Technology Entrepreneurship and Commercialization: A Set of Assessment Dimensions

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Abstract

Technology entrepreneurship is a new topic in the field of Information Systems, although attempts to handle this phenomenon have been made in the management and technical literature in the past. Furthermore, complex technology artifacts are yearly the output of compound research projects developed by highly skilful individuals. The exploitation of these artifact is the process to address more problems that can be solved or applications in more than the initiating case. The exploitation alternatives and pertinent vehicles include the process of new venture creation and technology entrepreneurship.

Particularly, the authors argue that technology entrepreuship is a commercialization option in the process of technological research and complex ITC artifact exploitation. This process, of research commercialization and developed artifact exploitation, is rather complex and is affected by a variety of factors including technology readiness issues, targeted market specific features and appointed exploitation team mismatch. A structured set of assessment directions is presented, aiming to contribute in the journey of successful transfer of technological research to society, through technology entrepreneurship. Further to this, a challenging commercialization case of complex research output, developed in a well-known European research center, is presented. The case is analysed through the proposed dimensions and key issues are highlighted.

Further research in the topic is required to shed more light in the various aspects and further dimensions may affect the successful technology entrepreneurship activity.

Keywords: Technology Entrepreneurship, Technology Commercialization, Innovation Management, Technology Transfer, Technology Exploitation, Augmented Reality Case, Entrepreneurial Potential

1 Introduction

Technology entrepreneurship (TE) can be considered as a process of new venture creation from technology savvy or expert individuals (professionals or students). The involved technology per se can play the role of enabler for the final offering or basically the offering itself. In 2012, Beckman et al. argued that technology commercialization exists when developments in science or technology constitute a core element of the opportunity that enables the emergence of a venture, market, or industry. These new ventures are considered as startups or spin-offs and their final services or products end up being very technologically dependent. This gives an initial indicator that the fields of technology commercialization and technology entrepreneurship are neighboring and examine similar phenomena. Based on the work of Alvarez (2001) technology commercialization can be distinguished in two categories, based on initial motivation: *opportunity based* motivated, or *opportunistic entrepreneurship, and technical resource* based motivated, or *technology exploitation* entrepreneurship. The primary motivation of the opportunistic entrepreneurship is to fill a gap in the market. The founders identify a problem with no current solution available in the market. Thus, they recognize an opportunity to build a (more suitable) in their understanding solution for this problem utilizing new technologies as a value proposition for innovative approach to this problem. On the other hand, the starting point for technology exploitation entrepreneurship is a sound technology developed in the context of a research project (mainly) that could have some exploitation potentials in many different markets. In other words, the founders have developed a solution for many potentially undefined problems which could reveal after a thorough creative thinking approaches and market analysis. These ventures function mainly as exploitation vehicles for complex ICT artifacts developed in technical Universities or applied research projects in research centers.

Establishing a successful path of a technology commercialization is a contentious issue. Empirical studies have generally reported mixed results: some studies did not find positive payoff of technology commercialization and failed on the market, while others describe cases that treated similar commercialization process and turned out highly productive. There are various explanations for this phenomenon. Consistent with any technology investment, the question should change from ‘is there a payoff’ to ‘when and why is there a payoff’, going beyond the ‘average’ impacts of a new technology.

Within this context, it is obvious that there are numerous possible ways that the commercialization process and strategy can be shaped. Such dimensionality produces uncertainties and fears in any stakeholder who wants to decide on a particular technology commercialization based on a credible assessment. There is no single fits-all strategic path that can be adopted and guarantee its success. The starting point for this research is therefore an attempt to assist any stakeholder (technology innovator, the managing team of privately or publicly held research institutes, consortium of research project, even if investors) in evaluating their commercialization choices, identifying the key directions behind successfully commercializing technology innovation and supporting their decision on moving to a particular commercialization path, though entrepreneurial activities. And this now is a matter of considerable concern for both practitioners and academics alike.

The motivation for this research is therefore twofold:

- to examine the complexities of technology entrepreneurship process aiming at spinning off new companies from universities, government laboratories, and other research and development organizations
- to highlight the growing importance of several key dimensions to support the design of the technology commercialization strategy

In order to address the above objectives, case research gained respect in this research as it is suitable for research in areas where theory is not yet well developed. Moreover, this approach is ideal for answering the 'how' and 'why' questions (Yin, 2003) allowing for a richer knowledge of issues associated with technology commercialization decisions. In this regard, the access to the real life context brings richness and flexibility, making case research a proven tool for achieving a deep understanding on how technology innovation can be successfully commercialized.

This paper is organized as follows. Section 2 offers a justification for the relevance of the work. Section 3 conceptualizes the proposed dimensions that hinder behind successfully commercializing technology innovation. Section 4 provides the case study of applying the key dimensions of technology commercialization within the augmented reality context based in a huge well-known research center and describes some interesting findings. Section 5 provides some discussion arguments on the set of presented assessment dimensions. Finally, Section 6 provides a number of conclusions and future actions for further validation (as this is a research in progress).

2 Related studies on technology entrepreneurship

The field of Technology Entrepreneurship compared to other fields such as economics, entrepreneurship, and management is considered to be in its infancy. However, it seems that this field is trying to interpret similar phenomena with neighboring fields such as technology commercialization, innovation management, product development and exploitation of research output (Ratinho et al., 2015). Furthermore, TE is multidisciplinary in nature, requiring researchers to understand the fields of technology, management of technology and entrepreneurship (Yanez et al., 2010), and relevant work has been published in journals of different disciplines, such as management, entrepreneurship and strategy that may not be included in the list of high impact journals.

In the previous literature, there have been developed some definitions that generally interpreted technology entrepreneurship from different perspectives. Such definitions that have been given consider the term either as a change (Jelinek, 1996), or as an investment, or agency (Garud and Karnøe, 2003), or business risk (Nicholas and Armstrong, 2003), or just solution to problems (Venkataraman and Sarasvathy, 2000).

Similarly, technology commercialization has been perceived in various ways and has taken many definitions (Bailetti, 2012). However, Kalaitzandonakes, in 1997 defined commercialization as any scheme that permits members of a technological innovation team to receive economic gains from their efforts, including patent licensing, research grants, and R&D joint ventures. For the purpose of this paper we will adopt and adapt this definition, arguing that in case of presence of an ICT artifact, this scheme of economic reward may also involve technology entrepreneurship and the creation of a new technology venture.

In an effort to bridge these two fields, we are proposing the following definition for technology entrepreneurship leveraging on the previous contributed work:

"Technology entrepreneurship is a process through which specialized individuals try to address societal problems by applying already built technology innovation in an effort to create and capture value for a new firm and the originating innovators."

This definition is a process oriented one, emphasizes on the presence of an already built technology innovation and involves the creation of a new venture, not from an SME or established technology intensive firm.

Based on the analysis of Bailetti (2012) and Marx & Hsu (2015), it is evident that technology entrepreneurship scholars have mainly focused on the contextual external factors and the commercialization environment that influence the formation of new technology venture, rather than the endogenous factors that may involve. Additionally, the research that has been conducted mainly adopt the level of analysis of an established firm. As technology commercialization and entrepreneurial exploitation is not a straightforward process, each case is unique and the successful outcome depends on many diverse factors both endogenous, meaning the characteristics of involved team, and exogenous, meaning the market environment (Marx & Hsu, 2015), that need to be addressed with a structured and holistic approach. In the following paragraphs of this paper we present a structured set of three dimensions to be followed when a team of individuals, inventors and stakeholders attempt to commercialize a complex ICT artifact that is developed in view of research collaboration or project through entrepreneurial activity. These dimensions aim to shed some light on the deferent aspects endogenous and exogenous, contributing in the literature of technology entrepreneurship.

3 Proposed Directions for Assessing the Entrepreneurial Potential of ICT Research Artifacts

In the following paragraphs we are presenting a set of dimensions that play a key role in a holistic and multidisciplinary assessment of the exploitation and entrepreneurial potential of a particular research output or a developed ICT artifact. The aim of this set is to assist the work of an examiner who is to assess the commercialization strategies of a particular developed technology. If all the particular dimensions are positively rated, an optimal exploitation strategy could be via technology entrepreneurship activities.

3.1 Technology Assessment (What)

3.1.1 Technology breakdown and Inventory

When it comes to the commercial exploitation of an ICT artifact, which was developed in the context of a research project, or individually, the first activity should be to conduct an analysis and document the various technologies utilized, along with their inventor or developer and the relevant licenses utilized from third party components (SDKs, frameworks, libraries etc.). In this way, there will be a clear declaration of the technologies involved, their owners and the relevant licenses that should be considered for the exploitation strategy to be agreed eventually after this process. Finally, this inventory may be handy during the composition of statute or team manifesto, where the distributed equity of the joint efforts will have to be decided. The technology baseline will also contribute as an input for the next steps of technology assessment.

3.1.2 Technology Readiness Level (TRL)

An important aspect that has to be examined before starting considering the various commercialization strategies of a specific technology is the technology itself and its capabilities. In order to perform this assessment, we propose the utilization of some already established tools combined with some new notions. Technology Readiness Level metric (TRL) is a systematic measurement system that supports maturity assessments of a particular technology and the consistent comparison of maturity between different types of technology. TRL was initially introduced by NASA during 1989 (Stanley, 1988) and was modified and adopted by various organizations since then. For the purpose of this paper, we will define a modified TRL to be used during the technology readiness assessments.

Technology Readiness Level	Description
TRL 1.	Basic principles observed
TRL 2.	Technology concept formulated
TRL 3.	Experimental proof of concept
TRL 4.	Technology validated in lab
TRL 5.	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6.	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7.	System prototype demonstration in operational environment
TRL 8.	System complete and qualified
TRL 9.	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Table 1. The Technology Readiness Levels based on the European Commission Approach

In an ICT artifact, it is essential to examine the TRL of the technologies utilized both individually and as a whole. In this way, the examiner will be able to have a better insight regarding the developed technology and use it as an input in the stages of business risk assessment and technology decomposition.

3.1.3 Features and capabilities

Once the previous steps have been completed, a thorough analysis of the system capabilities and implemented features is need, both for the involved technologies individually and for the artifact in general. The output of this process will feed the upcoming ones where functional benefits and further potential applications will be reviled.

3.1.4 Supported applications and initial application context

Based on the analysed features and capabilities of the ICT artifact, one should be able to identify relevant and feasible applications that utilize one or more of these capabilities. Although there are always some predefined applications for the developed technologies, there is always a handful of application scenarios with similar requirements or needs that were not in target right from the beginning. Through creative thinking techniques the examiner could be able to identify a handful of applications that the artifact with its features could serve.

3.1.5 Provided benefits in the context

Before we can continue with the next steps of exploitation assessment it is important to analyse, understand and map the functional benefits and business value provided by the developed solution and artifact in order to tackle the specific challenge that initiated the implementation of this artifact. While in this step, we need to measure, the business value and the functional or economic benefits of the utilization of proposed artifact or technology to the specific application area. In order to perform this, we could utilize tools and frameworks like the cost-benefit analysis, performance assessment and other tools for predicting the business value if IT, based on real options theory (option valuation theory, Black-Sholes model, binomial model etc.) (Dos Santos, 1991)

Afterwards, a process to identify the "transferable" benefits to applications out of the initial context will be initiated.

3.1.6 Transferable business value

During this step, for each of the previously identified application scenarios, we need to measure, based on educated assumptions and relevant insight, the business value and the functional or economic benefits of the utilization of proposed artifact or technology to the specific application area. In order to perform this, we could utilize the aforementioned tools and frameworks. After this process is done, we need to map these benefits with relevant needs of other applications, industries or markets that we could introduce the artifact. In this way, we will be able to identify the transferable value of the proposed applications. In order to identify those applications and industries we can utilize creative thinking techniques, highly involving in this process the initial stakeholders and inventors who potentially have some relevant insight, knowledge or impulses. The output of this process will be used in the process of market assessment, analysed in a later section.

3.1.7 Information Communication Technologies (ICT) value chain

With the term ICT value chain we propose a new dimension in the technology assessment of ICT artifacts so as to foster the potential of efficient exploitation strategy. The argument behind this dimension is that the societal and economics impact of an ICT developed technology of innovation raises as the technology lies closer to the lower/left side of the continuum. In parallel, this may be coupled with the limitation of greater time-to-market metric, as the technology needs more complex strategies and partnerships in order to get integrated in schemes and infrastructures.

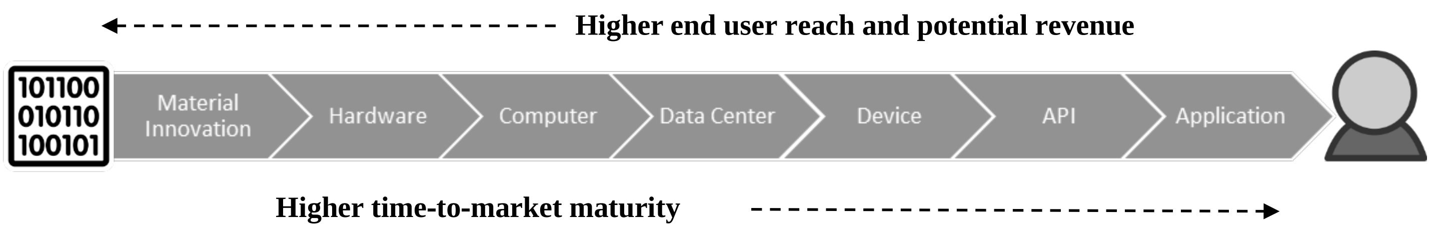

Figure 1. ICT value chain

On the other hand, as the ICT artifact under examination lies closer to the upper/right side of the continuum, the value proposition it reflects and the relevant applications supported may have a lower economic impact or end-user base, as it probably targets specific user segments and markets. Similarly, these technologies could be considered as more commercially mature and their time-to-market might be essentially lower than the ones lying in the left side of this continuum.

3.1.8 Technology decomposition for exploitation

As mentioned previously, in order to maximize the potential value and prospect exploitation of an examined ICT artifact, it is recommended to perform the aforementioned step with a second iteration focusing on a subgroup of the involved technologies or individually. Some technologies could compile a stand-alone solution for applications that have lower time-to-market potential schedule.

3.2 Market strategy Assessment (How)

During the previous steps there have been identified the transferable benefits and business value, along with the various supported applications by the examined ICT artifact. In this step, it is essential to map these benefits and applications with industries, processes and markets that could have similar benefits from adopting the examined technology and incorporating it in their operations.

It is true that there may be some cases of industries or applications that could be treated by the examined ICT artifact after some small modifications or extra features are implemented (due to specific functional requirements, mainly). The strategic board has to take the decision of spending the required resources to implement these modifications based on the expected commercial output from entering these markets.

In order to minimize these costs and the harshness of these decisions, the consortium can adopt right from the beginning an “exploitation mindset”. This involves the following practices:

- Tackle the phase of system design with approaches of lean development validating with users the developed solution, in many iterations.
- Filter every decision for the technical architecture from a commercial exploitation perspective, so as not to lock in the final ICT artifact in specific industries due to not easily adoptable technologies utilized.
- Seek for market feedback while in the phase of technical architecture development so as to incorporate any feasible and relevant requirements from this industry so as to be mitigate the time-to-market period.

Following this process, a thorough market analysis should be conducted for each and every major industry or market identified previously, so as to select and prioritize the most prominent ones to conduct further analysis. Tools like PESTEL, Competition, SWOT analyses or Business Model Canvas should be helpful to this process.

Once the identification process of the markets with the greater potentials for the exploitation of the technologies utilized in the specific ICT artifact has been finished, the next step should be to implement a comprehensive business plan for each market/ industry including strategic decisions on how to enter these markets, what extra partnerships are needed etc.

If the strategic decision of the consortium is to exploit their developed technology via a new venture creation (startup, spin-off, spin-out) the composition of these comprehensive business plans will be handy in the process of pitching and raising of funds both in public and private funding schemes.

3.3 Exploitation team assessment (Who)

3.3.1 Team and individual interests of stakeholders (technology providers, users, champions etc.)

When it comes to defining the exploitation strategy, it is essential to find the right team to execute the plan. In this direction it is essential to examine the capacity and intentions of the team developed the technology and if need be, try to complement their skills with some more entrepreneurship-oriented ones.

Stakeholders could be considered the involved researchers, their supervisors from academia or industry, the leadership of the involved institutions etc.

3.3.2 Technology development initiator (sponsor)

In every project in industry or academia, there is always a sponsor to initiate it. During this phase of initiation, the sponsor team sets the baseline and the expectations of the project. However, since the development of complex ICT artifacts requires the involvement of a big and multidisciplinary team, there are many more stakeholders whose willing should be taken into consideration. A failure from the sponsor side to address the interests from all the relevant stakeholders may directly or indirectly affect the commitment and incentives of related people which in turn could result in major project deviations or failure.

3.3.3 Team characteristics and skills complementarity

In order to identify the core team to be in charge of the exploitation, we need first to assess the complementarity of the available skills both technical and business wise. In particular, teams that lack of technical specialized individuals with the appropriate skills to further develop the core technology and initiate more services based on that, have a sever handicap on their potential for success, as they lack of the core capability and competence. Since high technically skilled individuals were employed to build the core technology, someone could argue that the aforementioned team limitation in technical skills cannot be present. There are factors that we will tackle later on that may avert these individuals from being part of the exploitation team. Similarly, if the team lacks of individuals with business acumen and skills, will fail to identify the prominent markets and applications to target, not to mention the challenge they will face to implement a concrete business plan for the new venture. Hence, the exploitation of this technology though entrepreneurial activity would be very difficult.

3.3.4 Individual entrepreneurial capacity and intention

Although the team that developed initially the ICT artifact may have already the various needed skills to commercially exploit their artifact, there also the human factor that we should take under consideration. Some of the team members (key or not) may lack the intention, capacity or in general the mentality of being an entrepreneur, creating already a gap in the exploitation team under formation. This aspect will also affect the management of intellectual property and the fair distribution of future revenue among the technology developers. However, this will be tackled later.

3.3.5 Individual entrepreneurial prior experience

There is also the possibility of the extreme opposite that in the exploitation team there is one or more members who have relevant previous entrepreneurial experience for technology commercialization, contract negotiation etc. The experience, lessons learned and knowledge coming from these members could be of valuable importance in the performance of the exploitation team in the long run.

3.3.6 Team dynamics and stages of development

Based on the proposed model by Tuckman & Jensen (1977), there are four stages in the development of the interpersonal relationships within a team: Form, Storm, Norm, and Perform.

A team in order to be able to perform (final stage) typically has to pass from all the previous ones. Research or technology artifacts typically last from 2 to 5 years with teams working in various ways (remotely, physically, part-time, full-time, etc.) Depending on the diversification of the team, the time allocation, frequency of meetings (remote or physical), these particular teams do not have the time, room or agility to evolve rapidly until the final stage.

These interpersonal relationships aspects need to be analysed before the exploitation team is finalized.

3.3.7 Presence of market lead from involved stakeholder

In some cases of complex ICT artifact development, there is a possibility that one or more participating partners come from the Industry or have a close relationship with companies. Thus, there is a great possibility that there is already a market lead from one partner with a commercial organization interested in collaborating with the team in order to exploit the developed system. However this may be an anchoring point, preventing the team from conducting a wider analysis of further exploitation possibilities. It is true that one the team has identified the targeted markets and applications need to focus on one application and deliver the solution, however by anchoring to an industry in the "safe zone" may prevent you from exploiting more prominent industries.

3.3.8 Presence of feasible business model based on known or faced limitations

If a team has followed all the assessment steps previously described and has been developed taking into consideration the personal characteristics of involved individuals, it should have come up with a clear roadmap on the actions needed for the successful commercial exploitation of the developed system. However, if the output of the process is that there is not a capable or willing team to commercially exploit the technology, or the technology itself is not suitable for entrepreneurial exploitation, there is also the possibility of exploitation through other vehicles, such as patenting and licensing.

3.4 Intellectual Property Rights (IPR) management

A great asset in the exploitation journey and strategy of an ICT artifact is the presence of an Intellectual Property protection form and especially, a patent. However, this is not always possible as software artifacts are not easily patentable. Typically, in the league of venture capitals and private equity funds, they assign a better value in new technology ventures that possess an ICT artifacts protected by a patent or any other strong protection vehicles. Additionally, the presence of a patent can open the possibilities for the exploitation path of licensing and royalties aggregation. Finally, the attempt of a new venture to enter a highly patent-oriented market may be abandoned if there is not a clear way to possess a competitive patent as well.

4 Applying the assessment directions: An augmented reality case

In order to test the applicability of the aforementioned set of assessing dimensions of entrepreneurial potential of new ICT artifact, we had the opportunity to apply it in the exploitation assessment of a complex ICT artifact developed at CERN (The European Organization for Nuclear Research) during the implementation of a European Commission Research project.

During this project, a big and diverse, mainly technical consortium across Europe developed an Augmented Reality headset that is meant to assist maintenance operators during interventions in hazardous environments. With step-by-step visual instructions with superimposed graphics over real visual field, and real-time communication with the supervisor in the safe control room, this device was rated by the users as the most prominent work companion during complex interventions at CERN facilities. This artifact was the output of an applied research project where specific components and enhanced state-of-the-art computer vision algorithms were assembled to produce this complex ICT artifact utilizing a head-mounted-display, advanced optics, simplified wireless commination algorithms, various sensor fusion hardware and algorithms and custom build computer electronics for edge detection on the server side. Based on the contribution of each partner in the development of the components, we developed the technology inventory which holds the technical, ownership and license dependences information of the system.

Based on a thorough technology assessment of the developed system and its components, we concluded that in the TRL scale out complex ICT artifact was in a good shape between demonstrator and functional prototype. Although this stage may not be fundable by equity funds or venture capitals, it was a great output from an 18-months development. During this period and since the consortium strategy was the commercial exploitation since the initialization of the project, we were able to present the system at an innovation conference in the USA and gather some initial market feedback on system architecture both from a technical and functional point of view. This feedback was evaluated and incorporated in the developed prototype.

Further to a thorough analysis of the artifact capabilities and features, we ended up with a list of supported applications which we mapped with the functional and operational benefits in the context of CERN use cases. Following this process, and based on the aforementioned mapping, we identified the transferable value out of the context of our CERN based project. This helped in the identification of markets and industries where out ICT artifact could be introduced. We will tackle this part later in the market assessment section.

In an effort to maximize the exploitable outcome, we performed a technology decomposition exploitation approach with multiple iterations of the previous steps for the individual technologies composing the final artifact or subunits of them. Through this approach we identified two standalone setting of the involved technologies that could compose a valuable offering for the industry individually. The first was a remote monitoring and real time audio-visual communication and supervision for operators in remote locations for critical or not maintenance, utilizing only the audio-visual and communication parts of the initial artifact. The second sub system was the offering of a completely paperless technical manual for every kind of complex machinery maintenance that is compact, lightweight, intuitive and efficient, which can be brought to the operating field and allows the user to perform her tasks due to hands-free setting. Finally, there are some developed components that could be marketed individually, such as the simplified algorithm for wireless connectivity module and the gamma radiation imaging camera.

Trying to identify the place that the whole artifact fits in the ICT value chain described previously, it is apparent that stands somewhere in the middle between computer and device. This position depicts that as an overall offering, the artifact achieves high impact to the operations of involved industrial customers and the overall quality of produced goods and the relevant complexity for the go-to-market approach is feasible through new venture creation and some relevant partnerships.

When it comes to market assessment within the context of entrepreneurial exploitation, utilizing the previously composed list with the various transferable value and supporter applications, we identified through structured discussions, brainstorming and other creative thinking techniques the applications and industries that the developed artifact can serve. Those are namely, maintenance in extreme or critical environments such as nuclear power plants, aerospace and aircraft Industry, oil extraction and refinery Industry, mining, heavy machinery for manufacturing and ship logistics. Medical interventions and surgeries is a market with great stream of supported applications, however, due to the criticality of this operations, further tests and validations need to be performed before such an artifact is released in this industry. There are also some other applications in Architecture visualisation, various manufacturing processes (buildings, vehicles, etc.) and intuitive guidance in cultural heritage sites. These applications and industries are very different by any mean. Thus, as described in the previous section, we had to prioritize and set an exploitation roadmap. Prior to this, we performed a quick market analysis so as to choose afterwards the most prominent. Further to our analysis, we chose to serve only two markets with two different applications; neurosurgeons medical industry and the complex machinery maintenance application for fabrication plants.

The sponsor of the project, CERN, had a clear vision from the beginning to be the first user of the final system and to exploit it commercially. Thus, the whole system architecture was filtered from the first drafts so as not to include expensive or unadaptable components that although could solve the problem of CERN easier, they would make the adaptability of the system more difficult. In the list of collaborating partners, there were both commercial and academic organisations. Although this is a good practice to foster the development of applied research that is closer to the market needs, there is a complex work of various stakeholders' management. The individual incentives and the very different organisational motivations made the decision making process within the consortium a challenging endeavour that resulted in a great period without clear technical architecture and "frozen" technical design. However, the final output was in the right direction of exploitability.

When it comes to team characteristics, it is always somehow difficult to find qualified researchers or skilful technology professionals that would be happy to engage in entrepreneurial activities. In our case, and although the extensive entrepreneurial training that was provided to them, there was not a lot of interest expressed by the involved researchers for such an activity in view of our artifact exploitation. As a European funded research project, the team had highly supplementary technical and non-technical skills. However, the commitment, intention and motivation are some key factors in the successful implementation of a project, such as the commercial exploitation of a joint developed artifact. In the case of our project, the various stakeholder incentives and the lack of entrepreneurial intention could not foster the entrepreneurial activity from the specific team.

During the end of the second project year, the consortium was pleased to hear from two of the partners, one academic and one commercial, that each one had an industry lead and that there is a great interest on the output of the project work. These news changed the team dynamics within the involved stakeholders and created a positive effect among some participants to try the entrepreneurial exploitation of the final system, after the successful completion of the project. Thus, a new team was created consisting from previous and new members that undertook the endeavour to create a new venture to serve the two foreseen market leads.

Based on the conducted IPR strategy assessment, it was apparent that there are some related patents that are possessed by some big companies, but are still unutilized, since there is no similar product in the market up until today. Since the patent strategy is highly costly for a new start-up company and because of the research project nature and ICT utilized technology, the consortium made the decision not to pursue the acquisition of a patent and follow an open innovation strategy were all the collaboration parties have equal access. This also follows the idea of the first and fast mover advantage in the market, meaning that a company that develops and penetrates the market faster has the competitive advantage towards the one that tries to patent technology or knowledge of questionable patentability and afterwards start to develop the system. Lately, there are some second thoughts for the new start-up to pursue a relevant patent protection through wish the involved parties in the project will be rewarded through royalties, although they have chosen to not participate in the new venture.

The final output of the aforementioned exploitation assessment approach was the composition of a business plan that describes the roadmap of a new venture creation that will tailor the developed artifact into the needs of the two selected markets, serving them initially with two applications (complex machinery maintenance and neurosurgical aiding tool).

These preliminary results of the experimental application in the aforementioned case illustrate that the proposed set of dimensions when it comes to complex technology commercialization tackle the targeting situation in a way that is it the right direction. Further validation is needed, so we are planning to apply this model in further commercialization cases with different characteristics (set of inventors, involved organisations, initiators, IPR situation etc.) so as to further explore the factors that affect the technology entrepreneurship.

5 Lessons learned and discussion

In the previous paragraphs we presented a set of dimensions to assess the exploitation potential of a developed technology through entrepreneurial activities. Furthermore, we employed these dimensions in the assessment of a particular augmented reality technology which was the output of a joint research collaboration. Though this analysis, it is evident that a more holistic and multidimensional approach is required, when it comes to the assessment of the entrepreneurial potential of a specific technology. The technology or market assessment alone can give limited insight regarding the business potential of the developed technology. In the previous literature, scholars have been examining this phenomenon by analysing part of the aforementioned dimensions and in most cases, with no focus on the entrepreneurial intention or capacity of the inventors' team. When it comes to the exploitation of ICT artifacts, it seems there is a great amount of know how developed by the involved researchers and inventors that cannot get easily transferred (and thus monetized) along with the developed technology.

When performing a technology assessment for the business potential of this particular technology, apart from the technical readiness level and functional completeness, it is important to identify the place that this technology has in the ICT value chain, so as to enhance its economic evaluation based on the potential societal impact. This analysis can give a better perspective on the market potential of such a technology along with the supported applications, based on its technical and functional capabilities. Thus, this information can be a valuable input for the process of market assessment and the identification of optimal go-to-market strategy.

Finally, the exploitation team is the one that will undertake the process of commercializing the research output or developed ICT artifact. Nowadays, most of ICT solutions that are developed utilize open source technologies that have difficult intellectual property handling when it comes to technology transfer. Hence, the exploitation vehicle of such technologies seems to be any entrepreneurial activity such as venture creation in forms of spin-off or startup. Since a lot of required technical know-how remains with the inventors, it is understandable that they should be part of this team. Things get even more wired when these individuals do not share any entrepreneurial intention or motivation, which is common, leading to unexploited ICT artifacts and research. Thus, the commercialization intentions of all involved stakeholders and partners in a project should be clear early on, in an effort to maximize the entrepreneurial potential and feasibility of technology exploitation though this direction.

6 Conclusion

It seems that IS community should start shedding some light on the topic of technology entrepreneurship, its aspects and its possible affects in the IS theory (Del Giudice & Straub, 2011). Though constructive discussion, the IS community can tackle this phenomenon and contribute to the research on technology commercialization, further impacting the lives and wellbeing of the global population, though the injection of new technologies and services in society.

Technology Entrepreneurial activity as a result of complex ICT artifact commercialization has many common characteristics with the idea of technology transfer and as such, there is no one-size-fit-all solution. Each case is unique and has to be analysed keeping in mind specific and structured dimensions so as to eventually conclude into an optimal exploitation strategy for the team of inventors and the rest stakeholders.

Further research is needed towards this direction both from quantitative and qualitative perspective, in order to validate and evolve the proposed dimensions, as well as understand the differences between the achieved performance of the twofold types of technology entrepreneurship, as they were described in the introduction. Hence, the output of this paper is a call for further research in these directions.

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