know, has not been explored in the literature. Non-research students, who are not part of the dedicated research teams, with no previous entrepreneurial experience and very little work experience can easily be dismissed as not having anything important to contribute to the spin-out process. With this focus, our investigation offers new insights and knowledge about an important resource in the university community, that with the right motivation can reduce some of the risks associated with academic spin-outs and the technology commercialization process.

The paper is structured as following. A brief review of some key literature provides a background and conceptual framework follows this introduction. The cases are then presented followed by a discussion of key findings. Implications for relevant stakeholders are next highlighted and the paper concludes a discussion of limitations and future research directions.

## **A Knowledge-based View of the University Spin-out**

The knowledge-based view of the firm regards knowledge as the fundamental resources of the firm and as such can be seen as an extension of the resource base view theory (Wernerfelt, 1984). The knowledge-based perspective of the firm is concerned with knowledge being the most strategically important resource influence and impact coordination within the firm (Grant, 1996). Knowledge may impact the firm’s organization structure, the role of management and of decision making as well as determining the boundaries of the firm and issues related to innovation management. Knowledge as key resource may also be leveraged (especially by new firms) for access to additional resources that are too costly to purchase (Grant, 1996; Spender, 1996). The influence and impact of knowledge on survival and growth is most obvious in the emergence of new firms (Autio, Sapienza and Almeida, 2000). The fundamental resource for research-based spinouts is their knowledge embedded in technology enabled process or product and the knowledge embodied in the human capital of researchers. They must leverage this knowledge to attract additional resources such as financial resources from investors but also complementary knowledge and capabilities missing from a start-up team of academics (Honjo 2000).

The research on university spin-out has emphasized the knowledge gap especially related to market development that exists among potential academic entrepreneurs (Lockett et. al.2005). Much of the support infrastructure provided by universities, including technology transfer offices, incubators as well as special entrepreneurship programs and projects are geared towards reducing this knowledge gap (van Burg et. al, 2008). The concept of the a surrogate entrepreneur is described as a non-academic individual with entrepreneurial or other relevant commercial experience

who is brought in to the university or incubator to help commercialize research results (Franklin et al. 2001; Vohora et al. 2004; and Lundqvist 2014). Surrogate or experienced entrepreneurs bring accumulated experiences, knowledge about specific business environments as well as professional networks to the commercialization process to bridge the knowledge gap thereby contributing to better outcome (Lundqvist 2014).

According to Lockett et al. (2005), spin-outs encounter evolving knowledge gaps throughout the spin out process. They identified five phases in the research commercialization process; research, opportunity, pre-organization, re-orientation and sustainable – suggesting the need for different approaches to satisfy identified gaps. The present analysis is based on activities occurring within the universities and is therefore focused on the earliest activities in the commercialization process namely research (especially later stage research) and opportunity. The literature suggests that knowledge of product and market development, brought in by surrogates raises the probability that the venture will succeed commercially. In addition, even when researchers perceive a potential opportunity to exploit a technological invention, that market knowledge is needed to define the best application for the technology and to identify the best market (Franklin et al., 2001; Lockett et. al.2005).

The above rationale and arguments suggest that prior entrepreneurial and or commercial experiences are needed to fill identified knowledge gap among academics. To widen this discussion and to increase our knowledge about how such gaps can be filled among spin-outs with limited financial resources, we explore whether or not non-research students can contribute in useful and significant ways in gathering necessary market information, that can influence the later stage research and opportunity phases of the commercialization process. To do this we examine how master's (degree) students create business and marketing knowledge contributing to the spinning out of three technologies from two departments at Denmark's Technical University (DTU).

## **Research Design**

This article reports the results of a detailed field study of students' participation in three spin-out businesses to exploit three different technologies developed at DTU.

## **Procedure**

A case study design is used to examine the three cases. Case studies allow us to investigate the student's role in the actual spinning out of the technologies as the process evolved in real-life context and allow for incorporating evidence from multiple sources including archival document (Yin, 1994). Information on each case was collected using a semi-structured guideline created to emphasize the students activities and to ensure that we collected similar data for all three cases. To validate the information provided by these guidelines their accounts of activities were corroborated by archival records available from the respective departments and by other team members (Yin, 1994).

The case study is ethnographic in nature because documentation of the spin-out activities was done by some of the students involved in the cases. The purpose of ethnography is to account for the social world of the research subject in the way in which the students themselves would describe and explain it. The subject of interest is the underlying assumptions of the social processes and activities, in which the research subject interacts and is useful in explaining social behaviour and activity. Four of the co-authors had significant roles in opportunity and pre-emergent phases of the three spin-outs outlined in this paper. Triangulated evidence from various data sources supported the primary data.

## **Sample**

The cases described below are all based on patented technologies owned by DTU. Norlase and SpecShell were spun-out in 2014 and have successfully raised seed capital and attracted first customers, whereas the third case, SHUTE is planned for spin-out by the end of 2015. All three cases are based on technology patented by DTU under a scheme where ownership is split three ways among the university, the department and a primary researcher (the latter include PhD students). For the sample cases, the students are not the inventors of any of the technologies and were introduced to the technologies during a taught course as described below. At the time of founding a company in the situations described in the cases, a total of 5 % ownership is distributed among the students.

## **Case1: Norlase**

Norlase develops a new class of ultra-compact lasers for a range of medical and scientific applications. The company is based on an exclusive license agreement of a patent portfolio owned by DTU. Norlase was spun out from the Department of Photonics Engineering at DTU in 2014. Although the patent portfolio dates back to 2008, until mid-2013, no clear plan for commercialization existed. In 2013, the patents were presented at a university course where students from Copenhagen Business School (CBS) and from DTU, working under a non-disclosure agreement (NDA), would collaborate to identify commercial applications and build a business case based on one of several patented technology presented. For the successful completion of the course students were awarded 5 European Credit Transfer and Accumulation System (ECTS). The key deliverable for the course was a comprehensive business plan based on information about key markets and applications. This confirmed the potential market value of the technology and formed part of the foundation for the subsequent spin-out.

Limited appreciation of scientific nature and background of the technology (especially for the business students) forced the groups to reduce the technology to a set of key performance parameters that could be compared to market demand. This proved highly effective in narrowing the potential value proposition and narrowing the market focus compared to the more academic approach previously taken by the inventors.

The students contacted several potential customers and competitors, to map demand, price points and market dynamics. They started by establishing an overview of the significant players in the potentially relevant industries, through desktop research. They went on to contact key personnel in these organizations through phone, email or LinkedIn, gathering valuable information such as production cost, financial data and technological challenges of established competitors.

Following the completion of the course two of the students (both from CBS) co-founded the company together with the inventors (four), and an external entrepreneur. The external entrepreneur (a photonics Ph.D.) focused mainly on product development, while the students handled tasks in marketing and finance, solving a range of practical, time-consuming tasks that would otherwise take away from product development including IT, budgeting, book-keeping, CRM, pay-rolling, meet-bookings, etc. Since both students continued their studies these tasks were done on a part-time basis. In addition the students attended board-meetings and have generally been included in decision-making at the strategic level.

Norlase has since gone through the early stage of development successfully with initial sales and attracted a \$ 1 million round of seed founding from a venture capital fund and a group of business-angels (BA's). Early on, the students secured an \$ 80,000 start-up competition grant that helped keep the company going until funding. Through their network on the university start-up scene, the students identified potential investors, two of which invested as business angels in the seed round (out of a total of three BA's). The students established the market analysis and financial projections central to the investment material. One of the students was included in the 3-person team negotiating with the Venture Capitalists (VC). The company has now grown from 1 full-time and 2 part-time employees, to 3 full-time and 4 part-time employees (2 of these are the students).

### **Case2: SpecShell**

Specshell specialized in development, design, manufacturing and operation of advanced analytical systems based on Infrared Spectroscopy (IR). The company was spun out of DTU in August 2014 and is based on years of research and development as part of a Master Thesis and a PhD dissertation for three of the four founders of the company.

A PhD-student at the Department of Chemistry developed the original idea for the technology. He made some functioning prototypes for a specific type of IR measurements and in 2013 the patented technology was included as a potential project in a masters level course offered by the department of Mechanical Engineering. The goal was to have student's develop a more functional prototype and more user-friendly design. Two master students were selected to work on the case and developed the first iteration of a prototype and became more involved in the case. They patented an additional technological capability together with the PhD-student. It was based on this development that they decided to form a joint team for the commercialization of the technology.

The master students were also following courses in entrepreneurship and used the technology as a business case concentrating on developing the business case around the technology as course assignment. The students worked on Specshell as part of their studies focusing both on new iterations of the prototype and on finding the right product-market fit for the technology. The students were the driving force in mapping out potential customers and competitors, initiating different tasks and activities in order to assess impact. These tasks were completed for academic credits (ECTS) but much of it contributed to the development of the core technology in a particular direction. To help focus the students' effort (on knowledge about the industry and building, growing and scaling a company), they were paired with an external entrepreneur as mentor and who later became a co-founder.

During the first two years they participated in student business plan competitions, attracting important attention to the project and secured both smaller student grants and larger grants to support tech-startups. In 2014 when they were finishing the master thesis they also secured approx. \$ 500,000. funding for the company to survive the first three years in close collaboration with the external entrepreneur. The students efforts were vital in keeping the momentum in the early establishment of the company, they were very active, committed and spent most of their class time at the university and their freetime working on the project.

### **Case 3: SHUTE**

SHUTE is a company in a pre-spinout phase in the commercialisation of a novel optical fiber sensor technology protected by two patents owned by DTU. In the spring of 2014, SHUTE had no targeted industrial application nor any clear commercial focus which hampered the spinout from the university. The technology together with other DTU patents was presented at a 10 ECTS lab-to-market course for masters students. A team of four interdisciplinary students investigated market applications for the optical sensors and developed a small-scale prototype and business plan focused on curing and structural health monitoring of concrete structures. The team received a grant of €20K (approx. \$ 22,000) from a student oriented competition (Climate-KIC ) for further development of the business case around the technology. After successful completion of the course, one of the student was intrigued and motivated to continue working with the spinout activities for SHUTE.

In the fall semester of 2014 the student worked on technical activities with the inventor but soon realized the urgency for a commercial focus. In the final months of 2014, he decided to pursue the commercialization activities for SHUTE as part of a master's thesis. Taking advantage of the possibility to collaborate with another student on the thesis project, he invited a second student (also from the Department of Management Engineering) to join the project. Both students were motivated by the opportunity to get practical experiences in building up a start-up and were fascinated with optical fiber sensors. The masters thesis was initiated in January 2015.

The students started out by investigating several markets (including concrete) to identify potential commercial applications for the technology which intensified the commercial activities surrounding the technology. They initiated contact and interaction with potential customers from four major industries. Their activities included identifying potential customers and presenting, and in some cases field testing the technology which led to tangible business traction in the form of a signed letter of intent, a memorandum of understanding and two NDAs with three different potential customers/partners. In addition, they performed field tests in the facilities of a market leader and potential business partner. This helped set the direction for the technical development and resulted in the technology being validated and tested outside of the lab for the first time.

The students provided the team with organisational skills that enhanced the planning and communication of the commercialization activities for SHUTE. Previously these activities pointed in different directions and progressed with varying speeds due to obligations at the university for the spinout team members. Planning of the commercialization activities enabled internal consensus of roles and direction of the spinout process was established.

The practical nature of the master's thesis and the responsibilities of presenting the technology to potential customers proved a good motivation for the students, increasing their desire to see the technology succeed commercially. According to the students, 'the hands-on entrepreneurial experience was realistic and relevant beyond the nature of the traditional thesis learning objectives'.

*“We gained terrain of industrial experience and academic knowledge as well as essential business momentum for SHUTE.”*

As of May 2015, SHUTE is still in a pre-spinout phase but has gained key contributions with concrete knowledge about different markets. The direct input by the student will influence SHUTE’s initial target of exploring opportunities and partnerships in the aquaculture industry . Both students are presently part of the team with the inventor working towards spinning out the technology.

## Discussions

According to the Knowledge-based view (Grant, 1997), knowledge is the most important resource in a firm. For university spin-outs, knowledge is embodied in technical know-how and capabilities embodied in technology enabled product or process. Firms, both new and established need more than technical knowledge to compete and sustain themselves. In the absence of strong income streams to purchase required complementary knowledge and capabilities on the open market, new firms must leverage technical capability to attract resources. This process of acquiring complementary knowledge and resources is not usually targeted at students. However, the cases presented here show that attracting students to work with the technologies as student projects constitute a form of leveraging. In exchange for working with interesting and exciting technologies, students were motivated to go out and gather real-world and relevant market information which helps to focus the opportunity and the early market development activities. A key motivator is what these students describe as *“something tangible and real”*, compared to working on text book cases which is the norm in much of their education.

The willingness of the researchers to spend time explaining the technology to the students was also an important factor in keeping the students motivated; *“After the initial panic-y feeling of being thrown into the deep water head first, we started to realize that this was what our education was meant for. The commercial point-of-view that we had learned to take for granted at CBS was crucial to harvesting the product development competencies of our DTU counterparts. We started to understand what in hindsight seems banal; of course it does not make sense to work on a marketing school project, without dealing with the technical aspects of the product or service that you are marketing. A pre-fabricated case might allow you to illustrate the points of theory, but it defeats the purpose of learning how to apply it in the real world. The experience was equally eye-opening for the DTU students. Where they were used to working with purely technical metrics for making decisions in their product development school projects, they were now forced to use tangible market data.”*

During the data collection process, the students were clear in identifying themselves as students from the relevant university, DTU or CBS. Both universities have good reputations within Denmark and that helped to open doors for access to important individuals and experts in various fields (Times Higher Education –World University Ranking). An openness and willingness to explain the project and the underlying technology (as much as they knew) created opportunities for the students to discuss aspects of technology application and market development with key experts. From these discussions, access to important information emerged which helped to define market potential and in deciding on various application and the strongest business case. They were able to gather financial data, market share information, technical specifications and emerging challenges for different market segments.

It is likely that the knowledge the students acquire has limitations and potential shortcomings however , to the extent that it helps to eliminate some market applications and point the development in a particular direction is important. All the student groups had experienced entrepreneurs as mentors and this helped them in targeting their data gathering. The mentors were helpful in refining key assumptions about potential markets and pointing the students in directions where they can verify some of these assumptions which added to the soundness of the information gathered.

In the case of Norlase, the students have contributed both as a cost effective resource that “shields” product development from more mundane tasks, but also by supplementing the competencies of an otherwise technically

oriented team. It is worth noticing that the inventors had no interest in leaving their jobs at the University – and albeit they had a desire to see the spin-out succeed, they had little time to dedicate to this. Hence, the students and the external entrepreneur formed an effective team for launching the spin-out. Handling the advanced technology and executive sales was done by the external entrepreneur, and on the other hand, the broader market intelligence and daily operational tasks were handled by the students.

It maybe tempting to dismiss the efforts of the students as trivial, however, the students were able to gather detailed market insight including strategic plans and product roadmaps of potential future customers and competitors. It is unlikely that such information would have been disclosed to entrepreneurs or senior researchers, who might have been viewed as competitive threats.

The basic data gathered for a course project with the guidance of mentors and constant feedback from the inventors and the students emerging knowledge and ‘expertise’ complemented the competencies of high-profile researcher. Although this might appear counterintuitive (considering Di Gregorio & Shane 2003), the students enable collection of market intelligence from a different perspective than the experienced researchers and established entrepreneurs. Acknowledging the potential limits of this data, inexperienced student should be incorporated in the very early stage of opportunity recognition and framing.

Finally, it is worth considering the study from the students perspective. Being deeply involved in a technical spin-out resulted in a significant professional experience for the students as reported by the students. They were forced to tackle key challenges in high-value sales, financial projections, fund-raising and more. They were involved in decision making at a level which would require several years of full-time experience in an established firm.

The students involved in the early market research activities have the possibility to become entrepreneurs in the associated companies, so not only do they provide important knowledge, they also helped developing the companies and spread the entrepreneurial culture to students. Offering spin-out projects to students should not be seen as exploitation since students have to commit hours to project work under all circumstances. In the cases described here, the students reported getting an improved outcome, compared to more theoretically oriented projects.

Furthermore there was a direct financial upside for the students in terms of employment and shared ownership. A less obvious implication for the students is a remarkable improvement in their academic achievements. In the case of the CBS students, they have gone from being above average to being among the best students overall. This happened despite the high time requirement of the student’s involvement in the spin-out. The DTU students learnt about developing markets and the intricacies of making a business function while working to make the technology meet the needs of the customer. This indicates that there is no academic trade-off for students involved in spin-outs – on the contrary, the involvement enables a better understanding of academia, by putting it directly into a practical perspective.

## **Conclusions**

Leveraging of technology portfolio and technical knowledge has a key objective of filling any knowledge gap in the start-up team and the cases presented in this study show one way to achieve that goal. This study contributes to the university spin-out/technology commercialization literature with new insights on how to fill knowledge and resource gaps in academic spin-out teams with student as resource persons. Based on qualitative evidence (Yin, 1994), we confirm the notion that university students represent a valuable resource that can help bridge the market knowledge and commercial development gap which exist in many research-based university spinouts. While the literature has identified the existence of this knowledge gap and has recognized the role of experienced or surrogate entrepreneurs to complement technical knowledge of academics (Franklin, et al., 2001; Vohora, et al., 2004; Lundqvist, 2014), any role that students may play in filling this gap is not usually emphasized. Although our analysis is exploratory, it suggest that students can generate useful knowledge that helps to better target market applications which has the potential to reduce time to market a challenge for many technology-based start-ups. The results point to the need for further more extensive analyses involving other contexts and greater breath of involvement of students.



This study has informed understanding of the perceived benefits of involving students in the spin-out process but has not addressed risks. Further studies should also address issues related to ownership of the patented technologies and implications for the students.

In addition to the contributions to the literature, the study also offers important managerial implications. Specifically, findings may be of interest to universities as they attempt to increase the number of spin-outs based on research results. The conclusion that the students eventually proved crucial to the spin-outs is important. Also that this was recognized throughout by the co-founding team, despite some initial hesitation and doubts whether such inexperienced students would be able add value. With the precaution of a limited study, our results indicate a large and mainly untapped resource for spinning out university research output. This resource is very difficult to access for the traditional tech-transfer offices, and points towards a potential for more bottom-up approaches to entrepreneurship, where the spin-out cases are thriving from the departments directly and encompassing teams of researcher, students and dedicated external entrepreneurs.

As with any study, limitations need to be considered in the interpretation of results. First, the study was conducted in the specific context of university research commercialization. The cases were deliberately selected to demonstrate a particular outcome which may not be typical for students working on academic projects.

These cases, however, offered useful insights from the perspectives of technology leveraging to fill knowledge gaps in potential academic spin-out teams that might be transferable to other similar contexts. To extend the findings and widen potential application of student resources in similar setting, future studies should extend the base of the analysis to include additional case studies especially cases studies where students work on similar projects but choose not to pursue the project after the course.

A second limitation is the early stage of the spin-out cases. Further longitudinal studies tracking the development and evolution of the spin-out companies may offer insights into how limitations in students' knowledge and the background of the mentors influence the pursued opportunity and subsequent outcome of the spin-out.

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