COMMERCIALIZATION PROCESS OF HIGH TECHNOLOGY: A STUDY OF FINNISH UNIVERSITY SPIN-OFF

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ABSTRACT

This article examines commercialization process of a high technology, which is characterized by a high level of research and development activities, resources-intensive and added values. The article employed a case study approach, by observing a Finnish University Spin-off between 2013 and 2016 and making use of documentary method. In contrary to many previous studies, the findings of the article showed that the spin-off process does not necessarily to be stage-based and has to be flexible. The findings also revealed the factors responsible for successful commercialization. Similarly, the findings pinpointed that "plan is always a plan" and that plan would change during the spin-off creation process. These findings provide an in-depth knowledge for commercialization practitioners, technology entrepreneurship educators, potential entrepreneurs (engineers and scientists) and business enterprises. Therefore, this article contributes to discourse of spin-off, commercialization, technology transfer and academic and university entrepreneurship.

Keywords: Commercialization Process, High Technology, Spin-Off, Finland.

INTRODUCTION

To achieve a financial success from exploitation of intellectual property (IP), a proper commercialization method must be selected (European Union, IPR helpdesk, 2015). Likewise, for an enterprise to be successful, it must be able to select and employ an appropriate commercialization mechanism for its new technology (Aslani et al., 2015). One of the commercialization methods is the creation of a new venture or spin-off (Grimaldi et al., 2011; Vincett, 2010; Ndonzuau et al., 2002; Carayannis et al., 1998; Gbadegeshin, 2017a). This method is well discussed by the scholars (Mustar et al., 2006; Carayannis et al., 1998) and different terms are used for it (Seguí-Mas et al., 2016; Mustar et al., 2006; Carayannis et al., 1998). For examples, it is called: Academic/University Entrepreneurship (Chang et al., 2016; Walsh and Hsini, 2014; Farsi et al., 2014; Hewitt-Dundas, 2012; Lehner et al., 2009; Hoye and Pries, 2009), University Spin-Off (USO, Evers et al., 2016; O'Gorman et al., 2008; Pimay et al., 2003), Academic Spin Offs (Czarnitzki et al., 2014; Festel and Rittershaus, 2014; Rasmussen et al., 2006; Vohora et al., 2004; Shane and Stuart, 2002; Klofsten and Jones-Evans, 2000), Research-based Spin-offs (Mustar et al., 2006) and New Technology Based Firm (Mustar et al., 2006; Al Natsheh et al., 2013). The spin-off can be simply defined as an establishment of a new company purposely to utilize commercial benefit of research results, knowledge or technology, which emanated from an academic institution (Pimay et al., 2003), public research organizations (Helm et al., 2013; Mustar et al., 2006; Fontes, 2005) or parent organization (De Cleyn and Braet, 2009; Clarysse et al., 2002).

Consequently, there are numerous studies on the spin-off, but they focused on different aspects and looked at it from the different perspectives. For instance, some studies focused on the IP (e.g. Dahlstrand et al., 2015; Fini et al., 2010), roles of participants (e.g. Gubitta et al., 2016; Slavtchev and Göktepe-Hultén, 2016; Farsi et al., 2014; Fontes, 2005; Roberts and Malone, 1996), funding (e.g. Gubitta et al. 2016; Festel and Rittershaus, 2014), responsible and success factors (Farsi et al., 2014; Shakeel et al., 2017) and problems (e.g. Tanha et al., 2011; O'Gorman et al., 2008; Lerner, 2004; Smilor et al., 1990). Similarly, some studies examined previous academic works to frame research focuses on the topic (e.g. Seguí-Mas et al., 2016; O'Shea et al., 2014; Djokovic and Souitaris, 2008; Rothaermel et al., 2007; Mustar et al 2006; O'Shea et al., 2004; Pimay et al. 2003; Carayannis et al., 1998).

However, few studies have addressed commercialization process of the spin-off (Seguí-Mas et al., 2016) and how the new technology is transformed to a consumable product or service (Djokovic and Souitaris, 2008; Rothaermel et al., 2007). In fact, it would be interesting to investigate a specific practical phenomenon of the spin-off process with theoretical explanation (Djokovic and Souitaris, 2008). Therefore, there is a need for an in-depth knowledge of the commercialization process of spin-off, especially through analysis of case study (Evers et al., 2016) so that there would be a better understanding of how the spin-off develops iteratively over time (Mustar et al., 2006).

To fill the above gap and to provide practical insight, this article employed a case study method by providing details of the commercialization process of a high technology-based university spin-off (USO). This method used documentary/texts and observation research instruments. The findings of empirical study revealed that the USO commercialization process does not need to be stage-based. Similarly, the findings revealed the success factors for the USO commercialization process. The outcomes stated that flexibility of the USO commercialization process is essential and the commercialization team should bear in their mind that plan is always a plan.

Therefore, this article contributes to theoretical knowledge on USO commercialization because it revealed that stage-based model is rigid and cannot be a cap that fits all. It also revealed that the flexibility of the USO process is crucial, which has not yet been discussed explicitly by the scholars recently. This article also contributes to the practice by outlining success factors which enabling smooth execution of USO commercialization process. This information is useful for the practitioners, especially entrepreneurs, business owners, business executives, entrepreneurship educators and trainers and commercialization experts. Most importantly, this article contributes to the methodology of commercialization studies. Most of the commercialization studies employed interview, case study analysis, questionnaire and other methods, but they have not yet used "*documentary*" and "*participatory*" methods.

The rest of this article consists of theoretical background, methodology, findings and discussion and conclusion, contribution and limitations. The theoretical background presents a literature review of previous works on USO commercialization process. The methodology section also presents research process and the case study company. The findings and discussion part elucidate the relationship between the findings and previous works. The last part lists conclusion, the contributions of the article and its limitations.

THEORETICAL BACKGROUND

The University Spin Off (USO)

While reviewing the scholarly articles on the USO, it was noted that the definition of USO is ambiguous (Pimay et al., 2003; De Cleyn and Braet, 2007; Djokovic and Souitaris, 2008) because the scholars tend to define the term by focusing on innovation and entrepreneurs who established the spin-off (Carayannis et al., 1998), parent organization (De Cleyn and Braet, 2007) or government as a unit of analysis (Djokovic and Souitaris, 2008). This resulted to the use of many anonymous terms to describe the USO (Seguí-Mas et al., 2016; De Cleyn and Braet, 2007; Djokovic and Souitaris, 2008). Meanwhile, in this article, the USO is adopted and its definitions are employed.

Therefore, the USO can be defined as a new enterprise, which is created purposely to utilize a new technology by transferring the resources of its founders from its parent organization (Carayannis et al., 1998). Also, it is a new company which is found to exploit business opportunities of a new technology, knowledge or research findings that are developed by the research institutions (Pimay et al., 2003). Additionally, the USO is a new firm established mainly to utilize an IP which is developed by a university (Shane, 2004). Basically, the purpose of the USO is to commercialize an invention or innovation.

Furthermore, there are two forms of the USO a planned spin-off and spontaneously occurring spin-off. A planned USO is a predetermined new business venture by a research institution through an organized effort. On the other hand, a spontaneously occurring USO is a new business venture which is not predetermined and which is sometimes not completely supported by the research institution. Thus, the planned USO has a close relationship with its parent organization (henceforth, PO); whereas, the spontaneously USO has none or little relationship with its PO (Steffensen et al., 1998). Similarly, a typology of USO consists of 2 dimensions according to the scholars. The dimensions are nature of knowledge transferred and individual status. The nature of knowledge transferred can be tacit and codified. Usually, if the knowledge transferred is tacit, such USO is service-oriented; while, if the codified knowledge is involved, USO is product-oriented. In the same vein, individual status can be either academic or studentship. When an academic/university researcher founded a USO, it is often called academic spin-off, but when student founded a USO, it is often called student spin-off (Pimay et al., 2003). More elaborately, different USOs can be established based on different driving factors. Examples of those USOs are direct research spin-off, tacit knowledge spin-off, indirect spin-off, student spin-off, opportunity driven spin-off, technology development spin-off, restructuring spin-out, market differentiation spin-out, mixed origin spin-off and academic spin-off. All these forms of USO depend on their reasons for the establishment and the PO (De Cleyn and Braet, 2009).

Summarily, the USO is a new firm which is based on an IP (Shane, 2004: Dahlstrand et al., 2015) even though, many of these firms are actually founded outside IP boarder (Fini et al., 2010), because the commercialization of new discoveries is more than patenting (Geuna and Muscio, 2009). This might be one of the reasons this kind of firms is heterogeneously discussed by the scholars. For example, the scholars explained them from resource based, business model and institutional perspectives (Mustar et al., 2006). Nonetheless, the scholars agreed that university researchers (including students) and other participants (e.g. PO, public research organization, investor/financier, etc.) and the funding of PO, are crucial for the establishment of this type of companies (Gubitta et al., 2016; Farsi et al., 2014; Tanha et al., 2011). Thus, the effort of these participants is either supporting the success or failure of the USO creation

(Shakeel et al., 2017; Slavtchev and Göktepe-Hultén, 2016; Farsi et al., 2014). Similarly, the origin, founder, driver, history and type of knowledge transferred determine the definition of USO (De Cleyn and Braet, 2009). Therefore, in this article, the USO is considered from the IP, resource based business model and institutional perspectives. Likewise, all USO participants are considered in this article because, the USO commercialization process is demanding, due to need of many resources like time, material resources and money (Slavtchev and Göktepe-Hultén, 2016; Lerner, 2004).

Commercialization Process of USO

The commercialization process of USO can be termed as a transformation process, where the business opportunity of a new technology or knowledge is exploited. The commercialization can result to either product-oriented or service-oriented USO (Fontes, 2005). It can be regarded as an entrepreneurial process (Van Der Sijde et al., 2013). The USO, thereafter, plays important roles in bringing the new technology/knowledge to market, improving under-utilized industrial opportunities and intermediating knowledge transfer. Bringing the new technology to market, the USO often does the following: (a) identification of application areas and conducting further research and development {if needed}, (b) development of prototype/service pilot for the technology/knowledge, (c) testing of prototypes to plan for production/market issues, (d) product development and considering of production, market, regulatory issues, and (e) product marketization. The USO can marketize its product/service as a stand-alone or complementary (in alliance). In some cases, the USO can licence or sell the core technology of the developed product. This transformation process reduces uncertainties of new technologies of research organizations (Fontes, 2005).

Similarly, the commercialization process can be described as a valorisation of research results. It is a stage model process. It consists of four stages: business idea generation, new venture project finalization, spin-off launching and economic value strengthening. The first stage, business idea, consists of idea identification and assessment. The second stage, new venture project finalization, includes selection of the best idea, protection of the idea, business development of the idea (consists of development that has technological and commercial activities) and financing of the new commercial project. The third stage is launching of the USO; considering of all necessary resources are the main activities of this stage. The last stage is strengthening of the economic value of USO, which can be tangible or intangible. Examples of tangible economic value are job creation, tax payment and investment returns. Examples of the intangible are economic renewal, entrepreneurial spirit and recognition (Ndonzuau et al., 2002).

In the same view, commercialization process is a multistage procedure. Its stages are: research result, creation and disclosure of the discovery, protection of the invention, marketization of technology/knowledge and licensing decision. The first stage is an outcome of the university second mission. The second stage is patenting, analysing of other IP and protecting the IPs of the concerned invention. Usually, inventors and research organizations (RO) are the key players at this stage. The third stage is when IPs is disclosed and this is commonly done within the RO. The fourth stage, the marketization of technology, often occurs with technology and business development and it often occurs within the USO. This stage also consists of prototype and market developments. This stage is termed as developmental phase and it is the most challenging stage of the USO process because inventors are technically-oriented people with less marketing knowledge (Shane, 2004).

Clarysse et al. (2002) contributed to the topic by creating a model for the USO process from their previous works. These scholars termed their model as "*the spin-off funnel*". The model has 3 stages: invention, transition and innovation. At the invention stage, the scholars explained that a new discovery is made by the public research organization's (PRO) research projects. The end-result of this stage is a validated business idea. Thereafter, second stage starts (transition) and it focuses on technical development in relationship with the market; the end-result of the stage is a validated growth expectation. The last phase is innovation which centres on business development.

Vohora et al. (2004) also contributed to the discussion by offering a stage-based USO commercialization process. These authors focused on the USO itself. Their stages are: research, opportunity framing, pre-organization and re-orientation phases. The author focused on how the USO moved from one phase to another and they identified four crucial milestones. These milestones are: opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability. The authors noted that if the milestones could be well-managed, the commercialization process could achieve its purpose successfully.

In their contribution, Gübeli and Doloreux (2005) explained that USO commercialization process has three phases with different aspects or activities. The phases are pre-founding, founding and post-founding. The authors explained that pre-founding consists of motivation, interest, vision and opportunity recognition; while, founding consists of business plan, legal issues, financing, prototyping, market analysis, office space and networking. The authors noted that founding stage is influenced by the skills, the experience and the business idea. The author listed that management, marketing, financing, networking, office space and product development as the post-founding stage activities.

In addition, Simmons and Hornsby (2014) analysed several scholarly papers and identified five stages of academic entrepreneurship. These authors enumerated that motivation, governance; mode selection, competition and performance are the stages. The authors explained that interest and motivation of faculty, university, industry and government is the first stage of any USO. These authors pointed out that the motivation sets the pace for the creation of USO. The authors also explained that the motivation is shaped with royalty and fixed fee arrangements and equity governance mechanisms, which are termed as governance (the second stage). The authors named the third stage as mode of selection. They explained that there are competitive, cooperative and backdoor mechanisms. The authors stated that creating a USO is a competitive mode. The fourth stage, according to the authors, is competition which includes technology transfer office, human and social endowments and patent portfolios. The authors concluded their stages by mentioning that performance is the last the stage. They stated that performance phase consists of knowledge spill over, faculty, university and industry.

Furthermore, Hindle and Yencken (2004), in relation with works of Yencken and Gillin (2002), Vohora et al (2002), Mustar (1997) and Lee and Gaertner (1994), developed an integrative model. This model considered the entrepreneurial capacity of the PO and potential entrepreneurial of the new USO; this capacity could be in form of advice, support, experience, monitoring and incubation services. The model also identified boarder scanning, which includes activities associated with the business environment screening. Boarder scanning consists of idea, competition, unforeseen events, economy and environment. The model believed that discovery and inputs are important peripheral activities of any new USO development. The inputs include research provider assessment/support, inventor's tacit knowledge, seed funding, business, equity and own revenue. The stages of the model are: research program provider, idea/new knowledge,

opportunity, vision, technology development/proof of concept/prototype and final customer. Notably, the model focuses on new technology-based firms.

In contrast to the stage-based models, Bradley et al. (2013) presented a new framework which was termed as "*Alternative Model*". These authors identified problems which associated with the stage-based models. They explained that the traditional models failed to consider formal and informal situations. They noted that the existing models seem to: oversimplify commercialization process, lay much emphasis on patenting, be too rigid, fail considering of uncertainties, not consider organizational culture and norms, not include university reward system and assume that all commercialization activities are the same across the university departments or RO or countries. To avoid the weaknesses of the stage-based models, these authors added many activities to their Alternative Model. For examples, different sources of funding for basic research and different forms of technology commercialization are added to the model. They also avoided drawing direct lines across commercialization activities. They tried to make the activities to be interconnected. Meanwhile, they still labelled their model with numbers, which depicted that their model is like that of stage-based model. Their model has 12 stages.

In relating to the work of Bradley et al. (2013), Al Natsheh et al. (2014) improved the model by proposing a generalizable model. These authors named their model as "*University technology commercialization process*". This model has 4 stages. The stages are called invention, evaluation, confirmed invention and decision making. For the invention stage, the authors kept it open to any discovery from whatever source. For the evaluation stage, they divided it into technical and business stages; they noted that these sub-stages are expected to be done simultaneously. They also stated that technical evaluation should consist of production and IP analysis. Similarly, business evaluation should contain supply chain and market analysis. The authors explained that if the results of the second stage activities are positive, the invention can be regarded as "*confirmed invention*"; thereafter, a decision can be made on the type of commercialization methods to be selected.

With the above-discussed academic works on the commercialization process of USO, it can be noted that these works are stage-based models, even though Bradley et al. (2013) and Al Natsheh et al. (2014) stated that their models are not stage-based. The whole previous works are summarized and presented in the following Figure 1.

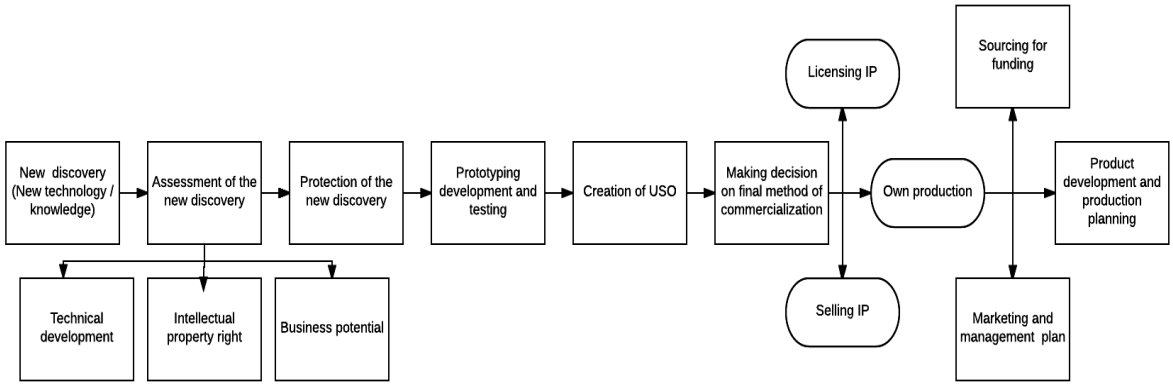

Figure 1
STAGE-GATE MODELS OF USO COMMERCIALIZATION PROCESS

Meanwhile, when the models were synthesized, the stages were grouped into three phases: pre-commercialization, commercialization and post-commercialization. The pre-commercialization phase consists of activities, which the founders of USO should execute prior to actual commercialization. The commercialization phase is the transformation of the new technology/knowledge into consumable products/services. The post-commercialization is when the USO is established and its product/service starts to be marketed and managed. This grouping corresponds to the work of Gbadegeshin (2017b) and the work of Gübeli and Doloreux (2005), which is denoted the grouping as pre-founding, founding and post-founding stages. With this grouping, the following Table 1 summarizes previous academic works into each phase, outlines activities for the phases and their influencing factors.

Table 1
ACADEMIC COMMERCIALIZATION PROCESS OF USO

Phase	Activities	Factors
Pre- commercialization	Discovery of invention (new technology/knowledge) and opportunity assessment of the invention.	Organizational vision and interest, inventor's interest and motivation, opportunity recognition ability, opportunity scanning and industrial trend information/knowledge.
Commercialization	Technology development, identification of application areas, IP assessment and patent application, prototyping, market research, prototype testing, business model analysis, supply chain analysis, funding and production evaluation.	Mode of commercialization (competitive, cooperative and backdoor mechanisms), organization culture and policies, technology transfer office, human and social endowments and patent portfolios.
Post- commercialization	Establishment of USO, licensing or selling of the technology, funding sourcing, marketing and production activities and economic added value.	Knowledge spill-over, faculty, university and industry.

The list of activities in the Table 1 is used in the empirical study of the article as "*themes*" and the factors are used as "*influencers*" for data analysis. The next section presents the research procedure of this article.

METHODOLOGY

A case study method was employed because it sheds more light on a specific issue and provides a mutual understanding of the phenomenon (Yin, 2003). The method assists researchers to get an in-depth knowledge on the phenomenon (Denzin and Lincoln, 2000). It is very good for investigating business related issues (Eriksson and Kovalainen, 2008), especially when an empirical study is involved (Creswell 2009). The method includes qualitative research instruments (Baxter and Jack, 2008) such as documents, interviews, observations and artefacts (Eriksson and Kovalainen, 2008; Baxter and Jack, 2008). Besides, this method was used because the USO scholars, like Evers et al (2016), Djokovic and Souitaris (2008) and Mustar et al. (2006), demanded for a case study approach which explains the commercialization process explicitly. Thus, the following subsections provide details of this article methodology.

Research Question and Research Instruments

The first step of the methodology was defining of research questions and research instruments. In relation to the research gaps identified from the literature review, these questions were outlined: (a) how does a USO commercialize its high technology? (b) Does the USO follow stage-gate commercialization process? and (c) why does the USO succeed in its commercialization adventure? The first question addressed the research gap articulated by Seguí-Mas et al. (2016), Djokovic and Souitaris (2008), Rothaermel et al. (2007) on the commercialization process of a high technology. The second question also examined the research gap instigated by Gbadegeshin (2017b), Shakeel et al. (2017) and Mustar et al. (2006) on stage-gate or process driven approach of commercialization. The last question investigated the relevancy of several factors outlined by scholars like Gubitta et al. (2016), Slavtchev and Göktepe-Hultén (2016), Farsi et al. (2014), Farsi et al. (2014) and Shakeel et al. (2017).

To provide valid and reliable answers to the aforementioned questions, observation and documentary methods seem to be applicable. These research instruments enable researchers to have first-hand information about a phenomenon, as well as, assist them to access robust data which cannot be easily got from other methods like interview and questionnaire (O'Leary, 2014; Silverman, 2011; Bowen, 2009). Similarly, these instruments seem to be relevant if the in-depth knowledge of USO commercialization would be attained (as proposed by Evers et al., 2016; Djokovic and Souitaris, 2008) and if there would be a better understanding of USO iterative development over a period of time (as pinpointed by Mustar et al., 2006). In view of these reasons, both research instruments were used for data collection.

USO Case Selection and the Case Study

In respect to the research questions and instruments, the case selection criteria were defined as the second step of the methodology. The criteria are: (a) its core technology should be developed from a university research, in relation to the previous works like Shane (2004), Pimay et al. (2003), Carayannis et al. (1998) and Smilor et al. (1990), (b) its founding team should be university researchers and the inventor should be among the team, according to the work of Gubitta et al. (2016), Slavtchev and Göktepe-Hultén (2016), Fontes (2005) and Roberts and Malone (1996), (c) before its founding, the owners should get public finance for further development of the technology and commercialization of the technology as it stipulated by the work of Gubitta et al. (2016), Festel and Rittershaus (2014) and Mustar (1997), (d) its head-office is located at the university campus as it is explained by Caiazza (2014) and Hayter (2013) and (e) researchers must have access to the USO documents and/or be able to participate in the USO commercialization activities. With these criteria, many USOs were checked, in which the author of this article had access to, but only "NAM" (anonymous name) agreed to be used as a case study. NAM satisfied the above-mentioned criteria and therefore, the company is a good example of USO.

Brief information on NAM, it was established in October 2015 but its commercialization activities started in March 2013 and ended in June 2015. The core technology of NAM product was developed from a previous basic research of the university. After disclosing the technology, the principal innovator and his team observed that there was a need for the technology due to limitations of similar technologies in the market and the new European Union regulation, which might compel the companies to use their new technology. This team, in collaboration with

university innovation office and business colleagues, decided to commercialize the technology. To get funding for further technology development and commercialization, the team conducted a preliminary market research. From this research, the team identified that there were about 4 competitors in the market, though their products included a component which was planned to be banned by the new EU regulation. The team also identified 3 strategies: selling new technology as a device, which can be used by the existing systems; selling the device as a stand-alone and selling service. The team noticed that the price for the device should be between 10,000-20,000 Euros.

Based on their preliminary research, the team divided their commercialization activities into 4 packages. The packages are proof of relevance, concept, business and investment. The proof of relevance consists of 3 sub-packages: technology development, market needs, market potential of the device and competitors and barriers to using technology and IP protection. The proof of concept package dealt with device prototyping and its field testing. The proof of business contained comparison of different productization strategies, business and contract models, value chains of business models and partners' network. The proof of investment had issues relating to feasibility of business models, investment calculations, risk assessments, funding for the business and most importantly, possibility of creating a new USO. Furthermore, the team had an execution plan which is presented in the following Figure 2. The commercialization planned to be completed within 2 years, but it was later extended by 3 months.

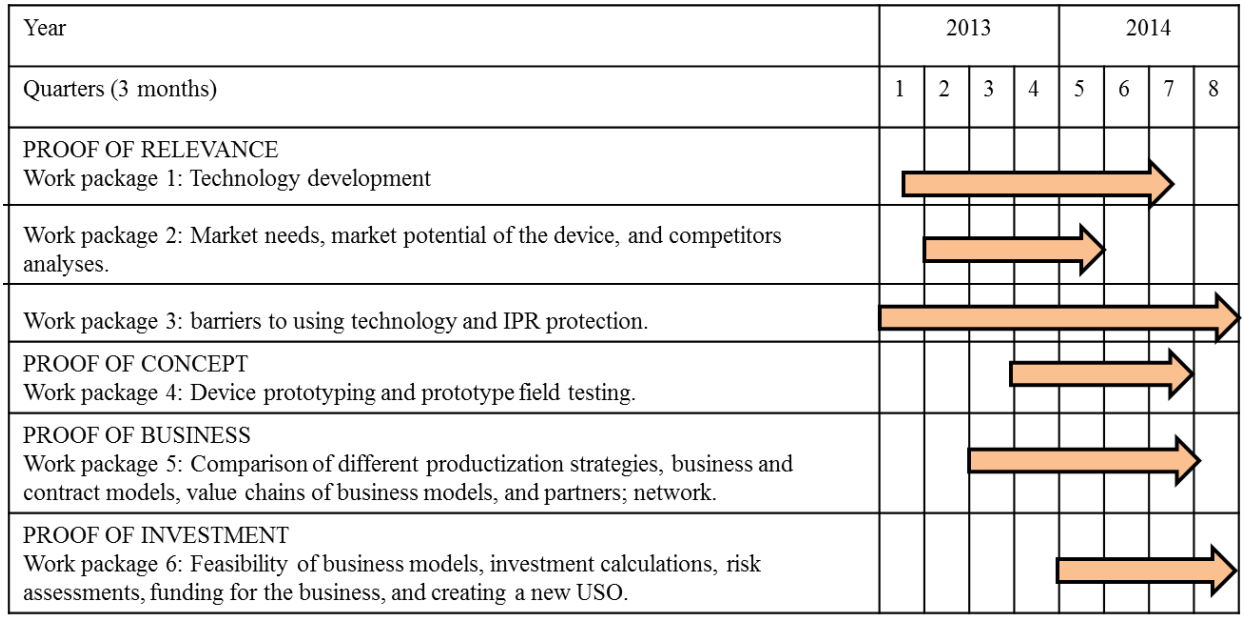

Figure 2
NAM COMMERCIALIZATION WORK PACKAGES

Data Collection

Data collection was the third step of the methodology. The data were collected via official and non-official documents related to the commercialization activities of NAM. The official documents include research and commercialization plan (which attached to the public funding application), steering group minutes and presentations, periodic reports, NAM website

and online news. The non-official documents are project team documents, project team minutes and writer's monthly work dairies and notes. Besides, the summaries of commercialization project interviews were used. The summaries are included in the project team documents. The interview participants consisted of potential customers, distributor, the government regulatory body, university innovation manager and the inventors. Moreover, it is important to state that there are some documents in Finnish language, even though their summaries in English were mostly used in the analysis. Similarly, the writer of this article was part of the commercialization team as a business advisor and the documents were anonymous due to confidentiality and privacy of NAM.

Brief information on the commercialization team is provided in the Table 2. The commercialization team consisted of different sections of the university, which include technology, innovation office and business.

Table 2
COMMERCIALIZATION TEAM

	Team member	Commercialization project role	Background
1	Manager/Innovator 1	General management and technology development	PhD, an analytical and bioanalytical chemist and expert.
2	Inventor/Innovator 2	Technology and product development	MSc has experience in sensory and electrochemistry.
3	Technician	IT, technology and product development	MSc, electrician and IT expert.
4	Innovation Manager	IP investigation and market investigation	PhD, biochemist and innovation management expert.
5	Senior University Researcher	Technology and product development	PhD, an expert in Biosensor.
6	University Researcher	Commercialization activities	MSc, technology and customer survey expert.
7	Senior Business Advisor	Commercialization activities	PhD, technology commercialization expert
8	Business Advisor 1	Commercialization activities	MSc, technology commercialization and SME internationalization researcher
9	Business Advisor 2	Commercialization activities	MSc, technology commercialization and SME internationalization researcher

Data Analysis, Reliability and Validity

The last step of the methodology was data analysis, reliability and validity. Due to the types of data collected, two forms of data analysis method were used. The first data analysis method was document analysis (Bowen, 2009) or textual analysis (Silverman, 2011). This analysis method extracts information and in-depth knowledge encompassed in the artefacts or documents (O'Leary, 2014; Silverman, 2011; Bowen, 2009). The second data analysis method is content analysis, which is used for preliminary results of document analysis. This analysis method is described as a process of deducing meaning from the documents (O'Leary, 2014; Bowen, 2009). It is also a process of reducing bulk data, summarizing the main points and presenting them (Miles and Huberman, 1994).

Thus, the document data were read and grouped into different phases of commercialization process: pro-commercialization, commercialization and post-

commercialization. Similarly, each activity of the phases was focused and the activities were termed as "*themes*" of analysis. The date of each document was noted to pinpoint their sequence in the commercialization process. Additionally, the purpose and audience of each document were considered in order to avoid biasness and personal subjectivity of the writer of this article. Afterwards, the themes, in relation to dates, were summed up and fixed to the stage-based model (provided in the Table 1). This summary was treated as preliminary results, which is provided in the Appendix. These data analyses were in accordance with guideline provided by O'Leary (2014) and Bowen (2009). The list of analysed documents is presented in the Table 3.

Table 3
ANALYZED DOCUMENTS

Phases	Documents	Number
Pre-commercialization	Research and commercialization plan	1
Commercialization	Project team documents	39
	Project team meetings' minutes	4
	Periodic reports	7
	Steering group minutes and presentations	10
	Writer's monthly work diaries and notes	33
Post-commercialization	NAM website and online news	2
Total		**96**

Furthermore, presenting the methodology details is an important step in establishing "*trust worthiness*" in qualitative research methods like case study. This trustworthiness ensures that the research process is reliable and valid (Eriksson and Kovalainen, 2008; Morse et al., 2002). To achieve this, verification must be done via investigator's responsiveness. The verification consists of methodological coherence, sampling sufficiency, data collection and analysis and theoretical thinking (Morse et al., 2002: p. 17). Similarly, trustworthiness can be attained via dependability, transferability, credibility and conformability. Dependability is a responsibility of the investigator to provide detailed information on the research process and transferability is the ability of the study to relate to the previous scholarly works. Likewise, credibility and conformability are the ability of the investigator to show his/her familiarity with the topic, logical presentation between the data and analysis and relationship between the analysis and the claims (findings). In relation to these scholars, this article establishes its trustworthiness by providing details of its research process as it is shown in the following Figure 3.

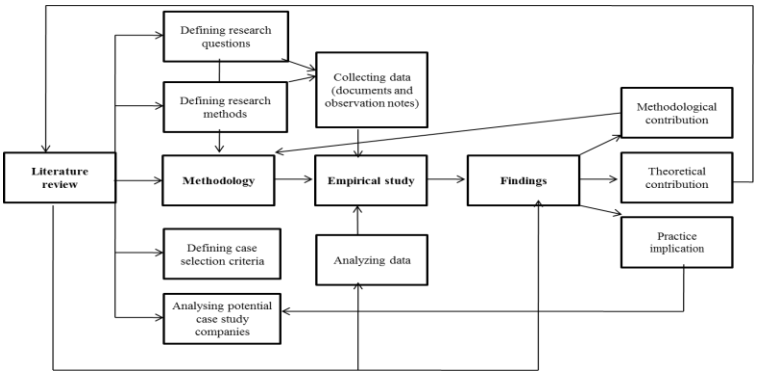

Figure 3
RESEARCH PROCESS

FINDINGS AND DISCUSSION

Methodologically, this article made use of first-hand information because of field/participatory observation. Therefore, its findings give practical insight and depict reality perspective, to some extent, on USO creation and commercialization processes. The findings are explained below.

USO Commercialization Process May Not Necessarily Be Stage-Based

From the Figure 2, it can be noted *ab initio* that commercialization process does not need to be stage-based. The figure depicted that all work packages were parallel to one another. Some activities, like technology development and IP analysis, were planned to be done almost every phase period of the project. This was the same when the project was executed. The Figure 3 displays the project real implementation. Both Figures 2 and 3 revealed that the stage-based models did not completely applicable in this case. Even, the work packages of the commercialization were not planned to follow the stage-gate process of the scholars. However, the pre-commercialization phase of the stage-based models (Table 1) seemed to be the same with the NAM case. For example, the discovery was made and the opportunity was assessed as it was written in the abstract of the NAM commercialization project plan:

> *The aim of this work is to further develop novel and rapid [NAM technology] and especially focus to develop new business opportunities for [NAM market]. Commercialization of efforts should be to serve its purpose as well as possible and create new business potential for developed [NAM] instrument. There is a clear need towards [NAM] instrument to determine [NAM stratifying needs]*.

Furthermore, the activities of commercialization phase of NAM were not executed on the stage basis as it was propounded by the scholars like Ndonzuau et al. (2002), Clarysse et al. (2002), Vohora et al. (2004), Shane (2004) and Fontes (2005). Although, Vohora et al. (2004) noted that "…*but each phase involves an iterative, non-linear process of development in which there may be a need to revisit some of the earlier decisions and activities*." (p. 147). Most of these activities were done simultaneously in the NAM commercialization project. For instance, when the market analysis was going on (using a couple of team members), IP analysis, technology and prototype development were also going on by other team members. This simultaneous implementation helped the team to identify important direction and to manage any potential problem. If the NAM team had followed the stage-based models, many issues would have blocked or delayed the success of the commercialization. As an illustration, there was an unexpected IP problem when the NAM technology had very similar features to an existing IP from the United Kingdom and other IP from a department of NAM University. NAM was able to manage this problem because IP analysis and technology development were going at the same (Figure 4).

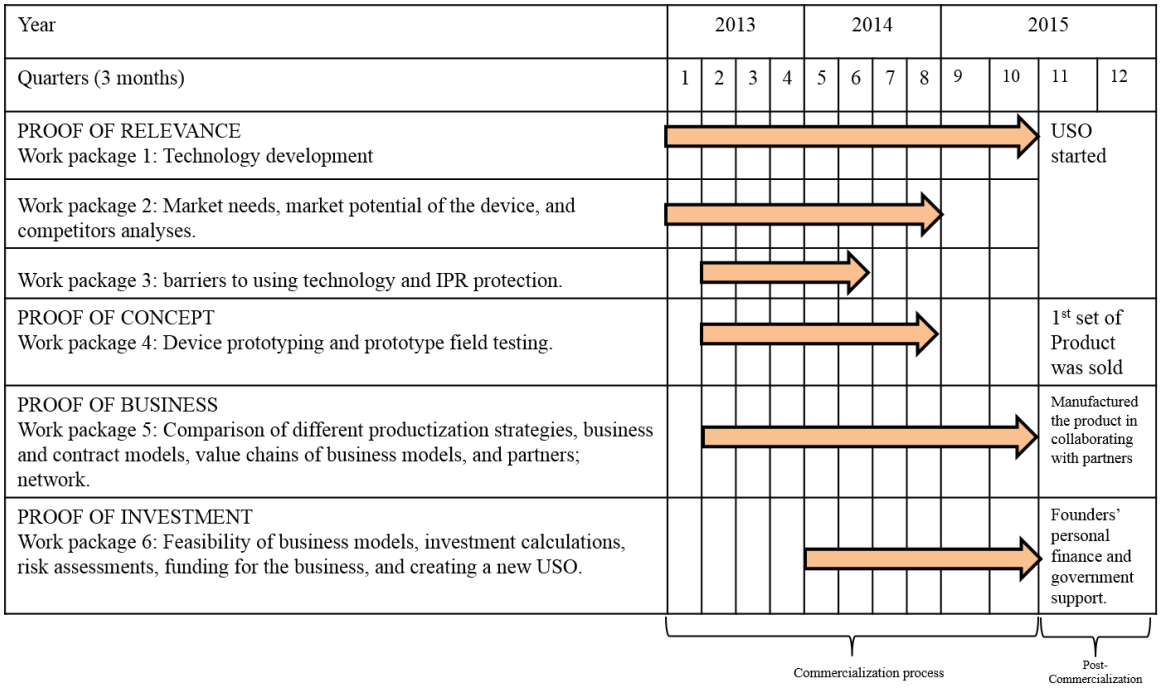

Figure 4
NAM COMMERCIALIZATION PROCESS

The post-commercialization of NAM was similar to the stage-based models. Most of the previous works, such as Shane (2004), Hindle and Yencken (2004), Fontes (2005) and Gübeli and Doloreux (2005), believe that the company should be established and normal business management activities should begin. This belief is realistic and logical; thus, NAM followed it to some extent. Meanwhile, business management activities had already started during the commercialization phase of NAM. For examples, attending of international conferences (for marketing purposes), negotiating with distributors and suppliers and writing a business plan (for funding purposes) were done in that phase.

In view of the above, it can be summarily argued that the USO commercialization process does not need to be stage-based or follow the stage-gate process, because simultaneous implementation of commercialization activities seems to facilitate the process as well as manage unexpected problems.

Success Factors for USO Commercialization Process

Although, many previous stage-based models did not outline success factors for the USO commercialization. Meanwhile, the "*influencer*s" that were mentioned in the previous works were analysed in the NAM. This analysis was done in relation to the practical knowledge of the writer of this article. The analysis resulted to "*success factors*". These factors seem to facilitate commercialization activities and they supported successfulness of the NAM commercialization process. They are briefly explained below.

(a) ***Pre-Commercialization Factors***: In the case of NAM, the pre-commercialization factors seem to be: university vision and interest, personal interest and motivation of both innovators and business team members, ability of innovators to identify opportunity and

mostly importantly, industrial or legal knowledge, working experience of commercialization team, trust and previous positive collaboration of the team. Firstly, the NAM University encourages commercialization of scientific results and it supports researchers via its innovation office. Each year, about 4 USOs emerge from the university. This environment enables the USO commercialization process as it was elucidated by some scholars like Simmons and Hornsby (2014), Bradley et al. (2013), Shane (2004), Caiazza (2014) and Hindle and Yencken (2004). These factors are regarded as institutional factors which influence academic entrepreneurship (Farsi et al., 2014). Secondly, the interest of innovators and business team was evident from the beginning of the discovery. They have an interest in solving societal problems and they always feel good when they notice their new knowledge is useful for society. One of the interview summaries quoted an innovator who said:

Actually, the main goal of most of our innovations is to commercialize them. Of course, we can patent them, but utilizing the new technologies is better. I do feel good whenever I see that what we developed is solving problem. I have participated in some projects, where companies provided finance and we developed innovation for them. Those innovations are now in the market. As you know, there are, may be 3 innovations soon and I think, they will be tried to be commercialized. One of them, XXX as you know, is solving societal problem.

This factor is corresponding to the work of Farsi et al. (2014), Gübeli and Doloreux (2005), Hindle and Yencken (2004), Yencken and Gillin (2002), Vohora et al. (2002) and Mustar (1997). Thirdly, opportunity recognition is well discussed among scholars, (e.g. Gübeli and Doloreux, 2005, Vohora et al., 2004) and it is noted in the case that the innovators quickly observed that their technology would be needed. This was actually supported by their working experience and industrial and legal knowledge. The innovators tried to provide more information whenever there was a need for it; even, during the commercialization phase.

Lastly and the most important of the pre-commercialization factors, is the working experience of commercialization team, trust and previous positive collaboration of the team. As it can be noted from the Table 2, the team possessed sufficient skills. They also trusted one another which facilitated smooth communication. This factor was discussed by some scholars, like Gubitta et al. (2016), Slavtchev and Göktepe-Hultén (2016), Fontes (2005) and Roberts and Malone (1996). Additionally, the roles of the team skills were pinpointed by Gbadegeshin (2017b) when explaining key commercialization activities.

(b) ***USO Commercialization Factors***: this includes individual network of the team, industrial connection/relationship, good leadership and team commitment. Throughout the NAM commercialization phase, most of the team members made use of their personal network, especially to reach out to potential customers and get information. This is as a result of team commitment. Of course, this is supported by the good leadership of the team and "*steering committee*" (a committee which is required by the Finnish funding organizations to discuss a project progression). Additionally, existence of industrial collaboration made the team to gain access to many people during information gathering, for example, from the distributor and government agent. This kind of success factor was discussed by scholars like Bradley et al. (2013), Simmons and Hornsby (2014) and Gübeli and Doloreux (2005).

(c) ***Post-Commercialization Factors***: these consist of international networks, creation of awareness and industrial collaboration according to the scholars. However, the activities relating these factors were actually done in the pre- and commercialization phases of NAM. For instance, conference attendance, international and local industrial visits. Executing the factors enabled NAM entrepreneurs to gain access to the market as well as creating awareness for their product. Thus, when the NAM started, it was easy for them to make referencing sales. These post-commercialization factors were pinpointed by Gbadegeshin (2017b) that for a successful commercialization to be attained, visiting industrial exhibitions or conferences is very important and they are supposed to be done in the commercialization phase.

Summarily, these factors need to be considered when potential entrepreneurs like technologists, scientists and engineers are planning to create their USO. These factors, if they are not considered, might work against the progress of the commercialization process. Of course, the nature of their technology, target market and specific country ecosystem may affect these factors.

Flexibility of USO Commercialization Process

Another important tool that made NAM a success story is its commercialization flexibility. Although there was a plan and it was monitored, yet the team agreed to be flexible and team leaders allowed the junior members to do their task at convenient times. Throughout the commercialization period, the leaders just ensured that the team delivered their official responsibilities as they were planned. This flexibility is not yet discussed in the most previous works. Many scholars like Bradley et al. (2013), Al Natsheh et al. (2014) and Vohora et al. (2004) noticed that commercialization activities are interconnected and not rigid. For instance, Hindle and Yencken (2004) state that "*For simplicity the model has been represented as a linear process, but it will normally be iterative and messy…*" (p. 800). Similarly, Gbadegeshin (2017b) stated that commercialization activities are not linear or one-bus-stop but rather they are continuous or circular. Meanwhile, this NAM case revealed that flexibility of commercialization is essential because many unplanned issues often arise. For example, interview summary of the distributor, alighted 10 issues, which the commercialization needed to address. Some of the issues are quoted below from the interview transcription:

> *…well, I think, many things need to be done. For examples, how the device operates in winter and in the long run. You know, liquids get frozen in winter, how the device can survive that? As you know, in Nordic areas and Russia, we've long winter. Also, how about maintenance agreement with customers across different countries? …when there's problem, how can your new company go there and solve it and problem can't be solved without face-to-face meeting…Another example, I have to make many calls before I got attention to present my products. This takes a lot of time and recourse. Also, don't assume that your customers understand the whole of what you're talking about. You need to explain to them so that they understand your device 100%. But, you don't need to do this in the beginning; otherwise your product is photocopied. How about cleaning of your device? Have you thought about certification? How are you going to convince authority? There are many issues to consider…!*

When these issues came, the team had to improve the device and a couple of more activities were also done. Similarly, when there was a challenge concerning IP, the team had to do a couple of more tasks, which was not initially planned for. Likewise, during the field testing, there was a challenge, in which the innovator, had to travel for few times and rectified them. Additionally, summaries of the customer interview brought some issues and changes to the original plan; with flexibility the team was able to manage them. The most importance of the flexibility is developing of Prototype 2 and 3. The innovator had to execute some tasks which none of the team members envisaged at the beginning. All these circumstances could potentially disrupt the NAM creation, but with the help of above-listed factors and flexibility, the team was able to succeed with NAM. Therefore, it is argued, in this article, that "*flexibility of the commercialization process*" is essential for the USO.

Plan is Always a Plan

The last finding, which is derived from the case study company, is differences between the plan and reality. Logically, a plan is expected to change because when it is made, certain things might either not considered or not relevant during the planning. The NAM commercialization plan is not different from this assertion. When its plan was compared with the real results, there were many changes. A couple of them are concisely presented below.

(a) ***Driving Force***: in the NAM plan (based on its preliminary research), the driving force for the market need was the new EU policy and government permit. Not surprisingly, when the interviews were completed, government permit was one of primary drivers. But, the main drivers are multi-task, accuracy, reliability, production process and maintenance of the device. These drivers are associated with cost reduction.
(b) ***Market Potential***: initially, 3 segments were targeted in the plan. Immediately the commercialization started, 5 more segments were identified. However, when the interviews were conducted from whole segments, only 2 segments appeared to be interesting and recommended. Additionally, 2 segments were completely rejected because the sampled companies pointed out that the NAM device might not be useful for their operations. When the USO started, the remaining 2 segments were targeted and 1 new segment was added.
(c) ***Customer Preferences***: all preferences, written in the plan, were confirmed from the customers. These preferences seemed to be normal or logical in relation to the innovators' industry knowledge and technological trends. Still, new preferences emerged, such as accuracy and "*no need to intervene*" the device.
(d) ***Competitors***: Four companies were identified in the plan, but when the market research was done, it discovered that there were many substitute products, though there was no direct competitor as it was mentioned in the plan. The results on indirect competitor analysis made the device improved.
(e) ***Business Model***: the plan had 3 business strategies and 3 commercialization options. Two of the business strategies were interesting and they were implemented after the USO was founded. Similarly, the creation of USO was adopted against licensing or selling of technology, though the USO seemed to be more interesting to the university and the innovators. The most important finding of the interviews in this area is how to position

the NAM device, either to be "*official*" device, which will be certified by the government and compel companies to use or "*non-official*", which can be just bought by any customers. This issue was not envisaged at the beginning of the commercialization project at all.

(f) ***Productization Strategy***: all the features proposed in the plan were not sufficient when the interview findings arrived. Thus, the team had to listen to the customers and other players. The recommendations of these players were implemented in the technology and market development for the USO.

(g) ***Certification Process***: there was no plan for the government certification, but during the interviews with the distributor and the government agent, this issue arose. It led to a discussion among the team and it was later put aside due to bureaucracy associated with the government certification.

(h) ***Sustainability of USO***: this issue was not included in the plan, but it came up as a result of commercialization interviews and business advisors' research. The issue led the team to consider many things more than the planned activities. For examples, the innovators decided to think about product line, sub-services and updating and maintenance of the NAM device.

Considering the above changes, it is argued in this article that plan is always a plan. Therefore, the commercialization team of USO should try to prepare their mind that the things they expect may not happen and many unexpected issues will definitely come up, directly or indirectly. Furthermore, when the NAM commercialization process was analysed, it was evident the case study firm followed "*planned*" type of USO as Steffensen et al. (1998) stated, not spontaneously occurred USO. Similarly, its creation seemed to depend on opportunity-, tacit knowledge and technology development-driven as De Cleyn and Braet (2009) stipulated. These analyses also made the NAM to be a product-oriented, which is related to discussion of Fontes (2005) and Pimay et al. (2003). And lastly, its commercialization was almost 3 years as Clarysse et al. (2002) stated.

CONCLUSION, CONTRIBUTION AND LIMITATIONS

NAM has showed that stage-based models cannot necessarily be accepted as a definite model for the USO commercialization. Instead, technology entrepreneurs, potential entrepreneurs, commercialization team and experts and technology entrepreneurship students should bear it in their mind that the USO commercialization process is not linear, but rather parallel, continuous or circular (in some cases). Therefore, it can be concluded that the USO commercialization process consists of several activities, which are interconnected (Bradley et al., 2013, Al Natsheh et al., 2014) and which do not need to be stage-based (Gbadegeshin, 2017b).

Additionally, it can be concluded that the university vision and interest, the ability of innovators to identify opportunity and the personal interest and motivation of, the industrial or legal knowledge of, the working experience, trust, the previous positive collaboration and individual network of the commercialization team, as well as, their team commitment are the success factors of the USO commercialization process. Likewise, industrial connection/relationship, good leadership and international network, creation of awareness and industrial collaboration will make a new USO succeed. Furthermore, it can be concluded that the flexibility of commercialization process facilitates the successful creation of USO. Flexibility will make the team to be adjustable to any unexpected conditions or issues.

With the above conclusion, this article has contributed to the theoretical knowledge about the USO commercialization using an empirical case study. It reveals that stage-based model is rigid and the flexibility of the USO process is important, which have not yet been discussed recently by the scholars. This article also contributes to the practices by outlining success factors that facilitate a smooth execution of USO commercialization process. Most importantly, this article contributes to the methodology of commercialization studies because most of the commercialization studies used interview, questionnaire and other methods but they have not yet used documentary method.

However, this article has some limitations. The foremost limitation is number of case studies used in the article. A case study was used which cannot be generalized. Although many documents were analysed to present the case, its findings are also limited by focusing on a new high technology. Another limitation is country specific issues. The case study involved a university from a small country of 5.5 million people. This shows that generalization of the results needs to be well considered. Nonetheless, these limitations do not affect the quality of knowledge produced by the article. This article is useful for academia and practitioners.

APPENDIX

Preliminary Results

Year	**2013**			
Period (quarters/years)	1	2	3	4
Pre-commercialization	a)Discovery was made. b) Application areas/4 market segments were identified. c)New EU policy was seeing as the main driver for market needs of the new tech. d) Three 3 business model/strategies were identified. e) Potential competitors and unique factures of the proposed product were identified. f) Operation sample of technology was used. g) Preliminary market research was conducted. h) Right people with relevant and need skills were selected for the commercialization team. i) Possible price for the proposed was used.			
Commercialization	a)Started WP 2 (market needs and competitors' analysis). b) Technology development. c)Understanding of technology by business team. d) IPR investigation. e) Device and service provider's analysis.	a) Development of 1st prototype. b) Presenting of WP 2 report (5 more segments were identified; 8 more competitors were identified with more 50 possible/similar product; more 20 similar service providers).	a) Perfecting 1st prototype b) 6 interviews conducted which included potential customers, distributor and government regulatory agent. c) Summary of	(a) Testing of the prototype at real life place. (b) Conducted 4 more interviews. (c) Attended international exhibition and saw a similar product. (d) Identified a

		c) Preparation to conduction of interviews. d) Identification of unique features of the proposed product.	interviewed were presented which showed that the proposed product needed had more features. d) 6 Very similar products were identified and were contacted. e) New important d unique features were identified. f) Piloting plan was drawn. g) Noticed that there was an IP in UK and Finland which similar to team new technology. h) Analysing different models/strategies, ownership structure, source of funds, products' price estimation.	couple of problems with the prototype. (e) Discussing with UK IP owner.
Post-commercialization				
Year	**2014**			
Period	1	2	3	4
Pre-commercialization				
Commercialization	a) Trying to solve IP issue by adding/using a new technique to the technology. b)Developing prototype 2. d)Attended international conference. d) Decided to have 3 business models: spin-off creation, selling or licensing technology. e) Identifying production strategies and supply chain players. f) Identifying service package for the proposed device/product. g) Identifying possible ownership structure spin-off.	a)Decided on IP issue. b) Finalized prototype 2 and preparing for testing. 3) Started working on business plan. 4) Investigating internationalization. 5) Noticing that spin-off could be OEM. 6) Discussing different business models/strategies and their conditions. 7) Identification of different sources of financing for the proposed spin-off.	a) Prototype 2 testing. b) More technology development. c) Requesting for extension of the project. d) Identified the supply chain players (for production purpose). d) Conducted innovator interview. e) Price estimation of the proposed device. (f) Promotion of the device in an international	(a) Continuation of field testing. (b) Decided on spin-off creation. (c) Development of business plan and sources. (d) USO risk analyses. (e) Finalized main market segments.

			market and international exhibition.	
Post-commercialization				
Year	**2015**			
Period	1		2	
Pre-commercialization	(a) Finalized business plan. (b) identified a couple of government support for the proposed USO. (c) Confirmed innovators' interest in creation USO. (d) Development of prototype 3. (e) Identified risks and their mitigation measures.		(a) Finalized prototype 3. (b) Writing final reports.	
Commercialization				
Post-commercialization	(a) Establishment of the USO. (b) Attending newspaper interviews. (c) Making international sales.			

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