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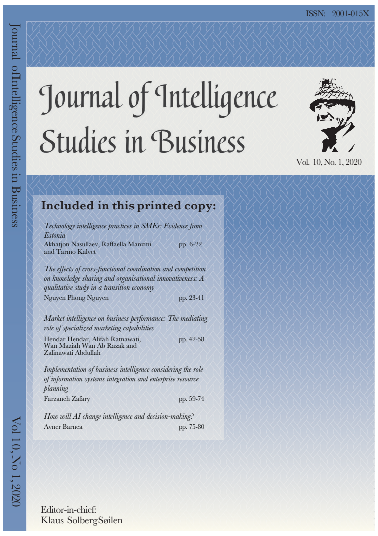

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Technology intelligence practices in SMEs: Evidence from Estonia

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ABSTRACT Technology intelligence is regarded as a strategic tool to support open innovation to identify promising niches of technologies, opportunities and threats, potential partners, future customers and markets. However, it has often been neglected by SMEs due to their constraints in money, time, skills and competences. Hitherto, the literature documented very few cases of the operationalization of technology intelligence practices by small firms of catching-up economies. To remedy this gap, this paper investigates the case of three Estonian SMEs in the manufacturing, information technology and life-sciences industries. Our analysis reveals that elements of technology intelligence in large and small companies are similar. The three medium and small sized companies investigated in this study adopted these elements to their specific context orchestrating their organizational and cultural characteristics. This study details these elements and allows us to understand more precisely the process underlying the phenomenon of technology intelligence in small companies. The major finding of this paper is that a unique set of technology intelligence does not exist. It is important to tailor different elements of technology intelligence to determined needs. It is crucial in the case of SMEs in order to address the limitations mentioned above.

KEYWORDS Case study, catching-up economies, technology intelligence, SMEs

1. INTRODUCTION

Although the role of large companies in innovation is prominent, smaller firms are of growing importance for industry R&D and thus for economic growth. Their positive impact on countries' economic well-being through job and wealth creation stimulates innovation, making them an engine of social and economic development. Small and medium sized enterprises (SMEs) generally have to cope with the constraints of size, financial resources, time and personnel (Acs and Audretsch, 1988; Rothwell and Dodgson, 1993; Freel, 2000). Unstructured processes of innovation, poorly defined internal capabilities and scant opportunities to hire the "best people" hinders SMEs to innovate and access new ideas (De Toni and Nassimbeni 2003; Parida et al., 2012; Bianchi et al., 2010). These restrictions compel SMEs to collaborate with other firms, particularly larger companies, customers, suppliers and research institutions. By accessing partner's technological competences, SMEs compensate for their limitations. Flexibility, adaptability, reduced bureaucracy and the risk-taking advantages of SMEs facilitate the benefit of such collaborations (Vossen, 1998; Laursen and Salter). Thus, open innovation is a promising remedy to overcome challenges, to develop new sources of income, and to reach more profitable positions in the competitive landscape (Gassmann et al., 2010; Vanhaverbeke et al., 2012; Edwards et al., 2005; Lee et al. 2010). In order to benefit from open innovation, SMEs need technology intelligence. An integration of systematic technology intelligence to decision-making processes can allow firms to monitor technological trends and the latest developments, to identify potential threats, to analyse competitor movements, to find new products, processes or collaboration opportunities. Thereby, using technology intelligence is becoming more and more important in the open innovation paradigm to observe the external environment, to tap into and benefit from external sources of knowledge and to create innovation competences. Hitherto, much of the literature mainly discussed how large and multinational companies implement technology intelligence practices (Lichtenthaler 2006; 2007; Mortara et al., 2008; 2009; Porter, 2005; Arman and Foden, 2010). Considering the fact that SMEs are different from their larger counterparts in many aspects, as stated above, these studies don't provide solutions for SMEs. At the same time, little is known about how SMEs operationalize technology intelligence practices. Savioz (2004) delineated two gaps related to technology intelligence in SMEs. First, there is no detailed investigation on technology intelligence in SMEs in the literature and secondly, the general literature on technology intelligence does not explore the case of small firms. Kilic et al. (2016) called for further contributions to answer the question: "How can SMEs perform technology intelligence more effectively and efficiently". There is still uncertainty in the literature on this question, if all methods and approaches of technology intelligence experienced by large firms are also applicable for SMEs (Stonehouse and Pemberton, 2002; Vishnevskiy et al., 2015). Battistella et al. (2015) argued that SMEs face difficulties in implementing technology intelligence tools and methodologies simply because they are not designed for such firms. More research is needed to find customization strategies. The available literature in technology intelligence evidences that many of the contributions are devoted to technology-based manufacturing firms. Similar studies that investigate the case of companies in the service sector are recommended by Ranjbar & Tavakoli (2015) and Khosropour et al. (2015). In addition, previous research documented poor innovation performance and different structures of SME R&D in catching-up economies comparing to developed countries (Zerka, 2010; Vrgovic et al, 2012; Shi et al., 2016). Vedina and Baumane (2012) stated that, compared with the EU average, SMEs in catching-up economies are lagging behind in terms of several innovation indicators, such as the creation of new knowledge, application of this knowledge in society and intellectual property rights protection. A recent extensive literature review by Manzini and Nasullaev (2017) proposed the necessity of further investigations of technology intelligence process in SMEs of catching-up economies. This study will contribute to the literature by bringing evidence from SMEs of catching-up economies. In doing so, we aim to understand how technology intelligence practices in small companies are organized. The results of this study will allow us to more precisely understand the process underlying the phenomenon of technology intelligence. In particular, this paper helps us to reveal the major issues of technology intelligence faced by SMEs and the best practices that we can learn from them. This paper is structured as follows: in the second section we discuss technology intelligence literature from a general perspective and from the perspective of SMEs. The third section describes the research setting. In the fourth section we detail our empirical case study with three Estonian firms in the manufacturing, IT and life-sciences industries. And finally, the last section discusses the main findings of this study and our conclusion.

2. LITERATURE REVIEW

2.1 Technology intelligence: a general perspective

There are many published studies in technology intelligence, as understanding technological changes and their consequences to the activity of companies has always been important. According to Kerr et al. (2006) technology intelligence is "capturing and delivering technological information as part of the process to develop an awareness of technology threats and opportunities". The classical form of this term is "technical intelligence", a process used to collect or analyze information about the broad range of foreign science, technology, and weapon systems (Ashton and Stacey, 1995; Kostoff, 1993). Ashton and Klavans (1997) believe that technology intelligence provides decision-makers with actionable results that will produce business assets. Implementing technology intelligence activities systematically ensures companies will master technological discontinuities and integrate intelligence results into decision-making in order to maintain a competitive edge. Lichtenthaler (2004; 2007) explained the failure of the companies due to the organizational inertia, managerial incompetence, lack of financial resources and insufficient technology intelligence. Therefore, many authors called for a systematic organization of technology intelligence already from early 1970s (Utterback and Brown, 1975; Brockhoff, 1991; Ashton and Stacey, 1991; 1995). For instance, Jain (1984) stated that in order to maximize their efforts and opportunities, and allocate resources to the foreseen future, companies need a systematic and more intensified approach of environmental scanning and it should be directed by the goal, focus and the scope of the companies. The author delineated four phases of scanning activities: 1) the primitive phase (scanning without any effort), 2) the ad-hoc phase (company realizes the importance of scanning and undertakes steps to understand some specific events), 3) the proactive phase (unstructured activities) and 4) the reactive phase (planned, structural and intensive approach). However, early identification of emerging threats or opportunities may not solely be enough; it is also important to respond quickly to these changes (Ansoff, 1980). As it was highlighted by Rupert Murdoch: "The world is changing very fast. Big will not beat small anymore. It will be the fast beating the slow." In this vein, the literature evolved by making advances in different aspects of technology intelligence. The first premise that needs to be mentioned here is that technology intelligence should be understood in a consolidated way: it is an organizational intelligence which eventually creates an organizational learning and technology intelligence cannot be fully organized in a dedicated unit (Gerybadze, 1994; Liebowitz, 2000; Savioz, 2004; Lichtenthaler, 2004). The technology intelligence process is a cycle of iterative and parallel interaction of activities that should juxtapose with several external and internal factors. Most studies agree that the technology intelligence process encompasses activities like definition of information need, coordination, collection of information, analysis, filtering, documenting and dissemination of information (Norling et al., 2000; Kerr et al., 2006; Arman and Foden, 2010; Lichtenthaler, 2006). Mortara et al. (2008; 2009) investigated these activities in the case of UK technology-based companies. Manzini et al. (2017) in their action research explored the patent intelligence process specifically tailored to technology intelligence intermediaries. Lichtenthaler (2004) complemented these activities with monitoring (directed) and scanning (undirected) perspectives. Successful operationalization of technology intelligence activities is dependent on several internal and external factors. The literature with various levels of sophistication pointed out some of them. Different literature streams studied include: organization and coordination of technology intelligence activities (Lichtenthaler 2004; 2007; Nosella et al., 2008), technology intelligence methods, tools and their application (Lichtenthaler, 2005; Porter, 2010; Arman and Foden, 2010; Yoon, 2008; Yoon and Kim, 2012), information sources and approaches for information collection and data analysis (Reger, 2001; Savioz 2004; Porter, 2005; Mortara et al, 2008), and players involved in the process (Vischer and Boutellier, 2010). Interesting perspectives come from the contributions that investigated technology intelligence in the context of open innovation (Porter, 2007; Schuh et al., 2008; Veugelers et al., 2010; Durand, 2014; Khosropour et al. 2015). To give some examples, Veugelers et al. (2010) described the selection process of external technologies for investment through real options reasoning. Khosropour et al. (2015) emphasized two approaches of companies in tracking technological changes: 1) building the future of the company based on collaborations, expert opinions and knowledge networks; 2) using technology intelligence to identify future technology areas of the company and adapting networking and open innovation according to these areas. As it should be already clear, the scope of the topics discussed in the technology intelligence literature is broad. However, according to Savioz (2006), size-related issues still remain uncovered. The next section is dedicated to this knowledge gap.

2.2 Technology intelligence in SMEs

Recognition of technological opportunities coupled with the identification of market needs is an essential ingredient of successful innovation (Albagli, 1997). Most SMEs have already realized the essence of intelligence activity; however, they tend to neglect this powerful tool due to resource and competence constraints. SMEs are more interested in immediate and short-term knowledge, whereas intelligence strategies are usually planned for long-term time horizons (Major and Cordey-Hayes, 2000). Nijssen et al. (2001) argued that, the ability to find potential technologies and strategic partners is easier for large firms, simply because in small companies managers tend to be occupied with day-to-day business. Even with these limitations, a survey conducted by Z-punkt found that SMEs envisage the future, analyze products, markets and competitors using simpler approaches (Jannek and Burmeister 2007). Technology intelligence models and approaches designed for large firms are replicable by SMEs only if they are tailored to the specific needs of SMEs. Although the literature portraying technology intelligence practices in SMEs is very scarce, few authors described such approaches. Savioz and Blum (2002) proposed and implemented a novel concept: the opportunity landscape, which combines gatekeeper and knowledge management concepts. Involvement of a formal gatekeeper network approach ensures advantages in terms of roles, resources and organizational learning. In his follow-up study, Savioz (2006) reported that similar elements of technology intelligence found in large firms can be observed in small companies as well. However, these elements need careful selection and customization according to company-specific requirements. Thus, there is no one best way of conducting technology intelligence, there exists only best situational solutions which are influenced by several factors (Savioz et al., 2003). To a large extent, the successful organization of technology intelligence depends on the organizational and cultural fit. Battistella et al. (2015) noted that actionable and collaborative technology intelligence, which also includes the role of innovation intermediary, may provide solutions to the innovation constraints of SMEs. In a similar way, Bianchi et al. (2010) proposed the TRIZ-based easy and quick methodology to identify alternative applications of technologies for small companies.

In sum, the evidence presented in this section clearly show that: very little is currently known about how small companies handle the technology intelligence process and that there is limited understanding on how SMEs in catching-up economies deal with technology intelligence.

3. METHODOLOGY AND RESEARCH DESIGN

A qualitative, explorative approach has been chosen in order to understand how technology intelligence practices are organized in SMEs. Case studies, as an empirical type of research method, help to investigate a contemporary phenomenon in-depth especially when the research object is complex (Yin, 2003; 2012). Therefore, the current study follows a multiple case study design as it allows researchers to develop and test generalizable theories (Eisenhardt & Graebner, 2007). According to Yin (2009) the choice of using a multiple case design grants researchers more robust and compelling results. In this study the cases aim to test and illustrate existing theoretical models in technology intelligence.

This paper investigates three Estonian SMEs in the information technology, manufacturing and life-sciences industries (Table 1). The primary condition for case selection was the size of the company (OECD classification). We contacted Estonian SMEs operating in different industries and three companies were willing to cooperate and provided all necessary information on the investigated topic. This willingness was also due to their interest in implementing formal practices of technology intelligence in the future.

Table 1 Cases and key informants.

Case	Main activity	Company size; (employees)	Key informant
Helmes Estonia	IT	Medium; (200)	Solution architect
Skeleton Technologies	Manufacturer of energy storage systems	Small; (100)	Vice president of product; head of cell development
Centre for Food and Fermentation Technologies	Life sciences	Small; (55)	CEO

Table 2 Interview objective and sub-questions.

Interview objective	*Research sub-questions*
To understand how SMEs handle the process of technology intelligence.	What are the reasons for conducting technology intelligence? How do they define information need? How is the process of technology intelligence coordinated? How do they search for information? Which sources do they use to get information? How do they filter collected information? How do they analyse collected information? Which methods do they use for analysing the information? Which tools (infrastructure) do they use to analyse the information? How do they manage (store, document) results of the analysed information? How do they disseminate and communicate the results of intelligence? How do they measure the outcome (quality) of the intelligence results?

3.1 Data collection and analysis

The data was collected from multiple sources. The primary source of information was semi-structured interviews with key informants from case companies (Table 1). The researchers prepared an interview guide to be used during in person meetings. The main objective of the interviews was to explore how SMEs handle the process of technology intelligence. Based on this information, we developed other research sub-questions or research issues that were included in our interview guide (Table 2).

We used a context-based questionnaire as complementary to our research protocol to collect the data. The questionnaire was developed by our researchers in the framework of the research project on technology intelligence and this process was performed in three stages. First was the development of the initial survey questionnaire after reviewing literature and existing scales, Next was the validation of the questionnaire with field experts and companies (pilot study). And finally, was the modification of the questionnaire based on collected feedback. This allowed us to achieve a variation in data collection and approach the research questions from different angles. The interviews lasted 90 minutes on average.

Secondary sources provided by the companies were used to triangulate collected information. This also enabled us to avoid post hoc rationalizations and ensure construct validity. In particular, notes from company visits and informal meetings, internal documents such as reports, brochures and presentations provided by the companies and other internet materials were used to complement the interviews.

We audio-recorded all interviews and the transcripts along with all other sources were used for data analysis. We followed the suggestions of Miles and Huberman (1994) and case analysis was conducted in three stages:

1) Data reduction and coding: first, the collected data was coded based on category systems (Richards, 2005) already existing in the literature (for example, Arman and Foden, 2010; Lichtenthaler, 2003, 2004a, 2004b, 2007; Mortara et al., 2009, 2010) and a short description of each case was prepared.
2) Within case analysis: then, we collected and analysed the data of each case separately in order to have a general understanding of the technology intelligence activities within the company.
3) Cross-case analysis: in order to detect major similarities and differences, we compared three cases. This helped us to identify commonalities and different perspectives on central issues (Patton, 1990).

To ensure the validity of the collected data we sent the early version of the paper to companies and collected their reviews and feedbacks.

4. RESEARCH FINDINGS

The findings start with the description of the individual cases. Then, it gives the summary of the main findings using a cross-case analysis approach.

4.1 Case 1: Helmes Estonia

Helmes is an international, Tallinn-based company that provides custom and ready-made software solutions and complex system integration projects for its clients across all around Europe. It is a B2B oriented company that looks for long-term solutions to enable clients to grow and aims to grow with its clients. During the 26 years of its existence, Helmes has worked with major industries including telecom, banking, insurance, logistics, public sector, healthcare and manufacturing. For example, the company provided tailor-made software solutions to actors such as OECD, E-Estonia, Telia, King's College London, and Audatex.

Helmes doesn't yet have a systematic technology intelligence process. Instead, it is possible to find some implicit elements of technology intelligence in the company. The intelligence process is directly incorporated in the Helmes business strategy. Technology intelligence activities are mainly conducted by the general development unit. Product development is carried out in permanent team structures whose members change according to the phases of the project. A typical team consists of team leaders, analysts, solution architects and developers (programmers) mentored by business area leaders. Each team is independent and not centrally regulated. Helmes analysts have a key role in intelligence activities. Their tasks are vision articulation and definition of goals, needs and success metrics, designing, planning and leading the research and efficient analysis process, mapping and visualizing business and technological processes, and documenting and keeping the analysis information up-to-date. When a business area leader brings in a new lead, the company assigns a "top gun" analyst to collect preliminary information about the potential client's organization in order to provide an initial solution. This "quickstart" process aims to map the current business and technological environment of the client, identifies the technology structure, manual interfaces, business deficiencies and if these deficiencies are fixable with information systems. After spending three intense days in the client's company, the top-gun analyst produces a report which will be used to find a solution to the client's need.

4.1.1 "Helmes Lab"

Some years ago, the company launched an initiative called the "Helmes Lab". By asking "what emerging technologies can be beneficial for Helmes?" and "what emerging technologies can be integrated to ongoing and future projects of the company?", the general development unit identified some areas that need to be tracked closely. The initial purpose was to first determine general topics and then analyse them stepwise in focus groups. As a result, the general development unit spotted the following topics for in-depth investigation: big data, artificial intelligence, neural networks, internet of things (IoT), block chain technologies, smart contracts, and microservices. The importance of these emerging technologies was realized by all levels of the company; however, employees didn't have time to familiarize themselves with these developments. Business area leaders who were aware of the competencies and capabilities of their teams and when the next customer was due formed a focus group from the members of the team by selecting a specific type of technology. Although, Helmes Lab was an interest-based process, the initiative came from above (general development unit, business area leaders) to the employees (team members). The choice of technologies selected by focus groups in most cases derived from the needs of clients and interests of the business area leaders and team members in order to have a thorough understanding in a specific field. Focus groups in turn went through several stages to test this technology in the lab to find potential uses. First, they collected information from different sources, analysed the collected information and filtered it. For example, in the case of IoT technologies, several questions were developed to collect the information. For example, "who are the vendors of IoT analytics?"; "Which one to select?"; and "Is it feasible for our project?" The main source of information was the internet and official documents of the other companies. For blockchain technologies, focus groups could address, for instance, udemy courses or e-platforms for getting preliminary guidelines. The work on the projects lasted from one to two months. When the collected information was analysed and proof-tested by the focus groups, they stored the process in the company wikipage. Then the results of the analysis were presented to the whole Helmes team. The overall process, including the final report, presentation and discussion notes were stored in the company repository "confluence". If any team wished to apply the result of this intelligence to their projects, they could come

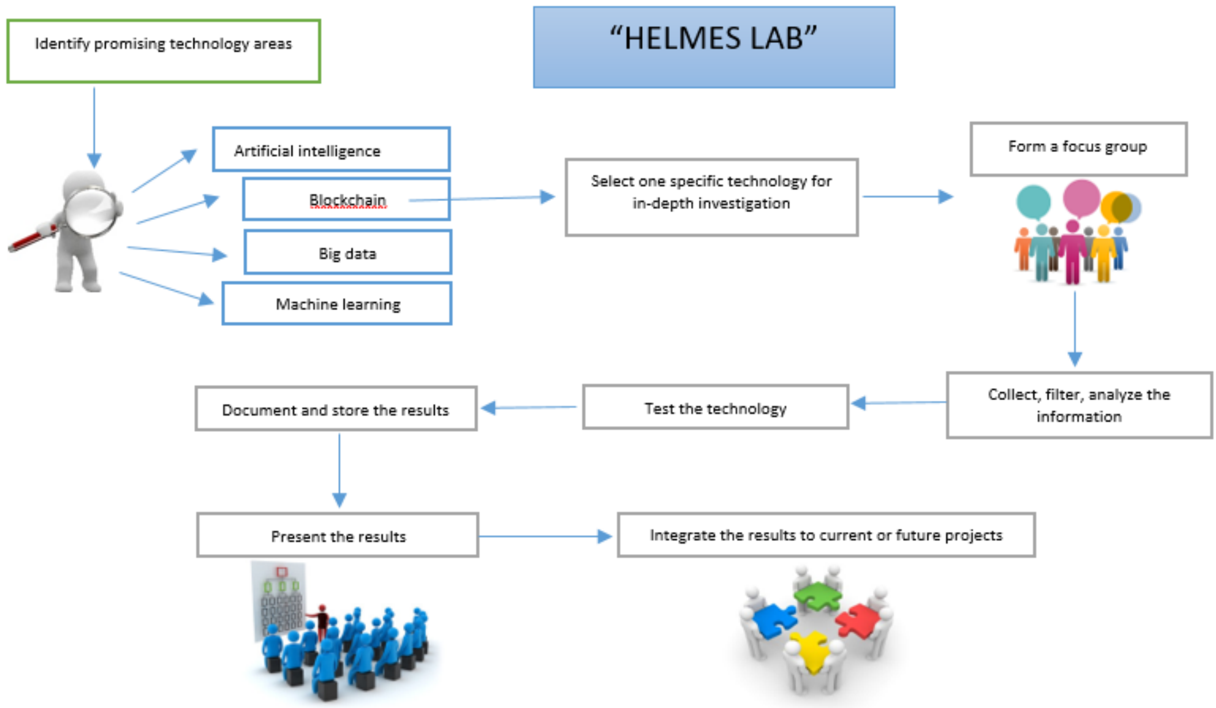

Figure 1 "Helmes Lab" initiative.

back to this repository and retrieve the information. The manager argues that, "identifying and implementing new technologies in our company is rather simple. However, it is achieved through continuous analysis, tests and discussions. One of the main criteria of their selection is, they have to be in the market for a while, proved their usefulness."

Helmes Lab is a dynamic process in a way that the members evolve constantly and several focus groups may exist simultaneously (Figure 1).

4.1.2 "Hack Day"

As with "Helmes Lab", "Hack Day" is another Helmes initiative, which takes place twice a year. Usually it is a two-day event organized with an aim to understand emerging technologies in the environment of the company. Again, the main objective is to detect interesting technologies and bring them into company projects. On the first day, Helmes invites an expert or group of experts from universities, research centers, government agencies or companies to discuss selected topics. On the second day, teams can choose a technology of interest, test this technology out during the day and conclude if this technology could be useful for them. Unlike Helmes Lab, here the approach is bottom-up and the employees decide which technologies to study. The general development unit may assign mentors to teams. Employees with preliminary knowledge about the technology are suggested to search for information. It helps to filter the data and select relevant and appropriate technology.

4.1.3 "Technation Talks"

"Technation Talks" is another format for discussions where every member of the company shares their experience, results of the projects, challenges, success stories, and suggestions in front of the management team. It is an interactive way of experience sharing to improve effectiveness of the ongoing projects. The event takes place twice a month and topics presented during the "Technation Talks" are stored in a confluence database. Storing or archiving the information has a great value for the company. The manager says that: "some ideas that five years ago were not relevant may become important today. Therefore, we try to document each process in our repository even if it is time-consuming".

For Helmes, internet, internal and external databases, conferences, fairs, seminars, exhibitions, online communities and web forums, consultants, job rotation, acquaintances and friends are major sources of information. The company closely collaborates with universities, associations and government agencies. The company doesn't have a selected set of methods that are adopted in every case. Alternatively, Helmes selects the methods according to the information that is being analysed and skills the employees have to use this method. Qualitative methods that support internal and external communication are preferred. The company uses benchmarking studies, market analysis, flexible expert interviews, expert panels, roadmaps, simulations, interviews, focus-groups (panels, workshops) and cost-benefit analysis to a larger extent.

For Helmes, one working solution or created tool in use which increases efficiency or creates a new client lead is a success of technology intelligence efforts.

4.2 Case 2. Skeleton Technologies

Skeleton Technologies was established in 2009 with an aspiration to bring innovative solutions into the energy storage industry. Over ten years, the company transformed itself as a major player in the industry with its "curved graphene" SkelCap ultracapacitors. Ultracapacitors are used for fast energy storage. Today the company develops and produces ultracapacitor cells, modules and systems for the automotive industry, transportation, grid and renewables, industrial manufacturing, material handling and maritime industries. The inventions of Skeleton Technologies are currently protected with 14 patent families. The company has three subsidiaries in Germany (manufacturing and sales) and Estonia (R&D and pilot production) with 100 employees in total. Surveying current and emerging energy storage technologies, competitors and markets is a special focus of the company. The company doesn't have any institutional arrangement for technology intelligence. Intelligence activities are performed in all levels of the company in unsystematic and informal ways. R&D in Skeleton Technologies is divided into four areas: material, module, cell and system development. Different development departments are constantly on the lookout for new technologies, ideas, opportunities and competitors. As the vice-president of products for the company stated: "That is not luxury or what you can do, that is what you must do in order to ensure that your developments are in vein".

The company has defined areas of interest to monitor. Technology intelligence activities are directed to identify the latest developments in energy storage technology, grid-based energy storage and their industrial applications. Different teams try to keep track of the broad market, new customers, potential applications of the ultracapacitors and competitors active in the same industry. These activities are carried out with questions in mind such as: What are the new technologies that might affect our business? In which direction should we develop our technologies? What are our competitors are doing? What are the plausible industries that might need our technologies? The information need for data collection and analysis in a specific technology or competitor comes from the internal process development and market itself, enriched with an input from different departments. For example, sales or business development departments with information about certain applications of technology can come to the cell development department and request further intelligence, because people in cell development have a bulk competence when it comes to deep understanding of the question. Team members also share their interests and information deficiencies during the daily stand-up meetings. So, the need for information can flow across levels of the company regardless if the approach is top-down or bottom-up. In company technology intelligence is a continuous process where each employee tries to keep up with daily news in business or industry, scientific research and technology development news, publicly available information regarding technology applications, competitors and business opportunities. Intelligence in Skeleton Technologies is based on the "old school of networking". Members of the company use internet, publicly available statistics and statistical data, patents, scientific publications, field and non-field publications, company press-releases, trip reports, meeting notes, conferences and seminars, "mouth to mouth propaganda", and customers and suppliers as sources of information to a considerable extent. The vice-president believes that,"We also look for companies that have similar organizational setup as we have here in Skeleton Technologies. For instance, we are collaborating with a company in Germany and its R&D department which has thorough insights about what the customer requirements about next generation energy storage technologies are".

In order to check if the information is stored by someone already or available in-house, employees can directly address team leaders. In Skeleton Technologies it is a straightforward process, a benefit of the small size of the company. Collected information is analysed through different intelligence methods. Within the company, methods in which employees have expertise and profound knowledge are preferred. Frequently applied methods include patent analysis, roadmaps, interviews, expert panels, benchmarking, market analysis, and SWOT. If the managers see the necessity for a large-scale analysis, they will outsource such services. The results of intelligence activities can be presented at weekly, quarterly or annual meetings, such as "demo days", "OKR (objectives-key results)" and "12-month outlook" (Figure 2). For example, "demo days" is organized once every two weeks. It is where team members present their findings from analyses they have done. These events are used to keep the company in line with its mission and strategies. However, if there are urgent cases, it is not an issue to organize ad-hoc meetings. Intelligence results, reports and meeting notes are stored in an internal company database. The effectiveness of intelligence results is measured with a project level metric. If the project was successful, then it is the success of technology intelligence results as well. Skeleton Technologies is looking forward to establishing a dedicated unit and budget for technology intelligence in the near future. The head of the cell department agrees that: "For an emerging company like us it is critical to have a devoted person or unit for such activities. We believe that, at this moment we are doing not bad, however we have to reconsider our capabilities how to do it in the future. Because a company of 100 employees cannot do it in the same way as a company of 300 employees".

4.3 Case 3. Centre of Food and Fermentation Technologies

Centre of Food and Fermentation Technologies (CFFT) is an Estonian R&D company based on modern analytical methods and principles of systems and synthetic biology that aims to develop and introduce innovative food and fermentation technologies. It was founded in 2004 and currently owns a state-of-the-art laboratory, 55 highly qualified personnel and necessary know-how. The centre provides contract services in solving specific problems regarding product development from idea to full solution, market analysis, chemical, physical and microbiological analysis, sensory evaluation, and consumer studies. The scope of expertise of the centre includes fermentation, analytics, food technology and sensorics. Some of the best-known customers are DuPont, Lallemand, Santa Maria, and Valio. The management of the CFFT realizes that the future of technological innovations in life sciences will be highly influenced by the aptitude of the company to analyse and take advantage of business and technological

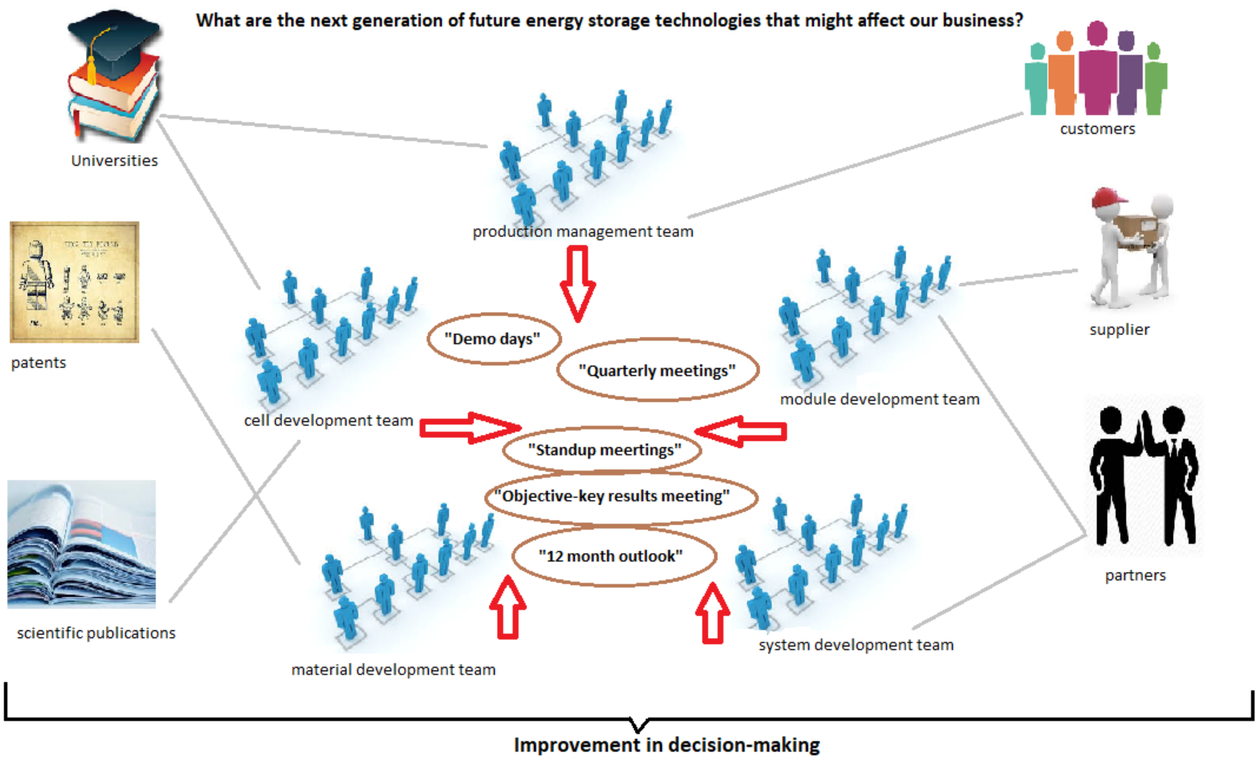

Figure 2 Technology intelligence system of Skeleton Technologies.

insights, as well as its ability to collaborate with different players who bring knowledge, expertise and new opportunities. Open innovation in the life sciences is more significant than other industries simply because this field is knowledge and resource intensive. Fermentation as a world class competence requires constant research, sharing of ideas and experiences, and continuous learning. Although, technology intelligence at CFFT is not done via a formal or systematic process, the centre tries to keep an eye on emerging technologies that will give a competitive edge. CFFT particularly focuses on systems and synthetic biology and tries to understand and use methods called -omics methods, e.g. proteomics, genomics, metabolomics, in a complex. In order to be ahead of the curve, the centre conducts research in microbiome and cell modelling, watches novelties in these areas, and tracks competitors and other companies to establish future partnerships. For CFFT, something that seems promising is artificial intelligence (AI). The centre is trying to apply AI methods and systems, like IBM Watson in its research projects to generate meaningful results. According to the CEO, "For us, the best solution would be if we could integrate some of the big data analytics that would teach the system to collect information, analyse it, make its own conclusions and help us to move forward".

Technology intelligence in CFFT is a collective and participatory process. The whole team of competent people includes department managers, team leaders and scientists that are engaged in intelligence activities. The centre doesn't have any unit or designated person for this task and the CEO of the centre considers it to be the correct temporary approach for small companies like CFFT. The role of the R&D director in this process should be credited as he has been with the centre since the beginning and involved in all directions. The approach for technology intelligence in CFFT is both continuous and project-based. All managers in the company are PhDs in their areas and in order to respond to specific needs of clients they always educate themselves, look for new opportunities, participate in conferences and organize meetings so that people can share experiences. The need for continuous learning is primarily dictated by the organizational structure that the centre possesses. Within the research directions—whether it is food technology (bakery products, plant-based products, beverages), bio-technology (yeasts, lactic acid bacteria, E. coli bacteria) or the sensory department—there is an ongoing intelligence process in order to be up to date with the latest news in these realms. And when there is a specific request from a client in one of these areas the management of the company assigns the people to be involved in the project. If the request of the client is a streamline issue and something that the centre has done before, then appointed department discusses the project and budget with the client, collects the necessary information, conducts market research and delivers the findings to the client and the management. But when the project is more complex and concerted effort is needed, the CEO along with heads of all departments and the client discuss the project and all possible opportunities, map out a plan, and negotiate the budget. Then again one or several departments are defined to work on the project. The key informant of CFFT reports are publications and internet, which are the most convenient sources of information when there is a necessity of further investigations on the client's need. The centre is a member of different networks and during the communications clients also provide valuable knowledge. The people from different departments are sent to conferences, fairs, seminars or exhibitions from time to time. However, one of the major concerns related with this type of events is that they are budget dependent. To rectify this limitation, the company tries to take advantage of networks, such as through R&D cooperation with universities, joint ventures, alliances with firms and participation in public R&D programs. The CEO of the company asserts that "We are always open for collaboration and not afraid of sharing our competences and knowledge with our partners. It is not a matter of your ideas or know how being stolen. It is a matter of if these ideas are good and how they serve common interests".

The person who collects the information in the company also checks the quality and relevance of it. All collected information is stored in the internal database and employees use e-mails or platforms like Slack to discuss their search results or findings. More qualitative methods are used in the company to interpret the collected information. Employees prefer practical approaches that imply interaction and co-working. Some widely used methods in CFFT are publication analysis, benchmarking, market analysis, competitor analysis, portfolios and roadmaps. These methods are applied according to "as little as you can and as much as you have to know about the method" principle. The outcomes of the analyses are presented and discussed in weekly project managers' meetings and weekly science seminars. The results are also shared with clients upon their interest and request.

4.4 Summary of findings: cross-case analysis

The cases of three companies were analysed in order to understand the situation of SMEs in terms of practicing technology intelligence activities. This, in turn, provided us some interesting findings that are summarized in a cross-case analysis. First, concerning the objectives of conducting technology intelligence, companies exhibited similar goals and purposes for performing this activity. Helmes and CFFT were more interested in identifying emerging technologies and incorporating them into their projects. Skeleton Technologies aims to monitor current and new energy storage technologies, track the activities of specific organizations working in the field and determine alternative technology applications. An emphasis also can be given to the scope of the search done by companies. In all three cases companies had a defined area of interest and technologies dictated by the business they are involved in. What emerges about the definition of information needs is that the companies practiced both top-down and bottom-up approaches where the need for new information came from both decision-makers and employees, making the process participatory. Particularly, organizing intelligence activities in different initiatives like the "Helmes Lab", "Hack Day", Technation Talks", "Demo Days", "Stand-up meetings", "OKR" or "12-month outlook" enabled the companies to involve all layers of the organization and benefit from diverse ideas. In terms of the coordination of the technology intelligence process, none of the companies had institutional arrangements for technology intelligence. Instead, this task was diffused throughout the company and everyone contributed for the fulfilment. Consequently, R&D departments (in Helmes' analysts and General Development Unit; in Skeleton Technologies four development departments, in particular the Cell Development Department; in CFFT the R&D director and CEO) had a special role in this process. The companies did not allocate a budget for the technology intelligence process. One interesting finding that emerged from our empirical study is that all of the companies followed continuous and project-based (issue-driven) approaches of technology intelligence (Rohrbeck and Gemunden, 2008). For instance, in the case of Helmes, a top gun analyst in a quick-start process performed project-based intelligence by collecting, analysing and disseminating information on an ad-hoc basis about one specific client before the launch of the project. In Skeleton Technologies, technology intelligence had a continuous flow. In CFFT technology intelligence was operationalized in decentralized groups (departments) and organized for each client (project) separately. Nevertheless, CFFT implemented continuous surveillance in microbiome and cell modelling research directions. Regarding sources for information, the internet was the most common source followed by internal and external databases, customers, suppliers, job rotations, conferences, fairs and seminars. However, putting both companies in the same box in terms of information sources may be misleading. The selection of information sources, aside from size and resource characteristics, is influenced by traits of the industry in which companies are active (science-driven vs market-driven companies – Savioz, 2006). For example, CFFT as a science-driven company deployed publications, internet, R&D cooperation with universities, joint ventures and alliances with firms to a greater extent, while Helmes and Skeleton Technologies used patents, statistics and statistical data, conferences, fairs, seminars and any type of informal meetings as major sources of information. When it comes to intelligence methods used, companies applied both quantitative and qualitative methods and tools that don't require profound expertise and that support internal and external communication (Rohrbeck et al., 2009). According to Popper's Foresight Diamond (Popper, 2008), companies used methods which facilitate evidence, expertise and interaction (market analysis, benchmarking, brainstorming, patent analysis, roadmaps, workshops, interviews, expert panels and others). One unanticipated finding was that the companies had a flexible structure for communication and information sharing. None of the interviews mentioned communication barriers or incompetence in the companies. As was stated in Savioz (2006) and Vossen (1998), advantages of smallness are the "direct-decision making process, clear coordination and communication". In all cases success of the project is associated with effectiveness of the technology intelligence results. The most important finding that emerged from this study is that all companies highlighted their interests in adapting systematic and formalized approaches for technology intelligence in the future.

5. DISCUSSION AND CONCLUSIONS

Given the importance of exploitation of technological opportunities and ideas, potential partners and customers, and competences in the open innovation paradigm, SMEs are becoming more involved in such practices in order to secure a competitive advantage (Van de Vrande et al., 2009; Edwards et al., 2005; Lee et al. 2010). Technology intelligence is regarded as a robust tool to support open innovation to identify promising technology niches, opportunities and threats (Iansiti, 2000; Durand, 2014). Although the real need for technology intelligence is quite well-realized by SMEs, it has often been neglected due to their constraints in money, time, skills and competences (Savioz, 2004; 2006; Battistella et al., 2015). On top of this, so far, the literature documented few cases of operationalization of technology intelligence practices by small firms in catching-up economies. To remedy this knowledge gap, the present study was designed to determine the process and elements of technology intelligence in SMEs. In order to explore how SMEs handle the process of technology intelligence, we investigated three Estonian firms in different industries in-depth. The results of our empirical case study show that the capacity of technology intelligence as a powerful tool is not fully exploited by SMEs yet. The past research pointed out spontaneous and unstructured organization of technology intelligence by small firms. Our analysis revealed certain processes of technology intelligence that don't follow the models presented in the literature. Despite this fact, the results of this study confirm the findings of previous contributions on the topic: similar elements of technology intelligence that had been found in large firms were also present in the case of small companies (Savioz, 2004; 2006). However, considering the fact that, "small business is not a little big business" (Welsh and White, 1980), these elements (technology intelligence aims and goals, structure, people, methods and tools, process) should be adapted to the specific context of SMEs. In our cases, SMEs orchestrated these elements of technology intelligence with their organizational and cultural characteristics.

The emergence of large volumes of data and the necessity of transforming it into useful information for decision-making posed some challenges for SMEs. Technology intelligence as a strategic tool has become equally important both for large and small companies. The results of this study corroborate the findings of a great deal of the previous work stating that technology intelligence is not a process specific only to large or multinational companies. Our case studies provided a general understanding how decision-makers of SMEs can benefit from technology intelligence if it is organized in a proper way. We do not argue that companies should implement unique technology intelligence. Probably, such a setting does not exist. As mentioned above, SMEs should tailor different elements of technology intelligence to their needs. In particular, early contributions provided intelligence related tools to meet this objective (for example, Mortara et al., 2009 – technology intelligence toolbox; Rohrbeck et al., 2006 – technology radar; Savioz and Blum, 2002 – opportunity landscape; Battistella et al., 2015 – extended map). SMEs have a favourable position in this situation as they have less bureaucratic decision-making, but more creative and dynamic organizational culture.

The findings of this study also suggest the importance of the alignment of the business strategy and technology intelligence objectives. In fact, Kerr and Phaal (2018) asserted the necessity of future studies that investigate a formal link between Technology intelligence and strategic planning. Our study demonstrated this relatedness even though the companies had an informal arrangement of technology intelligence.

The second objective of the paper was to understand how SMEs in catching-up economies deal with the processes of technology intelligence and open innovation, both understudied (Tiits et al. 2015; de Jong et al. 2010). Although our sample includes only three companies, we notice considerable differences between SMEs of catching-up economies and developed countries based on the results given in the literature. For instance, de Jager et al. (2002) distinguished four levels of technology capabilities of firms in their staircase model, namely 1) low-

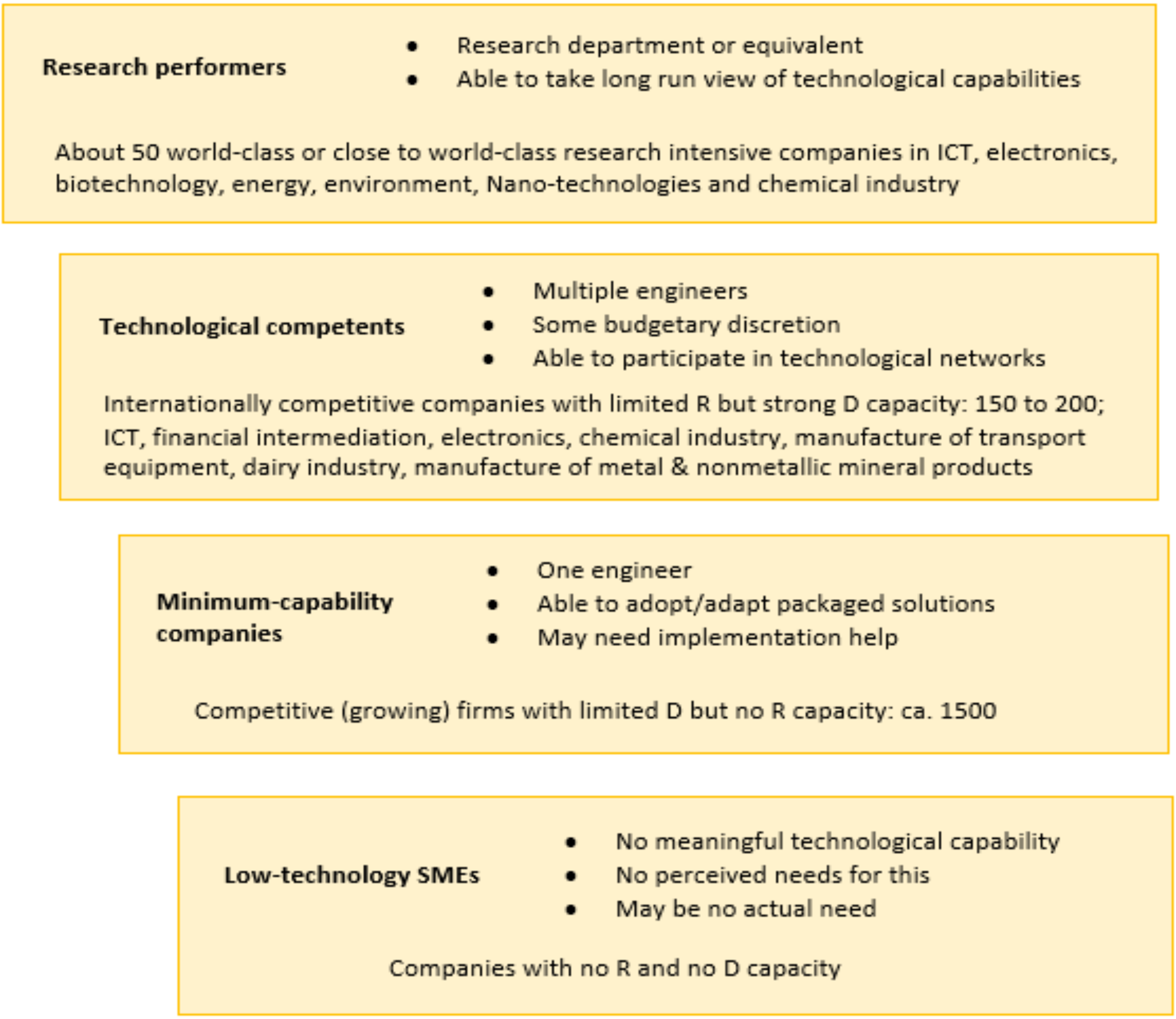

Figure 3 The competence staircase. Source: de Jager et al. (2002) and Kalvet (2009).

technology SMEs, 2) minimum-capability companies, 3) technological competents and 4) research performers. This is in line with Kalvet's (2009) three types of Estonian firms classified in terms of R&D competencies. Figure 3 summarizes these two approaches. We believe that this model synthesizes the position of our case companies also from a technology intelligence point of view. As Nosella et al. (2008) stated, the technology monitoring process in firms is influenced by several factors including the level of resources devoted to R&D activities. That is to say, the companies we investigated have medium R but strong D capacity with informal and uncoordinated technology intelligence approaches.

5.1 Research and managerial implications

This paper has research and managerial implications. It contributes to the current body of knowledge with general understanding about technology intelligence activities in small companies. Researchers can benefit from this article to explore elements of technology intelligence that are operationalized in the case of SMEs. The findings from these cases can provide an overview in terms of approaching SMEs to identify technology intelligence practices. From a methodological point of view, the paper brings to light questions that can be used to learn more about technology intelligence in such settings. From a practitioner point of view, this can be helpful to managers to identify best practices to learn and implement in their own companies. The activities described in the case studies can be taken as a template to implement technology intelligence practices.

5.2 Limitations and areas for future research

The major limitation of this paper is that it investigates a limited number of SMEs in a specific county. In order to have a thorough knowledge about technology intelligence in such settings more companies in different contexts should be investigated. Moreover, discussions in the latest literature highlight the rising interest in start-up companies. Further investigations with this type of companies seem promising.

Moreover, further research may focus on each element of technology intelligence independently to review how SMEs deal with them. We also propose to use other methods of qualitative research (i.e. action studies) or quantitative research to answer specific questions.

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