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CAPITALIZING ON KNOWLEDGE FROM BIG-SCIENCE CENTRES FOR INTERNATIONALISATION

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ABSTRACT

Purpose – This study investigates how resource-constrained, knowledge-intensive firms capitalise on knowledge gained from collaboration with big-science centres. It pays particular attention to what kind of knowledge a firm obtains and how it can be efficiently used in exploring and exploiting opportunities in international markets.

Design/methodology/approach – The empirical basis for the study is a longitudinal case study of knowledge-intensive Estonian companies that collaborate with the European Space Agency (ESA). A rich data set was collected over three years.

Findings – By studying the inward and outward activities of the two case companies collaborating with the ESA, we found that the internationalisation process of these firms had unique characteristics. Their international expansion was not driven by increasing market knowledge and reducing risk or uncertainty, but by seeking resources for R&D. It was a cyclical, nonlinear process, which was advanced by co-creation, learning, and exploitation of the emergent knowledge, leading to an improved network position and identification of further opportunities.

Originality/value – Our study reassesses the theory on the internationalisation process of the firm and gives voice to companies which have been marginalised in earlier research.

Keywords: internationalisation, knowledge-intensive, big-science centre, Estonia

Paper type: Research paper

1. INTRODUCTION

Knowledge has been central to explaining a firm's internationalisation process (Åkerman, 2015; Eriksson *et al*., 1997) and it is even possible to argue that a knowledge-based theory of internationalisation exists (Welch, 2015). Unfortunately, we know very little about the knowledge acquisition and utilisation of internationalising small and medium-sized enterprises (SMEs) (Åkerman, 2015; Durst and Edvardsson, 2012). This is quite surprising, as SMEs offer great contribution to the global economy but suffer from resource constraints which hold them back from international markets. Given the considerable number of such companies worldwide (Cusmano *et al*. 2018; European Commission, 2010; Keen and Etemad, 2012), we can expect that a deeper understanding of the knowledge acquisition of internationalising SMEs will have wide managerial implications, and thus increase the utility of our study (cf. Corley and Gioia, 2011).

Another contribution of this research lies in its originality (cf. Corley and Gioia, 2011). Besides its utility to practitioners, our study offers a novel view on the internationalisation process of the firm and reveals that despite the significant number of studies that have been conducted, the understanding of how entrepreneurial firms leverage knowledge in their international operations is rather limited. Two approaches have dominated the academic discussion. Early theories on the internationalisation process of the firm explained it as being driven by an active but incremental collection of knowledge from preselected markets (e.g. Johanson and Vahlne, 1977). Later, scholars interested in international new ventures (INVs)

found that the process was not accelerated by knowledge created during the process but rather by the active utilisation of knowledge already possessed by key actors before a company's inception (e.g. Oviatt and McDougall, 1994). Both streams of scholarship assume that internationalising companies hold proprietary assets (e.g. products or technologies) before entering foreign markets. Recently, this premise has been questioned (cf. Kriz and Welch, 2018; Hewerdine *et al*., 2014) with a proposition that small knowledge-intensive firms may also internationalise in order to obtain the financial and knowledge resources required to feed their research and development (R&D) efforts. This non-linear, discontinuous, and emergent internationalisation pattern results in an increased knowledge base, which is not purposefully compiled, but unintentionally accumulated.

One potential source for resources is collaboration with big-science centres. In Europe, among the best known and most studied examples of big-science centres are the European Organization for Nuclear Research (CERN) and the European Space Agency (ESA). Their activities are typically built around specific mission-oriented programs that feed into the economic growth of society (Mazzucato, 2013). The centres are hubs in a knowledge-based network and, to meet their mission targets, they need to collaborate with high-tech firms. Consequently, a large share of such centres' annual budgets is dedicated to the procurement of novel high-tech products. This business of the 'public procurement for innovation' has been defined as '*the purchase of a not-yet existing product or system whose design and production will require further, if not completely novel, technological development work*' (Edquist and Hommen, 2000, p. 5).

Collaboration with big-science centres is a source of high-level technical-knowledge inflows (Autio *et al*., 2004), enabling the development of innovative products and technologies with superior characteristics (e.g. Byckling *et al*., 2000; Hertzfeld, 2002). At the same time, the role of big-science centres in the internationalisation processes of SMEs has been overlooked in the literature. This is surprising, as internationalisation is implicitly considered one of the intended consequences of the public procurement for innovation (Edquist and Zabala-Iturriagagoitia, 2012). Collaboration with big-science centres can play an important role in the evolution of the business networks of firms' suppliers, for SMEs in particular (Bach *et al*., 2002). Involvement with big-science centres may also be a highly valuable marketing reference for their suppliers (Cohendet, 1997; Autio *et al*., 2003). All this indicates that these centres may also play a role in the internationalisation of these entrepreneurial firms.

To sum up, existing theories of the internationalisation process of a firm have focused on firms with existing products or services whose growth is either driven by increasing knowledge and decreasing uncertainty or firms that already have experiential knowledge within the company or available through their network. This study focuses on firms which are working with new-to-the-world technologies (cf. Kriz and Welch 2018) and whose internationalisation is driven by their constant need for resources for R&D. Collaboration with big-science centres may offer them an opportunity for such resources but it remains unclear *how resource-constrained, knowledge-intensive firms capitalise on knowledge from collaboration with big-science centres*. In addition to the scarcity of prior studies in this area, we assume that there is a need to challenge the underlying assumptions of the existing theories on the internationalisation process of the firm. Thus, the research question of this study is built on both the identification of a gap in the existing research and the problematisation of what is already known (cf. Alvesson and Sandberg, 2011).

This study focuses on what kind of knowledge a firm obtains through collaboration with big-science centres and how this knowledge can be efficiently used in exploring and exploiting opportunities in international markets. It adopts a broad definition of internationalisation, including both inward and outward operations in international markets[1], something which has been called for (Hernández and Nieto, 2016). The empirical study is based on longitudinal data from two Estonian firms that have successfully participated in the ESA's tenders.

The contribution of this study is considered as envisioning, i.e. making the reader aware of what previous research has been missing, revealing new insights and providing a revised view of the internationalisation process of knowledge-intensive firms (cf. MacInnis, 2011). Guided by a review of the literature, we examine empirical cases to refine the internationalisation process theory of the firm (cf. Welch *et al*., 2013). Thus, our study is also a response to the call for case studies to modify existing theories and offer alternative explanations (Welch *et al*., 2011). The result of our investigation is an alternative frame of reference that is presented at the end of the paper. It proposes a novel theoretical explanation regarding the internationalisation of resource-constrained, knowledge-intensive firms. Furthermore, our study is unique in the sense that it gives voice to a type of firm that has been marginalised in earlier research. Therefore, examining their internationalisation process provides novel insights into the role of knowledge in internationalisation and further advances the knowledge-based theory of internationalisation.

2. LITERATURE REVIEW

2.1 Internationalisation: A knowledge-development process embedded in networks

Even 40 years after its introduction, one theoretical model dominates the discussion on the internationalisation process of the firm: the so-called Uppsala model (Welch *et al*., 2016). The original model (Johanson and Vahlne, 1977) was introduced in the 1970s, and the authors updated and revised it 30 years later (Johanson and Vahlne, 2009). In the early model, lack of market knowledge was considered to be the main obstacle to the development of international operations. The authors considered experiential knowledge to be a pre-requisite to identifying international opportunities and learning, but also the driver which kept the internationalisation process going. The fundamental assumption was that collecting market knowledge and the resulting increased commitment to international operations would take time. In the revised model, knowledge is embedded in the context in which firms operate. In other words, it is still considered relevant, but firms' knowledge base is not limited to their own activities and resources but extends across company boundaries to their business networks (Johanson and Vahlne, 2009). Furthermore, knowledge is the framework through which the decision makers identify and exploit opportunities (Johanson and Vahlne, 1977), and international expansion requires membership in relevant business networks; otherwise, a firm suffers from the liability of 'outsidership' when compared to its key competitors (Johanson and Vahlne, 2009).

In the Uppsala model, knowledge—particularly market knowledge—is a significant factor in reducing uncertainty and risk, thus promoting firms' international expansion. *Market knowledge*, i.e. an increased understanding of markets and customers, includes the behaviour of clients, competitors and other stakeholders as well as the surrounding institutional frameworks, rules, and norms (Fletcher and Harris, 2012). Increased market knowledge leads

to improved marketing capability, that is, a company's ability to better meet the market-related needs of the business and the demands of competition (Weerawardena, 2003). It is also viewed as decreasing uncertainty and risk and thus facilitating internationalisation (Liesch *et al.*, 2011). On the other hand, researchers have mentioned that companies also need *marketing knowledge*: they need to understand how to enter international markets, to localise offerings and to run international business (cf. internationalisation knowledge, Fletcher *et al*., 2013). This knowledge can be acquired through direct and indirect experience, external search or internal information (Åkerman, 2015; Fletcher and Harris, 2012). In this study, both market knowledge and marketing knowledge are of interest.

The Uppsala model is often contrasted with scholarly work investigating INVs, that is, companies which operate internationally at or near inception (the most notable study being that of Oviatt and McDougall [1994]). Prior research shows that these firms may be able to enter international markets rapidly because they efficiently exploit knowledge gained from their network(s) (Coviello, 2006), and they utilise it without the constraints of pre-existing organisational routines (Autio *et al.*, 2000). INVs combine knowledge from different sources and, in particular, benefit from the congenital knowledge base that the top-management members bring to the company (Bruneel *et al*., 2010). Thus, a significant part of their relevant knowledge base has been formed prior to the company's inception (Hewerdine and Welch, 2013). This interpretation of internationalisation is not contradictory to the Uppsala model: knowledge is created in relationships and networks, and it may have been created even before the inception of the firm (Johanson and Vahlne, 2009).

Both streams of literature have been heavily influenced by the resource-based view of the firm, and knowledge and relationships have been considered as key resources in the internationalisation of the firm (Grant, 1996; Wernerfelt, 1984). For SME internationalisation, these intangible resources are crucial, as they offer a way to compensate for the lack of more tangible resources (Gassmann and Keupp, 2007). Resources are considered both as indicators of a firm's commitment to internationalisation (Johanson and Vahlne, 1977) and as assets which facilitate internationalisation (Coviello, 2006). Unfortunately, studies which offer an in-depth investigation of resource-based SME internationalisation are rare (Ruzzier *et al*., 2006).

Recent studies on the internationalisation of knowledge-intensive firms bring resources more into focus and also indicate that there might be a third alternative way to develop knowledge during internationalisation. Instead of a target-oriented search for knowledge in preselected markets (Uppsala model) or the effective integration of pre-existing knowledge (INVs), a firm's knowledge base may also accumulate unintentionally during internationalisation. Some small knowledge-intensive firms may internationalise to seek resources (Hewerdine *et al*., 2014), and it can be assumed that in these cases, the process of knowledge acquisition, assimilation, and integration may be different, with the process being more emergent than planned. The resulting knowledge-development process is probably ad hoc, irregular, and non-linear, but without any prior studies on this phenomenon, it is not clear whether this is the case. Understanding this process is the core of this study.

2.2 From information to relevant knowledge

Given the 'paradox of information availability' (Welch *et al*., 2016), that is, the richness and easy access to information, one could easily assume that internationalising companies have, by now, overcome the challenges of a lack of market or marketing knowledge. However, this

is not the case, as changing information into usable knowledge requires effort and specific competencies. Nor does the quantity of information compensate for quality. In fact, earlier research has demonstrated that excess knowledge may lead to overconfidence and misinterpretation of customer reactions (Nummela *et al*., 2016). Thus, possession of knowledge does not guarantee smooth international expansion.

In line with Costa *et al*. (2016), this paper presumes that information precedes knowledge and that knowledge is created from information through interpretation. Thus, internationalisation is also a process of knowledge management, that is, acquisition, assimilation, and interpretation, during which information is transformed into relevant knowledge. International business and marketing research is based on the assumption that while internationalising, firms search widely for information, and the use of one source does not limit the use of another (De Clercq *et al*., 2012; Fletcher and Harris, 2012). The significance of experiential knowledge for internationalisation has been particularly highlighted (Blomstermo *et al*., 2004; Eriksson *et al*., 1997), but objective, codified knowledge can also be beneficial. Both market knowledge and marketing knowledge can be either objective or experiential.

However, companies vary in terms of their ability to benefit from this knowledge. Their absorptive capacity, that is, the ability to recognise the value of information and assimilate it (Cohen and Levinthal, 1990), is decisive in exploring and exploiting international opportunities. It is also possible that the management recognises the value of the acquired information, but while it remains 'nice to know', they do not know what to do with it. This problem originates from a lack of transformational capability: the management is unable to develop routines which would facilitate meaningful combination of existing knowledge with newly acquired knowledge (Zahra and George, 2002). Thus, future absorptive capacity is determined by the current absorption of new knowledge in organisational routines and processes (Todorova and Durisin, 2007).

Relevant knowledge for internationalisation is acquired and assimilated through inward and outward activities (Hernández and Nieto, 2016). Studies taking a holistic view of internationalisation have typically searched for links between inward (international sourcing and R&D) activities and outward (sales-related) activities. A number of studies have shown that firms use inward activities as a springboard for outward operations, particularly in the early internationalisation phases (Holmlund *et al.*, 2007; Karlsen *et al*., 2003; Jones, 1999; Korhonen *et al*., 1996). However, from this study's viewpoint, it is pertinent that inward links are the interorganisational relationships which add resources to a company's internal processes, whereas outward links exploit the internal resources (Rilla, 2016). Unfortunately, existing research does not describe the formation of inward–outward links, that is, the utilisation of knowledge created during inward activities but also used in outward internationalisation.

This study argues that links between inward and outward activities extend a company's knowledge and experience base and provide a platform for knowledge assimilation and interpretation. The study asks what new knowledge firms acquire as they collaborate with big-science centres, and specifically with the ESA. We are particularly interested in market knowledge and marketing knowledge and how this new knowledge is utilised in subsequent internationalisation efforts. Following the call by Holmlund *et al.* (2007), these questions are answered by combining quantitative and qualitative process data from two Estonian companies.

3. RESEARCH DESIGN

3.1 Research strategy

This study investigates the acquisition and use of market and marketing knowledge which knowledge-intensive SMEs obtain through collaboration with big-science centres. To capture the knowledge development in the internationalisation process of these firms, a multiple-case-study approach was chosen. This research strategy allows for an in-depth investigation of the research topic, analysis of the phenomenon in its contextual setting, and a more holistic view of the selected companies (Ghauri, 2004). The theorising focus of the study is on the processes that generate new knowledge and promote knowledge transfer within the case companies. Instead of building a new theory, this study aims at refining the internationalisation process theory (cf. MacInnis, 2011).

In our case study we focused on two firms in order to combine deep understanding of the cases with the possibility of pattern matching between the cases (Eisenhardt, 1989). In this respect, our study can be labelled as a 'matched-pair' case study (cf. Piekkari *et al*., 2009). The selection of appropriate cases was based on the study's purpose—what the researcher wants to be able to say about the unit of the analysis—and access to information (cf. Fletcher *et al*., 2018). This study is based on a purposeful sampling of cases, which is typical for studies focusing on real-world problems (Emmel, 2013). Critical case sampling, a subcategory of purposeful sampling, was adopted. As Fletcher and Plakoyiannaki explain, critical case sampling '*focuses on selection of cases that are rich in information because they are unusual, special or make a point quite dramatically*' (2011, p. 179). This study focuses on internationalising firms that have benefited from collaboration with big-science centres. It is unique in the sense that it gives a voice to resource-seeking firms with new-to-the world technology, a group that has been marginalised in earlier research on the internationalisation of firms.

Two main criteria were applied in the selection of cases. First, small knowledge-intensive firms were sought which had experience in collaboration with a big-science centre. Second, the firms needed to be accessible, observable, and trackable. Both selection criteria pointed towards Estonian companies which had cooperated with the ESA. By January 2014, when data collection started, 13 companies in total had experience of ESA collaboration. Of these firms, two information and communication technology (ICT) companies were chosen for investigation. These information-rich 'archetypical' cases were viewed as being able to provide the best answers to the research questions (cf. Patton, 2015; Silverman, 2013; Stake, 1995).

The sampling process was iterative and could be labelled as 'through the research process sampling', which is typical for qualitative research (Uprichard, 2013). This started early in the process before the researchers entered the field and continued until the data-analysis phase. Purposeful sampling led to cases that provided detailed insights and in-depth understanding—a benefit which would not have been obtained using other sampling strategies (cf. Emmel, 2013). The study did not search for representativeness but the credibility of the findings (cf. Patton, 2015).

3.2 Data collection and analysis

This study focuses on how resource-constrained entrepreneurial firms capitalise on the knowledge they obtain during internationalisation. Following the tradition of international entrepreneurship research (Coviello and Jones, 2004), the unit of analysis in this study was a single company. The studied firms were quite small, and because of their size and centralised decision-making, a holistic case analysis was possible.

When studying a change in the knowledge base of internationalising firms, a longitudinal approach is recommended (Ibeh and Kasem, 2014). For this study, we collected a rich data set spanning three years. It includes both primary and secondary data for both cases, collected both retrospectively and in real time. In SMEs, knowledge sharing typically happens informally and not very systematically (Durst and Edvardsson, 2012). Major decisions are made by the top management and presumably these key decision makers also have the best overall view of knowledge acquisition and utilisation within their companies. Therefore, the CEO of company C and the VP of company A were the key informants interviewed for this study. The interviewees had been with their companies since inception. Therefore, they were knowledgeable about both past decisions and motivations and also about the acquisition and utilisation of knowledge during internationalisation. Besides interviews, the data set comprises Skype sessions and face-to-face meetings with the key informants, as well as internal company documents and annual reports. Figure 1 presents a timeline of the data collection.

INSERT <Figure 1. Timeline of the data collection**> HERE**

Semi-structured interviews were carried out with the key informants. All interviews were conducted face to face in Estonian, as the interviewees and the interviewing author were Estonian nationals. By using their mother tongue, the interviewees could express their opinions, thus increasing the credibility of the findings. Follow-up Skype sessions were organised with the key informants during the research process; altogether, close to 100 sessions were held. The Skype sessions were informal, mainly focusing on different events related to resource-seeking and internationalisation and the managerial reasoning behind them. They provided supplementary information and allowed for the tracking of the development process.

During the research project, one of the authors worked as a consultant assisting Estonian SMEs in ESA projects and hence had an observer role (cf. Piekkari *et al*., 2013). While he could follow the case firms' activities at all levels, he was not directly involved in their internationalisation processes.

Data was also obtained from several publicly available and internal documents. Estonia has comprehensive public databases on company performance, as every company is obliged to disclose its financial statements. Company websites, newsletters, professional magazines and newspapers supplemented the understanding of the companies. Utilisation of other types of internal documents such as reports related to publicly funded projects or internal memos also allowed for the validation of the views of the informants and a better capturing of the phenomenon over time.

The aim of our analysis was to create a 'thick description' (Geertz, 1973) of the cases. In order to manage the rich data set, we applied tools for organising and structuring the data: it was coded systematically with NVivo software and the Gioia method was applied in the first phase of the analysis (Gioia *et al*., 2013)[2]. The next step involved the preparation of a primary narrative or a 're-storying' of the case from the raw data (Eisenhardt, 1989) to unite the contextual and focal elements temporally (Makkonen *et al*., 2012). This involved the process of selecting, focusing, simplifying, abstracting and transforming the data by writing summaries and coding.

The list of codes evolved over the research process, as new themes emerged inductively from the data and deductively from the simultaneously evolving theoretical framework (cf. Bazeley, 2007). The codes included, for example, 'ESA as a gateway to business networks, 'signal of the potential of the company to business networks, 'market information from the ESA', 'resource-seeking activity', 'cross-border inward link', 'market information from ESA events', 'learning from marketing knowledge' and 'change in business strategy'. After the themes were coded, the data was categorised accordingly. This enabled the researchers to write narrative descriptions or 'microstoria' (Makkonen *et al*., 2012). The result was a lengthy researcher narrative on the emergence and internationalisation of the ventures.

To increase the external validity of the research, case-study databases were compiled. The databases contained case-study memos, relevant documents from secondary data sources and the narratives collected during the study (cf. Gibbert *et al.*, 2008). The reports and the interview transcriptions were made available to the respondents to obtain their feedback and, thus, further mitigate subject biases.

3.3 The case companies

Company A was established in 1989 by an entrepreneurial team aiming to rekindle cartography in Estonia. Since its early days, the company's product range has continuously expanded from cartography to geographic information systems, to mobile and satellite applications. However, all these business fields are connected to spatial-information usage by different end-user groups. In 1993, the company's current owner was appointed as the CEO. He recognised the potential of the digitisation of core business processes. By the mid-1990s, the whole process of map production was supported by ICT tools. This step led to entry into a new business field: the development and sale of geographical information systems. By 1998, Company A became the leading software developer in this niche in the domestic market.

In 1999, the company won a contract from Ericsson AB to develop a software platform enabling and supporting the provision of location-based services (LBS) for telecom operators. The new business field benefited from a partnership with a leading local mobile operator who was among the first in the world to launch innovative mobile LBS. Mobile operators around the globe are still the main customer group of the company. In 2000, a publicly traded Finnish company acquired Company A. The acquired unit focused on developing the software platform for mobile operators to provide LBS. In 2001, the company signed a distribution agreement with Ericsson AB, a major supplier of mobile network hardware for telecom operators. But the 2000 Dot-Com bust caused the bankruptcy of the Finnish group in early 2002. A management buyout of the assets of Company A led to the ownership structure of the company which continues to this day. Since 2009, the company has been actively developing Big Data solutions for the telecom sector and satellite applications. In 2013, it

embarked on a corporate restructuring program to divest some of its internationally less competitive business departments and dedicate more resources to its recently introduced, more innovative knowledge-intensive fields of activity. Today, the company turnover is €3.5 million and it employs over 50 people.

Company C was founded in 2013 to provide innovative software for additive manufacturing (AM) systems. The three founders have worked in different managerial positions in the ICT industry. One had a career at Nokia, one was an export manager in an Estonian company, and the third was the CEO of another successful Estonian ICT company. By summer 2014, the company had secured funding for the development of a prototype. In July 2014, negotiations for a contract with the ESA commenced. This proved the credibility of both the concept and the company in the eyes of a seed investor from Japan; by November 2014 that investment was finalised. By December 2015, the first prototype of the software platform with limited functionality was delivered to the ESA. This milestone was essential for raising equity for further R&D and marketing. The negotiations with the next venture investor started at the beginning of 2016 and they were successfully completed by September 2016. This equity round was sufficient enough to bring the software to the market.

The software platform is currently targeted at the business-to-business market. The main target groups include manufacturers of 3D printers and providers of 3D printing services. The company has developed state-of-the-art software tools which make the integration of a 3D printer for plastics and the cloud system extremely convenient for its would-be partners. In both segments, the first paying customers are, surprisingly, from Latvia, even though the company has held talks with various companies from a wide range of industries (e.g. automotive, software, 3D printing) and from different areas (Europe, North America, and Japan). As of 2016, the company had made no sales and its employees were the founders. The first tailor-made software was delivered to a commercial client in September 2017. The key facts of the case companies are summarised in Table 1.

INSERT <Table 1. Summary of case companies**> HERE**

4. FINDINGS

4.1 Obtaining and capitalising on knowledge

The case companies sought to build cross-border linkages to acquire resources needed for exploiting perceived market opportunities. The companies were followed for three years to capture their internationalisation processes and to understand how the role of the ESA was instrumental in establishing new cross-border linkages. Our investigation brought forward several mechanisms by which experiential market and marketing knowledge was obtained through collaboration with the ESA and how it was translated into useful knowledge, which supports outward internationalisation. The following case descriptions (see Figure 2 and Figure 3) illustrate the collaboration between the case companies and the ESA, and the resulting effects on the companies' internationalisation processes.

4.1.1. Company A

Company A launched a new business line in 2010 when Estonian companies and research institutions gained an opportunity to access ESA-funded programs[3]. The decision to

diversify was based on the vision of exploiting the company's core competencies—spatial information technologies—in a different market setting. The access to the ESA procurement was seen as a resource-acquisition instrument to accumulate new capabilities that would differentiate the company from its competitors. The initial plan of Company A was to develop technological capabilities, a software platform prototype, and validate a business case in collaboration with the ESA as the first paying international customer and lead user. The successful implementation of the ESA projects would then pave the way towards commercial upscaling in a number of international markets.

The plan worked, but only partly, for Company A. The collaboration with the ESA boosted the company's technological capabilities and validated them in the eyes of potential clients. The marketing reference enabled the company to successfully bid for public tenders internationally:

If we had not had ESA contracts and that Lithuanian contract, then we would be in trouble. But without the ESA, there wouldn't have been the Lithuanian … Yes, indeed, having reference projects is essential to bid anywhere at all.

However, the plans related to the service platform—which was supposed to be the core of the value proposition of the new business unit—did not materialise. Over time, the top management realised that the ESA was searching for a different solution than the one that they had offered. At the same time, the ESA provided funding and justification for Company A to visit potential end users, e.g. German insurance giants:

Yes, with the insurance industry, we are in the process where we are helping them to tell us what technical specifications are and where the business is … The market analysis is a part of the product development. We simply don't ask for technical requirements, but only in tandem with a question regarding WHY it [information product] *is needed.*

The ESA has also created structures to stimulate further collaboration. It offers Thematic Exploitation Platforms which are networks of companies and R&D organisations operating in virtual workspaces with a common theme and with access to dedicated resources (including data, computing, and software components). Company A benefited from this interface in the form of specific market and marketing knowledge:

I wrote to a company leading the platform and stated that I was an interested party eager to launch its services on its platform. What are the terms and conditions imposed on me to do this? After a few months, we met and negotiated … In practice, I have asked more than 40 questions regarding technical issues, and questions on the business and commercial sides for this collaboration.

The link with the ESA facilitated, either directly or indirectly, the company's access to highly specific knowledge about international markets and value-delivery mechanisms in different market contexts. Contacts with potential end users and accumulating market and marketing knowledge made the company rethink its understanding of market opportunities and revise its approach towards potential customers accordingly. The acquired knowledge stock also highlighted when additional resources were needed to exploit some of the identified opportunities. For example, further tests of user cases or novel technological components were required to pursue operations. These international activities led to the formation of inward cross-border linkages, often in the form of partnerships and consortia for collaborative R&D projects, which were also sources for additional funding from European or national

public programs. Some of the new relationships also provided access to critical elements of service infrastructures with favourable terms.

These inward links often arose at various ESA events. The ESA organises a wide spectrum of industry days related to a certain technological domain or a space mission, or days dedicated to supporting the involvement of SMEs in the ESA programs. These events have turned out to be highly valuable for expanding the business networks of the case company:

Even though I have difficulties with differentiating which people I've contacted in the workshops organised by the European Commission and those in the ESA events, my (good) business contacts have still come from these two circles rather than from any other types of conference.

At the same time, Company A continued building outward links to make use of resources obtained through the ESA contracts. Making offers to and communicating with potential end users resulted in new marketing knowledge which further augmented the company's resource pool:

...then there are next-use cases and other ones where the service delivery is based on different principles. And these use cases are our ... I would say ... as strong and as important as the intellectual property of the software algorithms. I mean our business knowledge and how to couple pixels and frequencies with the needs of users. (Company A)

Collected marketing knowledge is utilised in multiple ways. Besides affecting what to offer and how to offer within international markets, it also impacts pricing decisions:

What's important now is that we are able to put a price tag on these value-added services. Not only what the CAPEX-OPEX of the services are—this is now possible to calculate—we are also able to provide an estimate to our customers about the value we add. And we are able to price the added value. (Company A)

Linkage to the ESA has been instrumental in the company's journey towards a sustained competitive advantage in its new market. The continuous refinement of Company A's business model, understood as a '*hypothesis about what customers want, and how an enterprise can best meet those needs, and get paid for doing so*' (Teece, 2007, p. 1,329), is an outcome of learning by experience from various actors in its business networks (see Figure 2).

INSERT <Figure 2. Capitalising on knowledge in Company A**> HERE**

4.1.2. Company C

Company C was registered just a few months before it submitted its bid to the ESA in early 2014. Thus, the company was in an embryonic phase of development when it first approached the ESA. It had an original technological concept and a tentative business strategy, but it had not developed prototypes, nor did it then possess the resources for prototyping. At that point, the company believed that the software would create most value to customers from strongly hierarchical industries such as the automotive or aerospace industries. Based on this existing perception, Company C approached the ESA and successfully proposed a project. The collaboration with the ESA was an outcome of a creative entrepreneurial move to acquire external resources. On the surface, the ESA appeared as a technologically distant partner for the company to realise its business concept.

The strong reputational content of the 'ESA label' has manifested in many contexts for the company. It has been a real door-opener. The signal of legitimacy it provides has played a decisive role in the company's search for financial resources when they were most needed. The ESA contract led to an equity investment by an Asian investor:

It [ESA contract] *worked for the Japanese. Absolutely!…When we received confirmation of it*, *then on that basis, they were instantly ready to invest in us.*

Association with the ESA helped Company C to extend its business network. Based on this credential, the company had a chance to visit and pitch its first prototype (developed for the ESA) to several leading multinational groups from various industries such as the automotive and medical industries in 2014 and 2015:

[The ESA label] *is a positive sign. Otherwise, it is difficult to verify. Typical situation—up pops Company X, almost without employees, no one seems to know them, tells a nice story; why should I bother to continue to chat with them if I don't know what qualities are behind that company? But the ESA badge is on them—that the ESA has procured and approved software that works. Alright—it is worthwhile speaking with those guys!*

Even though most established business ties with large multinationals were short-lived and are currently in hibernation, highly specific knowledge about the market conditions in different countries was conveyed to the company. Access to potential customers to whom the company expected to create the most value demonstrated that the company's technology was several years ahead of the target group's real business needs ('*One needs to fine-tune an engine before starting to invest in golden bumpers*').

Inward cross-border links were equally important to Company C in obtaining market information. The company established contacts with several companies in its value chain in an industry event organised by the ESA ('*That's the place where the industry actors meet!*') and they negotiated a possible partnership to continue the development of the technology together with the ESA or another resource provider. During negotiations with potential development partners, it became evident that in some geographical markets (e.g. Germany) prevailing attitudes towards software security issues in general did not support the implementation of the company's business strategy:

They said after a month that they still were not ready and had to investigate what the potential risks related to this software were … They have their own standards. Certain regulations regarding the Internet … For us, it was nonsensical … Nonsensical but reality.

During the implementation of the ESA contract, Company C learned more about the structure of and actors in the European space industry's value chain. Based on this market knowledge, it was possible to approach the ESA and ask its staff to act as brokers for new business ties. The ESA mediated access to European system integrators, the large business groups residing at the top of the highly hierarchical space industry's value chain. Without the ESA's facilitating role, it would have been unthinkable for a start-up to reach these companies.

Witnessing the power of the ESA contract as a sign of the potential and inherent value of the technology, the company built on the momentum and created channels to several major industrial groups. For example, the company made a sales pitch to a multinational company,

but instead of a sales deal, they became a beneficiary of the global player's freshly launched cooperation platform for engaging with promising start-ups in emergent technology fields:

In addition, we have a contract [with a large MNC] *which* [for us] *is equal to an investment. They invested €360,000 in us. It means they provide us services* [back-end infrastructure] *that we don't pay for. It is free for us … They may consider us a test case of some sort.*

The contract with the ESA made the company investigate whether the ESA had provided more benefits in terms of business development. Participation in ESA events enabled the company to establish most of its inward links for R&D collaboration, but also outward cross-border links:

I picked up many exciting themes from there. One was a German company, another an Austrian with whom we principally agreed [upon R&D collaboration] *… Yes, we are continuing with a Canadian company. We will develop an integration layer for them. A real customer. Potentially a paying customer.*

A reassessment of the company's business strategy was based on market and marketing knowledge collected from the large number of cross-border links that were created by virtue of a single contract with the ESA. Company C has strongly benefited from highly knowledgeable expert feedback on the merits and weaknesses of different possible-use scenarios for the software platform. The collected marketing information has been crucial in deciding which technologies and features are to be embedded in the product:

Then again … you massively save time. Time and money when you don't do things the market does not seek and the market is not yet ready for. This is so huge a thing, but often, people don't appreciate that … All in all—not developing it in spring [2016] *was the right thing, as we would have run in the wrong direction, spent our limited funds and would have … bitterly murmured that no one wants our thing, even though it is awesome!*

The marketing knowledge that was obtained increased understanding of how to customise offerings in different international contexts to win deals, e.g. by forming commercial partnerships with emergent and agile companies more willing to align their business strategy with the case company's value proposition. One example was a Latvian hardware manufacturer, originally a potential development partner. The ESA order offered credibility and financial resources to nurture this first inward cross-border link. In less than three years, the R&D collaboration and reciprocal learning evolved into a 'deep technical integration' and a commercial agreement between the parties, that is, an inward link progressed into an inward–outward relationship.

INSERT <Figure 3. Capitalising on knowledge in Company C**> HERE**

4.2 Cross-case analysis

The starting point for collaboration with a big-science centre for both case companies was a commitment to an initial understanding about how they would deliver value to customers. However, the resource base to exploit the identified business opportunity was inadequate for Company C, whereas Company A, as a more mature enterprise, had allocated substantial funding of its own to cover investments in space technology R&D over the years. Nevertheless, the top management of Company A considered their internal resource base insufficient to run its business '*at a pace that they would like to'*. Thus, gaining access to

additional external resources was the main driver for the international activities of the companies.

The routes leading to collaboration with the ESA were different. The ESA has been a partner of long-term strategic importance to Company A due to the nature of the nascent business sector, which is highly dependent on institutional customers (such as the European Commission, national agencies, and international organisations). Altogether, Company A has won four contracts with the ESA to develop applications based on satellite imagery and methods to process satellite data. It also intends to collaborate with the ESA in the future and respective goals have been set for 2018 and beyond. At the same time, Company C viewed the cooperation with the ESA as '*a bit opportunistic*'. However, for both case companies, the ESA was their first international paying customer and still remains their most important international source for sales revenues.

The ESA orders to its suppliers can be seen as 'experimental procurement' (Uyarra and Flanagan, 2010). That is, the ESA is a lead user that procures the first prototypes and emerging designs of the most innovative but highly specialised products and services, which its contractors later offer in (non-space) niche markets. The collaborative relationships involve co-creation, which brings knowledge resources into internal development processes. Long-term organisational learning effects on a big-science supplier are stronger when the technological content of a contract is tightly linked to the core competencies of the suppliers (Nordberg *et al*., 2003).

The initial plan of both companies was to develop a prototype and validate a potential use case in collaboration with the ESA, and then replicate it in non-space markets. In earlier research, the results of collaboration with big-science organisations have been denoted as 'quasi-immediate' knowledge spillovers (Cohendet, 1997), and this seems to be valid for our cases. Although the spillovers are rapidly visible for the company, the newly acquired technological resources as well as market and marketing knowledge, need to be adapted to various contexts. The pertinent, even growing resource need is accelerated by the discrepancy between the factors driving the procurement of a new technology at the ESA and the value proposition which would appeal to other potential customers in international markets. Accumulating market and marketing knowledge demonstrated to our case companies that their initial beliefs about market opportunities were not supported by potential customers. This was contradictory to the results of the market research that Company A had conducted prior to launching their new business line.

Our original business model … or one of the provisional models … was to take a specific market segment and a core process of a customer and to add value with our product to this core process … It does not work that way! (Company A)

Nor did the companies have a clear understanding of the ESA's needs and motivations to enter into a contract. This hindered learning from the customer–supplier relationship between the ESA and the companies:

The reasons and arguments of the ESA to procure the project were different from those that we initially perceived them to be. This is something were learned over time. We could not know it in advance. (Company C)

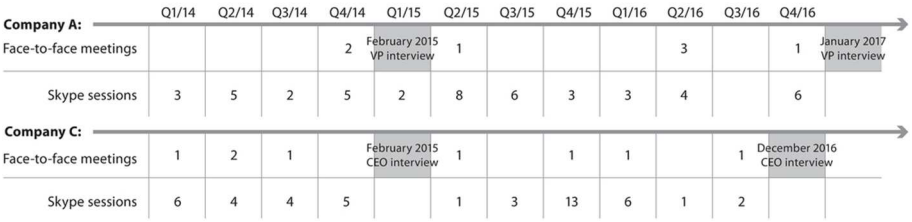

Figure 1. Timeline of the data collection

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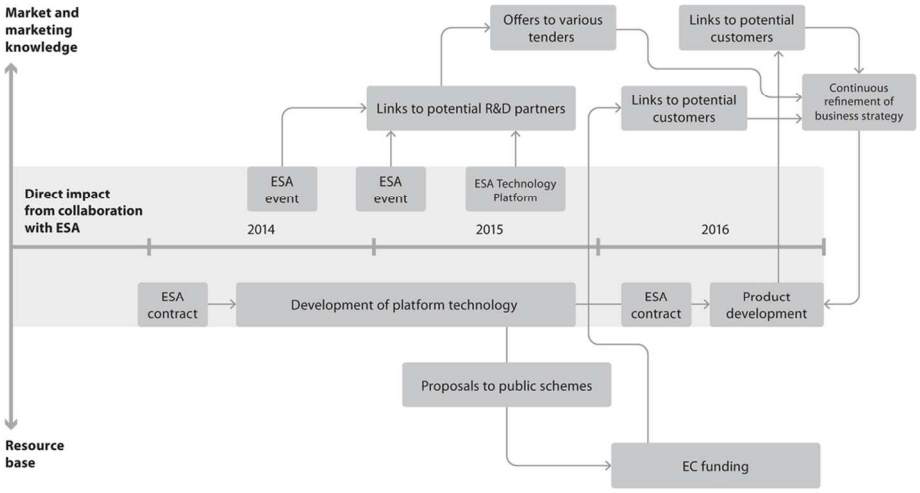

Figure 2. Capitalising on knowledge in Company A

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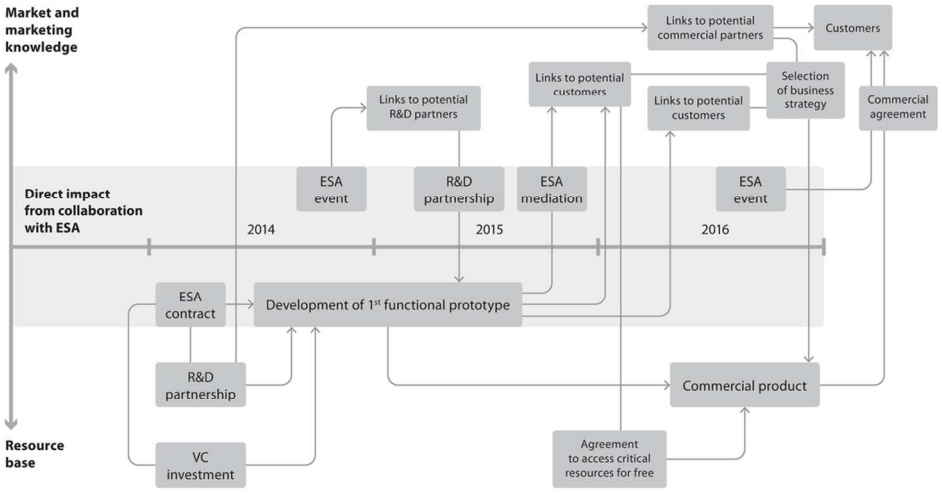

Figure 3. Capitalising on knowledge in Company B

209x148mm (150 x 150 DPI)

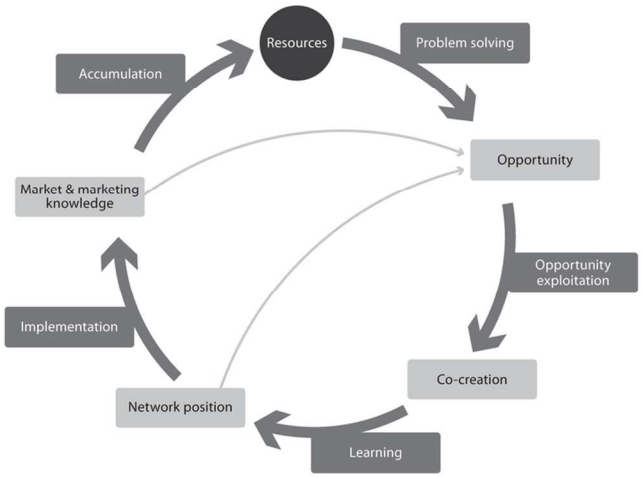

Figure 4. Tentative framework for knowledge acquisition

209x148mm (150 x 150 DPI)

Table 1. Summary of case companies

	Company A	**Company C**
Founded	1989	2013
Started collaboration with the ESA	Since 2010	Since 2014
Employees	50	3
International markets	Since 1999	Since 2014