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Theoretical Reflections

Master of Science in Entrepreneurship at Lund University

THE ROLE OF TECHNOLOGY DEVELOPMENT IN RESEARCH COMMERCIALIZATION: LESSONS
FROM A CASE STUDY OF A LIFE SCIENCE PROJECT AT LUND UNIVERSITY



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Abstract

This paper aimed to explore the main role of technology development in research commercialization through review of relevant theories and a comprehensive analysis of the case using autoethnography as methodology. The objective was to gain insights into relationship of three variables – technology, entrepreneur and resources – of a technology startup during evolutionary stages of an idea from opportunity recognition to the final stage of commercialization. The observations indicate interdependency between the variables, including lack of technology development, which impacts research commercialization.

Key words: Entrepreneur, Venture Creation Process, Technology, Resources, Commercialization

1. Introduction

New ventures are crucial for economic growth in the sense that, they are created to exploit 'real or perceived entrepreneurial opportunities' resulting from an imbalance of product or service offerings by existing organizations and the need of the market (Hsu & Ziedonis, 2008: p.1; Bureth et al., 2010). There are many sequences of creating a new venture which entail several elements, including a venture idea¹ – a difficult but important element because if it is feasible, it can attract necessary resources and if it is not feasible, it can cause failure of a new venture, or prevent its launch (Bureth et al., 2010; Fitzsimmons & Douglas, 2010).

The ideas for a new venture come from many sources, including patents – conduits of innovative ideas or technologies – which provide exclusive rights and offer incentives to inventors to create and commercialize new technology (Svensson, 2012). Different technologies may experience different risks²; creating a challenge for entrepreneurs to commercialize new technologies that are unproven (Svensson, 2012; Hsu & Ziedonis, 2008). To mitigate associated risks, patents filed with the intent of commercialization³ of an innovative technology are expected to adapt to market opportunities, which can be costly and time consuming (Svensson, 2012; Eldred & McGrath, 1997; Bureth et al., 2010). Consequently, successful commercialization of a new technology requires a process to enable: proper evaluation, technology development, resource acquisition and exploitation (Hsu & Ziedonis., 2008; Eldred & McGrath, 1997; Park, 2004).

There are many process models such as, milestone⁴, venture capitalists' investment process⁵, and market entry⁶ models, but it is difficult to determine the start and end point, transitory

¹ A mechanism that offers a solution to a problem that exists in the market (Hisrich et al., 2010: p.100).

² The probability and magnitude of downside loss derived partly from entrepreneur's uncertainties over the market demand, technological development, and the actions of the competitors (Hisrich et al., 2010: p.81).

³ Some patents are filed as a preemptive or deliberate strategy to prevent a competitor from entering specific technological area and are not intended for commercialization (Svensson, 2012).

⁴ A type of new venture creation process that follows critical milestones to avoid mis-timing errors from completion of critical steps from proof of concept forward, that are unique to each venture (Block & McMillan, 1985).

⁵ A model that is specifically governed by sequential acquisition of financial resources (Ruhnka & Young, 1987).

⁶ A model that utilizes marketing strategies to overcome the barriers to entry associated with early adopters of generic technology towards the early majority (Moore, 1999).

phases or sub-processes (Kaulio, 2003; Bhave, 1994). Yet, the problem may not be the process itself, rather the relationship of critical elements during the process which this study aims to investigate.

Research Question: Does lack of technology development lead to failure of research commercialization?

To answer the question, this research paper explores theories on developmental stages of an idea from opportunity recognition to the final stage of opportunity exploitation – commonly referred to in literature as start-up or new venture (Cunneen & Mankelow, 2007; Kaulio, 2003; Gartner, 1985) – and evaluates interaction of key elements during each stage. It specifically looks at main variables of a technology start-up – entrepreneur, technology, and resources – previously identified in the literature to explain success or failure of new ventures (Bureth et al., 2010; Shane & Venkataraman, 2000; Gartner, 1985; Bhave, 1994; Park, 2004).

This paper presents a case study of a life science project that had aimed to commercialize a patent-pending technology developed at Lund University. The technology did not commercialize that is, it could not be sold to customers in the market during the span of seven months. The reason to analyze the role of technology during commercialization is because it was the central business idea of the project.

The author acknowledges that this paper offers a limited analysis of miscellaneous management theories related to venture creation, entrepreneur, technology, resources and commercialization of technology. Further, it provides an introspective and retrospective analysis of a case, and lacks empirical data. The intent of the examination is for a multitude of reasons: identification of any gaps that may exist in the current literature concerning pre-startup stages of new technology commercialization; enhancement of personal knowledge by analyzing the outcome of the project; reflection on conceptual framework to provide readers with a preview on the complexities in the field of new technology commercialization; and to study the subsequent impact on new venture creation. For simplicity, the author uses the terms 'stage' and 'phase' synonymously in the paper.

The next section provides background information on the project. This is followed by a brief survey of literature on relevant topics. The paper utilizes autoethnographic methodology. The subsequent section offers a qualitative analysis of the case. This is followed by results and discussion of the findings and conclusions.

2. Background

Lund University's (LU) origin dates back to 1666 and is considered one of the largest Scandinavian universities. LU is known to contribute to the regional development and growth by engaging and supporting extensive academic research (Benneworth et al, 2009). The University has established internal investment companies and complementary organizations, such as Lund University Innovation Systems (LUIS), to assist in commercializing research stemming from the academia (Benneworth et al, 2009).

LUIS is Lund University's innovation organization which shares the same goals as LU by contributing to the regional growth through successful implementation of research from LU. The organization provides assistance to researchers with business advice and coaching to effectuate research findings by creating and incubating high-technology firms. To further enhance commercialization process for researchers, LUIS helps create complementary teams that can advance the projects and build new ventures. (<http://luis.lu.se>).

LU offers a one year Master's program in Entrepreneurship (program) based on two tracks – New Venture Creation and Corporate Entrepreneurship. The New Venture Creation program offers an intensive and motivating curriculum combined with real-life experience to enable students to start an independently owned business. Additionally, the program provides opportunities to gain practical experience in research commercialization. Most importantly, the program provides access to experienced and knowledgeable teachers and mentors to assist students in developing their respective project (<http://www.lunduniversity.lu.se>).

In fall 2010, the Master program in New Venture Creation collaborated with LUIS to provide students with opportunities to commercialize selective projects in their portfolio. This paper presents a case study of one of the projects – a cost effective and natural method – enhanced certain nutrient content in spinach which, if consumed, could convey health benefits to the consumer; particularly, promote eye health. This technology was developed by an experienced researcher and a professor in life sciences; he primarily taught the relevant subjects at the LU Biochemistry and Structural Biology department.

This project was advanced by a team of three students, including the author, all of whom came from diverse international backgrounds. Nonetheless, each student had some level of prior experience or education in the area of life-sciences such as Biology, Agri-Business, and Food Technology. The team was presented with two main objectives: evaluate the market opportunity of the patent and develop a business plan; also, endeavor to take the technology to the market, if feasible and desirable⁷.

The program requirements guided project development and no specific process model was recommended for further assessment. The technology could not be commercialized despite of three entrepreneurs, an experienced researcher, intellectual property rights, and an award winning business plan – elements that should have coalesced. Additional details are highlighted in the case analysis section.

The next section provides a theoretical analysis of the literature on relevant topics of venture creation and in what manner commercialization is associated with the venture creation process.

⁷ The literature explores interaction effect in an expectancy framework which argues that entrepreneurial intentions depend on perceptions of desirability and perceptions of feasibility and may influence preventative or promotion focus during the viability screening or exploration phase (Fitzsimmons & Douglas, 2010).

3. Theoretical Analysis

The field of entrepreneurship⁸ is a 'multidimensional phenomenon' with numerous characteristics that explicate venture creation including, initial conditions, and the transitory stage which may lead to the evolutionary process of a new venture (Bhave, 1994: p.237; Gartner, 1985; Kaulio, 2003). For instance, Kaulio (2003) asserts that 'a new venture is an organization that is transformed from a project into a company' through the utility of the core idea, such as patent, and the initial core team; and, upon occurrence of certain 'decisive incidents', such as 'first round of financing and the reference or first customer' (p.165). Likewise, Bhave (1994) defined venture creation as 'the process that roughly begins with the idea for a business and culminates when the products or services based upon it are sold to customers in the market' (p.224). These findings infer that commercialization has the same objectives as venture creation in the sense that it requires taking an idea to market through a process.

This creates a dilemma since the project did not follow any specific process model. To gain a better understanding, the paper surveys additional literature on pertinent activities and stages of process models. Further, the paper orients to three variables: entrepreneur, technology, and resources; previously recognized in the literature as relevant variables in venture creation or commercialization (Bhave, 1994; Gartner, 1985; Shane, 2003; Park, 2004; Cunneen & Mankelov, 2007). The author acknowledges that this review is not comprehensive due to intricacy of the topic.

3.1 Venture Creation Process

Kaulio (2003) emphasized the process of venture creation in terms of developmental and evolutionary perspectives: developmental perspective defines organizational transformation under the assumptions that change occurs in cycle(s) of emergence, growth, maturity and

⁸ The primary phenomenon of entrepreneurship from a behavioral approach defines it as the process by which new organizations come into existence (Sandberg, 1992).

decline (Aldrich, 1999); evolutionary perspective interprets organizational development as a dynamic path-dependent process (Barnett & Burgelman, 1996). As such, there are many variations of process models that articulate development or evolution of ventures: independent growth firm creation model (Cunneen & Mankelaw, 2007), entrepreneurial process (Hisrich et al., 2010), innovation model (Park, 2004), and venture creation model (Bhave, 1994). Nevertheless, this study does not attempt to challenge process models. Instead, it concentrates on generic characteristics of the process to establish key activities leading up to venture creation.

The literature specifies three to four main activities that must be performed during venture creation process – discovery of an opportunity, evaluation, development and exploitation – and an accomplishment of each activity determines the decisive performance of the venture (Shane, 2003; Cunneen & Mankelaw, 2007; Shane & Venkataraman, 2000; Hisrich et al., 2010; Park, 2004; Bhave, 1994).

This paper has isolated a process model that describes creation of independent firms (Cunneen & Mankelaw, 2007); the activities defined within each stage closely resemble the set of activities observed in the case study, which is the foremost reason to analyze this model.

3.1.1 A Process Model for Independent Firm Creation

This theoretical model is proposed by Cunneen and Mankelaw (2007), which outlines four 'broad stages' – opportunity recognition, evaluation, development, and commercialization stage – that 'map the entrepreneurial behavioral process pursued during founding episodes of new growth firms' (p.90). It is important to note, the iterative nature of the model does not imply sequential progression.

The first stage, opportunity recognition, is described as a three step process through which a good idea is subjected to selective activities to identify the initial 'strategic competitive advantage, also referred as SCA; namely an innovative product, process, service, distribution

method or business model' (p.93). As an example, the activities may include, recognizing relevant profit potential of the idea, identifying a market, assessing feasibility to build and test a prototype. In the event SCA is established, the progression continues to the second stage and if the SCA fails to establish then the activities regress back to market research, product development, and reassessment of business model.

The second stage is known as evaluation stage which requires 'a preliminary personal and commercial appraisal' to assess whether the opportunity is a good fit on a personal level, and if a product can retain its strategic competitive advantage during development and preliminary financial calculations (p.95). This stage offers flexibility for modification or termination of the SCA.

The third stage, or development stage, requires implementation of the SCA and a comprehensive business plan – a detailed SWOT analysis (strength, weakness, opportunities and threats); in depth financial plan for potential investors; and, an in depth competitor examination. It also involves fabricating an effective strategy to enact the new business model, inclusive of production and distribution of new product. The latter part of this phase often concludes with search for funds using business plan as a 'tool' to procure adequate capital to cover necessary 'costs of start-up and beyond' (p.97).

The fourth stage or commercialization stage instigates if the venture secures initial round of financing and is ready to implement production of the product. The authors assert the scope and promptness of taking an idea to final stage is strongly linked to funding; any problems with the funds could impede or retard business implementation; restrict or 'prevent the new firm achieving startup or, commencing its first systematic sales' (p.98).

This model has been utilized by the authors over a period of nine years to guide undergraduate and postgraduate university students at the University of Newcastle (p.99). It is acknowledged that the model is highly conceptual since it lacks supportive case analysis or empirical testing

(p.100). Further, it is not clear whether the process model is effective for technology based start-ups. On the other hand, the authors make inferences to 'innovation, technology, and use of patent,' which may suggest that the model could be advantageous to technology based ideas (p.93).

These cumulative findings convey a structured paradigm to develop an idea from initial stages to founding stages of a firm, but it does not address the role of three variables, entrepreneurs, technology, and resources or their influence on venture creation, which is described in the following sections.

3.2 The Entrepreneur – Characteristics and role

Many different traits have been identified in past research to describe entrepreneurs and the ventures they create (Gartner, 1985; Shane, 2003). Entrepreneurial motivations (McClelland, 1961), intentions (Cha & Bae, 2010), alertness (Ardichvilli & Cardozo, 2000), life experience (Shane, 2003), personality traits (Antoncic, 2009), cognitive mechanism (Baron, 2008), and self-efficacy (Bandura, 1986), may also influence various stages of venture creation process (Park, 2004).

An entrepreneur has also been defined as someone who takes initiatives to gather resources creatively while assuming certain risk and uncertainty (Hisrich et al., 2010). Moreover, Shane (2003) suggests that '[these] alert individuals then obtain the resources and design organizations or other modes of opportunity exploitation, and develop a strategy to exploit the opportunity' (p.10).

Further analysis specifies that one of the most difficult tasks faced by an entrepreneur is to find uniqueness in an idea (Hisrich et al., 2010). Prior knowledge of markets and customer problems can help entrepreneurs in recognizing value of new information (Ardichvilli & Cardozo, 2000). However, this task does not fall entirely on the shoulders of the entrepreneur because this person is not considered a 'single agent but belongs to a network and has to interact with other

members to succeed' (Bureth et al., 2010: p.257); and relies on 'assemblage of a mix of competencies distributed over a wide range of individuals and organizations' (Bureth et al., 2010: p.278). In that respect, 'entrepreneurship arises within a collective network of heterogeneous actors, each of them acting on a fraction of the system but inseparable from the other members' (Bureth et al., 2010: p.278).

These suggestions infer that entrepreneurs play multiple roles to obtain required resources, integrate a range of variables, and interact with other members in the network during the process of venture creation.

3.3 Technology – Opportunity and Market Needs

University research is an important source of scientific knowledge (Park, 2004); market exploitation of research requires collaboration with multiple parties and relies on different types of knowledge (Bureth et al., 2010). Patents play an important role in obtaining proper return on investment in the life sciences (Bureth et al., 2010). An empirical study on patent commercialization suggests that 'the quality of a patent may influence its commercialization' and 'increase the probability that the patent is renewed' (Svensson, 2012: p.197). But, the study fails to specify the factors that determine the quality of a patent. On the other hand, Hsu and Ziedonis (2008) offer a broad definition of the quality signal 'as information capable of altering an observer's probability distribution of unobserved variables' (p.2). In other words, their definition conforms well to previously proposed conceptualization of a signal: 'a mechanism by which the quality of a startup's innovative capabilities can be identified and sorted' (Hsu & Ziedonis, 2008: p.1). These findings imply that the quality of patents may influence commercialization efforts, but the study does not offer sufficient evidence to determine market readiness of patented technology.

Nevertheless, there are other studies that offer supplementary information by emphasizing that new technology alone is not enough to provide the foundation for a new venture (Freeman

& Engel, 2007); innovation requires creation of profitable opportunity by successfully combining technology with market needs (Trott, 2002; Carayannis & Alexander, 2002); additional knowledge and resources are also required either from the founding entrepreneur or from within the evolving firm (Shane, 2003); and, new technology must be prepared through deliberate action by the R&D management process to incorporate into successful new products, because there are risks associated with technology development which may not lead to product development (Eldred & McGrath, 1997). The reason to present such arguments is that technology development and product development are regarded as two different processes (Eldred & McGrath, 1997: p.41). Therefore, it is imperative that the technology development process efficiently evaluates and facilitate suitability of a given technology for successful commercialization (Eldred & McGrath, 1997).

Furthermore, there is strong emphasis on utilization of proper business model to commercialize innovative technology by 'bringing it to market implicitly involves paying more attention to the choice of business model in originating research as it may be vital for achieving a satisfactory and sustainable level of commercialization' (Corkindale, 2010: p.37). The author further asserts that a business model can: 'articulate the value proposition' to users by identifying the target segment (to whom the technology or product is useful); define distribution channel (what is needed to get the product or technology to the market); specify the revenue generating mechanisms (cost structure and profits); formulate competitive strategy (enable the organization to gain and maintain advantage over rivals (Corkindale, 2010: p.39). In other words, a business model translates technical probabilities into commercial worth and is a critical success factor for every organization from startup to an established firm (Corkindale, 2010).

These outcomes suggest that technology presents an opportunity which could be exploited (by entrepreneurs or firms) through a proper business model, if it is efficiently developed to meet market needs. The next section offers discussions on resources.

3.3 Resources – Financial and Human Capital

In the life sciences, patents serve as 'tangible assets' that provide leverage to gain financial resources (Bureth et al., 2010: p.260). Moreover, it has been asserted that resource holders, such as investors, assess value of patent by approximating 'patent signal or conditional probability that a firm will succeed' which is significant for new firms that pursue exploitation of 'unproven technologies' (Hsu & Ziedonis, 2008: p.1). This suggests that it may benefit a patent holder to invest time and resources to reduce uncertainties associated with new technology, and increase the conditional probability of acquiring external financing. However, a venture needs numerous other types of resources (Gartner, 1985; Bhave, 1994).

For instance, it has been inferred in the literature that entrepreneurs' ties to their personal network, potential suppliers, and customers could qualify as resources, and have 'positive effect on both speed and growth' of venture (Capelleras & Greene, 2008: p.317). In addition, 'personal contacts with financiers are necessary to attract funds' (Bureth et al., 2010: p.275). Indeed, proximity of universities, governmental support, technical support, business advisers, external contractors, competitors, and other environmental and social factors may serve as direct or indirect resources for new ventures (Gartner, 1985). Nonetheless, close proximity with the network is not enough; it is essential to collaborate, establish alliances with other organizations and develop 'tight interactions'; and, 'set up agreements among all interested parties' (Bureth et al., 2010: p.276 & 277).

These findings suggest that numerous kinds of resources may be utilized to exploit an opportunity including collaboration and personal contacts within a network. The next section offers insights into the relationship of these elements.

3.4 Relationship of the Elements

Park (2004) synthesized available literature into an integrative model for high-technology start-ups based on qualitative research review and proposed that opportunity recognition is a crucial stage in the formation of new venture. He further argued that opportunity recognition does not consist of a 'single component in isolation' and that the entrepreneurial process is 'an interactive combination of three components – people, technology, and environment – which ultimately effects market innovation' (Park, 2004: p.740). The most interesting contribution of his proposed model is the nature of the elements which must converge and overlap to create the desired effect.

Similarly, Sarasvathy (2001) proposed contingency theory on effectuation asserts that 'entrepreneurs begin with their own traits, tastes, and abilities; the knowledge corridors they are in; and the social networks they are a part of,' and the 'primary set of means combine with contingencies to create an effect that is preselected but that gets constructed as an integral part of the effectuation process' (p.249 & 250).

Additional studies also imply importance of 'integration, interplay or a relationship' between entrepreneurs, new business opportunities, technology, environment, social systems, and a range of other factors (Baron, 2006; Ozgen, 2011; Shane & Ventakaraman, 2000; Shane, 2003).

These theories suggest that the critical variables are interdependent and must interconnect to effectuate the process of creation.

3.5 Collective illustrations of the theories

This section will attempt to provide collective illustrations of the theories reviewed in the previous sections.

The literature on venture creation process suggests that it may consist of four 'broad stages' – opportunity recognition, evaluation, development, and commercialization stage – that govern the process pursued during founding stages of new firms (Cunneen & Mankelow, 2007: p.90).

This process allows a good idea to navigate through selective activities to reach a desired outcome.

Further, relevant theories on entrepreneurs, technology, resources, and their relationship infer the following: entrepreneurs play multiple roles to obtain required resources and integrate a range of variables during the process of venture creation; technology presents an opportunity which could be exploited (by entrepreneurs or firms), if sufficiently developed to meet the needs of the market; personal contacts and collaboration within a network can serve as resources; these critical elements are interdependent and necessitate interconnection to effectuate the process of venture creation.

Therefore, based on collective conclusions offered and assumptions drawn from the literature review, the author proposes the following illustrations of the venture creation process (see Figure 1).

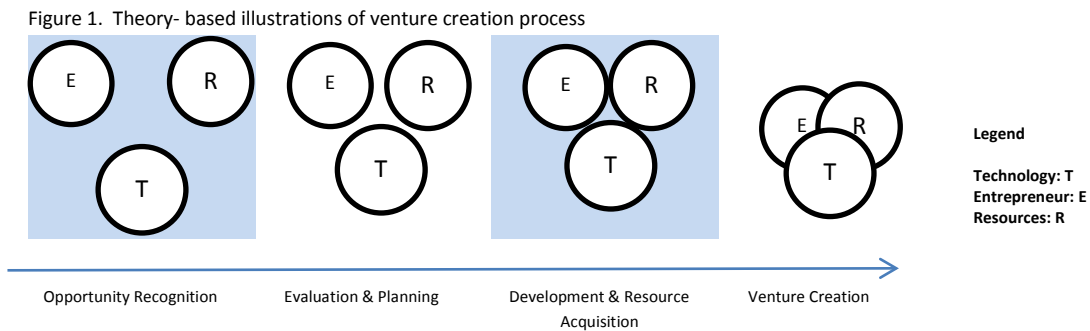


Figure 1. Illustrates the relationship of critical elements that must close the gap and converge closely as an idea progresses through various stages of development; the performance of each element is contingent upon closeness of these interactions.

4. Methodology

I have utilized autoethnographic methodology to provide readers with my personal perspective on critical events that transpired during the development of the project, which is under

investigation in this paper. Although other methodologies may also be suitable for case analysis, the reason for choosing this methodology is to comply with the instructions of the program. The data was gathered from December 2010 until April 2011 and documented in the form of learning journals. The learning journals were written weekly to reflect on the activities of the project and the theories taught during the program. Aside from the learning journals, electronic communications and minutes from the board meetings may be used for analytical purposes of the study. Identities of persons involved have been withheld for privacy reasons since most of the relevant documents will remain unpublished. Anderson (2006) referred to autoethnography as a qualitative inquiry, which is also known as introspective and retrospective rendition of the events (Wall, 2006). For these reasons, autoethnography offers a different perspective on past events and lessons learned.

5. Case Analysis

The project was presented to the students on September 9th, 2010; none of us had any prior experience in commercializing such technology. However, the academic requirements of the program guided project development by establishing performance criteria and timeline; this facilitated planning of relevant activities and fulfillment of objectives for both, the project and the program.

The main motivation to work on the project came from the inventor who was enthusiastic about capitalizing on his invention; he held majority ownership of the patent and had full discretion. Furthermore, the project was overseen by a board of knowledgeable advisers, including the researcher, LUIS, and an Assistant Professor from the program; a chairman of the board was not designated. The expertise of the advisers navigated students through market evaluation, planning, and development; the project would have suffered considerable delays without this support.

This paragraph offers a limited history of the project prior to students' involvement which may be of relevance and appreciated by the readers. The project had received early stage funding in the amount of 200,000 SEK around May 2010, from Innovationsbron – an entity which provides financial support to innovators in Sweden to encourage proliferation of innovation up to international level. It is unknown as to who governed the accounting of the funds. Nonetheless, this financial support was said to have been consumed to file the patent. Additionally, the project procured an independent SWOT analysis – strengths, weaknesses, opportunities and threats – of the patent, which identified four applications, including selling licensing agreements. The report also suggested that the technology was in its infancy but, it had feasibility in the frozen foods industry. Consequently, this prompted a dialog with Findus, a reputable frozen foods company in the Nordic region. This interaction increased the confidence in technology and became the initial focus of the project. Due to the fact that these discussions were initiated prior to students' involvement in the project, it limits my ability to provide further details.

The sections below provide a chronology of events that were vital to the project. The chronological order depicts four phases of commercialization process, beginning with opportunity recognition. It was astonishing to distinguish data into phases since many activities overlapped during the seven months. Nevertheless, I have attempted to keep the information succinct and organized for ease of reference.

5.1 Opportunity Recognition Phase

The duration of this phase is estimated between September 2010, and December 2010. The chosen team had until the end of September to conduct preliminary market evaluation of the patent in the frozen foods sector; our proposal was taken under consideration, 'the researcher is positive to run this project with your group. We should have a startup meeting where we share our expectations and goals for the project,' (Internal communication, October 20, 2010). The goals were periodically re-evaluated.

In the following month, the board selected 'direct licensing agreements within frozen foods sector and extract production of the nutrient to be wholesaled to food supplement companies as an ingredient' (Minutes of the Meeting, November 19, 2010).

We received discouraging news at the next board meeting in December; Findus had receded discussions on licensing agreement due to lack of clear technology benefit. The details remain unknown since the students were not involved in discussions with Findus after they joined the project. This outcome lowered the feasibility of the frozen foods sector and made the ingredients market central for further investigation. Yet again, objectives were defined for each member, including further tests for technology validation (Minutes of the Meeting, December 08, 2010). To alleviate the scheduling pressure, I offered my assistance to run some tests in the laboratory. Parallel to these events, the team continued its relentless efforts to gather market data, interview experts and potential business angles.

While the team continued market investigation, the technology development remained quiescent due to lack of resources and committed technology partners. By the end of December, a couple of issues were ostensible. First, there was lack of supporting research to substantiate any health benefits to the end-consumer, which could create difficulties with EFSA –European Food Safety Authorities. Second, there was lack of knowledge among the consumers about the nutrient. Consequently, this created a disadvantage for the technology because its uniqueness could not be translated into value proposition as anticipated. Hence, the activities in the next period detracted from licensing agreements. Instead, product development became the focal point of the project.

5.2 Evaluation and Planning Phase

This phase extended from January 2011 until April 2011. Soon after the holidays, the team had filtered extensive data on relevant markets, health food trends, and competitors. In particular, we had identified several competitors in the European eye health market that were mass producing the nutrient themselves or getting supplies from China. But, the most dominant global player was a US based company with several variations of patents covering formulations

and usage of the nutrient, and it was in the midst of settling multiple patent infringement lawsuits with international contenders – the caveat! The bewilderment was, ‘do we need a license to produce a nutrient for which we already have a patent, because that would convert us from a license seller to a license buyer’ (Internal Communication, January 11, 2011).

The rudimentary question begged for a response; I recognized that, writing a business plan was not justifiable if the project feasibility was endangered and imminent, unless we changed the course of action. Consequently, it was essential to plan, prepare and present laconic information to the expert during an upcoming meeting (Learning Journal, January 21, 2011).

Aside from being the former chairman of the board to Swedish Food Academy, the expert had extensive experience in product development and its’ launch; and, was linked to multiple networks of established companies in the food industry. The meeting went well; the expert proposed to act in an advisory capacity instead of being designated as the chairman of the board since the project had not formalized to a company at that time. He concluded that the project had a good potential, but the technology had not reached a sufficient level of maturity.

Further, he advised that health based value proposition would be difficult due to regulatory reasons; deter from being an ingredient player; investigate food supplements market since it had higher consumer acceptance; think globally if starting a business; start building the brand because, ‘science does not sell product and without science we cannot sell product,’ (Minutes of the Meeting, February 2, 2011). This meant, we had to procure funds to maintain activities, establish a presence through social media and a website, increase awareness among the consumers through a series of marketing related activities, obtain clinical facts, and invest in product development – quite a challenge.

Over the next couple of months, the team gathered data from industry experts, customers, and potential partners to transition the ‘idea to concept stage,’ in the shortest time possible, and without compromising the integrity of the technology (Hisrich et al., 2010). Yet, the question remained how to filter all this information into a business plan. The recommendation was simple, ‘continue to work on the details and do not make assumptions. Find facts and make your business plan trustworthy,’ (Internal Communication, February 4, 2011).

This phase was highly intense due to numerous ensuing activities on both academic and project level. As an example, we applied methods of 'joint utilization' in the sense that, we borrowed equipment and used laboratory at the biochemistry department to create a crude prototype to showcase at two separate competitions – The Dragons (pitch to investors) and Venture Cup (business plan competition) (Winborg & Landstrom, 2000: p. 245). Individuals that use such techniques have been identified in the literature as 'relationship-oriented bootstrappers' (Winborg & Landstrom, 2000: p.245).

The team secured top position at the Dragons event on February 17, 2011, followed by winning a second place in Venture Cup on May 5, 2011; each performance built 'legitimacy' of the project (Zimmerman & Zeitz, 2002). The publicity increased public awareness of the conceptual product and its benefits. The project also attracted interest from investors that were present during these events; they wanted proof of technology benefit to the end consumer; without corroborating evidence the project had difficulties attracting external financing.

The project faced a few additional challenges. First, the team had suffered setbacks by losing two students during the months of October and January. This created an intense pressure on the remaining two members. However, recovery was swift since a student, whose background was complimentary to the project, decided to join the team in January, 2011. Second, the technology advanced at a slower pace than anticipated which made it challenging to comprehend 'the competitive advantage of the technology' in comparison to the market needs (Cunneen & Mankelow, 2004). Third, we could not establish partnership with external technology providers to initiate clinical tests for verification of technology or refine prototype which 'required 60,000 SEK to get the proof of concept ready' (Internal Communication, March 8, 2011). The project also needed to launch an interactive website – a concept that was developed with the help of ISIT students at LU – and required an additional 50,000 SEK. These costs were anticipated after February 2011, since the initial focus was on selling licensing agreements. Nonetheless, it was understood that the financial resources of the project had depleted by this time, which hindered its progression.

5.3 Development and Resource Acquisition Phase

After successful conclusion of Venture Cup, the project needed to accomplish critical milestones which meant increasing productivity of developing technology. The team continued advancement of the project; we participated in a tradeshow at LU which increased exposure of the technology and provided good feedback from the consumers on the product concept. Also, our application was accepted at Venture Lab, an incubator for early stage startups; however, it required a company registration. Given the situation, it raised some concerns among the team about the future of the project.

Therefore, the team pursued a meeting in early May 2011, with the researcher and LUIS where all parties had an opportunity to share their thoughts and discuss options to overcome the limitations, if possible. However, it was determined that technology development would take time; the researcher was unable to devote adequate time for its development due to his teaching obligations; there was lack of adequate support in the Biochemistry lab which meant that technology development or product development could not be delegated to anyone else; project lacked funds to acquire assistance from technology partners who could influence the rapidity of product development; and external financing through business angel could be negative for product development. Therefore, it was decided that joining the incubator was not suitable at that time, instead the project needed to pursue additional grants or soft funds in the coming months to continue its development since it was too far from the market.

This phase commenced on May 1st, 2011, and ended on May 19th, 2011, due to abovementioned limitations. The team had fulfilled its objectives and the academic program had also reached its conclusion. Furthermore, in the absence of reasonable incentives from the project, the team was relinquished from any further obligations. Given the situation, it was not practical to pursue venture creation.

5.4 Commercialization Phase

The project ceased commercialization activities in the previous phase and did not complete its transition to this phase primarily due to limitations of technology; we did not have a competitive product that could be tested in the market i.e. the technology was too far from the market. However, the project did not cease entirely since we had succeeded in defining a target product that would be competitive and serve needs of the market (Internal Communication, May 19th, 2011). Based on unequivocal recommendations of the team and the board, a new opportunity was created to guide technology development and product development from that point forward.

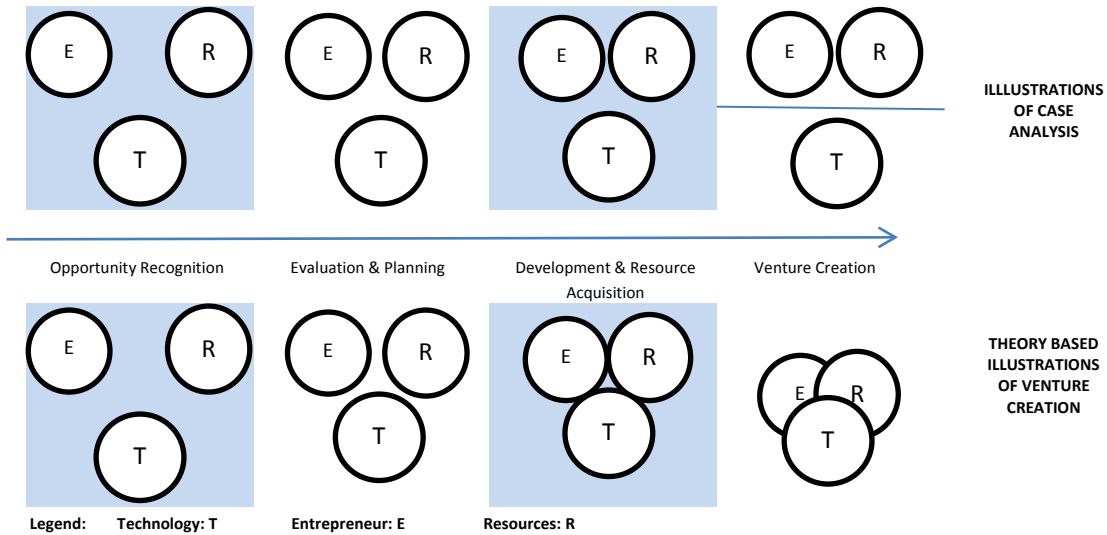
This concludes the qualitative case analysis. The following section endeavors to investigate the results and discuss the observations.

6. Results and Discussion

This section will attempt to synthesize observations of the case and discuss the outcomes based on qualitative approach adopted in this paper. Notwithstanding the significance of other variables or dimensions of the project, the paper focused on the role of technology since it was the central business idea. The next few paragraphs offer illustrations and a narrative of observations from the case study.

These illustrations suggest interaction or interdependency of critical elements during various stages of project development in comparison to the proposed conceptual model (see Figure2).

Figure 2. Comparative Illustrations of case analysis & theoretical concepts



6.1 Opportunity Recognition Phase

The most direct, and cost effective, application of the technology was through the utility of licensing model. The interest from Findus delivered sufficient confidence in technology and did not necessitate technology development or an immediate need for additional resources. On the basis of which, the team allocated its efforts on gathering information to sell licensing agreements. As inferred from the proposed theoretical model, no interdependency between the elements was observed or necessary in this phase.

6.2 Evaluation and planning phase

The technology could not be sold to Findus due to weak quality signal i.e. the technology did not convey clear benefit, which prompted technology validation. Soon, ingredients market and food supplements market became prime focus of investigation due to higher desirability. Market data also suggested that these markets were lucrative, but highly competitive, which implied technology development and external financing. Meanwhile, the team developed a comprehensive business plan and made suggestions for a proof of concept; however, technology feasibility and financial viability remained low. Although, the team was successful in

gathering market knowledge, and establishing supporting networking, it could not connect additional resources to assist technology development which may explain the gap between entrepreneurs, technology and resources. In contrast, the theoretical model infers a closer interaction between all three elements during this stage.

6.3 Development and resource acquisition phase

This phase required systematic implementation of the business plan. The team had fulfilled the objectives of the project, but lack of resources and sufficient technological development hampered further progression. The theoretical model suggests a connection between all three elements at this stage. On the other hand, case observations indicate a significant gap between technology and other two elements, which could not be influenced in a short time. Hence, the project could not transition to the final stage.

As observed, the technology had foremost influence on essential resources and activities pursued by the entrepreneurial team. These findings confirm that lack of technology development leads to failure of research commercialization. Additionally, the other major contributing factor was lack of sufficient funds. It is also possible that entrepreneurs' lack of prior experience with such technology or lack of market knowledge may have contributed to the gap between them and technology. Nonetheless, these findings may be one-dimensional in some ways since the project objectives were not scrutinized during the analysis and may offer a different perspective.

To elaborate, market evaluation and development of a business plan facilitated planning of certain activities, filtered out some uncertainty in the process, and may have also enhanced self-confidence (Karlsson & Honig, 2009). On the other hand, activities related to gathering market data, and financial projections were time consuming, detracted from seeking new customers and interfered with team's efforts to formalize collaboration within the network (Karlsson & Honig, 2009). The literature indicates lack of sufficient data that could clearly establish 'a relationship between planning, profitability and survivability of nascent

organizations' (Honig & Karlsson, 2004), and offers inconclusive evidence on the effects of business planning before the start of business (Karlsson & Honig, 2009). These findings imply that business planning may have also retarded project development and negatively influenced timely procurement of certain resources. In contrast, business planning also allowed proper evaluation of the market, technology and resources.

7. Conclusion, limitations and learning outcome

A new technology was presented to a team of students for evaluation of market opportunities and development of a business plan that could define its feasibility and desirability for commercialization. The technology failed to commercialize. Therefore, this paper aimed to investigate the main role of technology development in research commercialization through review of relevant theories and a comprehensive analysis of the case. The objective was to gain insights into the relationship of three variables – technology, entrepreneur and resources – of a technology startup during evolutionary stages of an idea from opportunity recognition to the final stage of commercialization.

The case observations combined with theoretical analysis indicate that commercialization of new technology is an exceedingly complex and interactive process. A venture idea based on new technology necessitates proper evaluation, development, extensive planning, various resources, and a good team to reach final stage of commercialization. It is critical to choose the right business model to articulate the value proposition of the technology in the interest of potential customer. Business planning is essential and must be done concurrently with technology development to capitalize on the business opportunity.

To conclude, entrepreneurs play a major role in a startup by acquiring market data and necessary resources; technology development requires resources and its lack of development has a significant impact on successful commercialization. Moreover, these variables are not effective in isolation as a driving component and must establish a closer bond during

evolutionary stages to meet the objectives of commercialization. Most importantly, the performance of a venture is contingent upon a closer interaction of these elements and requires commitment from all parties involved.

The main contribution of this paper is to offer illustrations of relevant theories to demonstrate the complexities in the field of new technology commercialization and the subsequent impact on new venture creation. The paper lacks an in-depth theoretical analysis and empirical data which limits its scope and findings.

On a personal level, this project has had a tremendous impact on my experiential learning. Despite the challenges, the project achieved much success and accomplished many benchmarks in a limited time. Furthermore, it has increased my comprehension of the theoretical knowledge in combination with practical implications. Nevertheless, the current body of knowledge on evolutionary stages of embryonic technology startups is limited. Therefore, it is proposed that there is a need for future studies that can expand current understanding of the subject to allow entrepreneurs and scientists to successfully transform technologies into desirable products and create new enterprises.

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