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Abstract

Many countries are investing in the development of robotic applications for health and elderly care services. Some care robots have already been commercialised, and new products are being prepared for future markets. However, generating profitable business from care robots is somewhat challenging and the business ecosystem is growing quite slowly. This paper focuses on emerging care robot business opportunities from the perspective of companies operating on the care technology field. Based on interviews of 10 companies and an online survey data of 13 companies, all from Finland, we highlight the potential and barriers in the care robot business, and suggest actions supporting the growing ecosystem. By using the service ecosystem framework, we describe the business enablers and challenges in a care robot context.

Keywords: care robotics, service ecosystem, health and care technologies, service business orientation

Introduction

Demand for health and welfare services is increasing as a consequence of the ageing population all over the world. Also our example country, Finland, is currently in the middle of a major reform in the management of health and social services, in order to meet the growing needs in an equal and cost-effective way (Ministry of Social Affairs and Health Finland, 2018). In parallel to the changes in the service system, the role of different technologies as part of health and care services is increasing. Robotics is considered as one potential technology in many countries, in Japan in particular (‘New Robot Strategy’, 2015), but also in Finland (‘The Finnish government’s resolution on intelligent robotics and automation’, 2016; ‘The Well-being and Health Sector’s Artificial Intelligence and Robotics Programme’, 2018).

A ‘robot’ is a physical object that can move and potentially manipulate the physical world and has at least some degree of autonomy.[1] Robots can be divided into two categories based on their purpose of use: industrial robots and service robots (IFR, 2012). Service robots are those used by service providers or individual consumers. Service robots to be used in healthcare may be called as care robots to separate them from other types of service robots (Okamura et al., 2010).

Care robots include various kind of devices in different forms, sizes, and purposes - from therapy animal robots to logistic and delivery robots, robotic walking support systems, exoskeletons and robotic prosthetes, to name a few - and the borders between robotics and other health and care technology are sometimes blurred (e.g. Niemelä & Melkas, 2019). Care robots can be considered as one sub-category within the general class of assistive technology or gerontechnology (e.g. Taipale, 2014). In this paper, “care robots” refer especially to such robotic solutions that are targeted to support independent living or wellbeing of older adults, or to facilitate the work of professional caregivers in the field of elderly care.

Attempts to introduce care robots into the care service system have not been very fruitful so far. The general attitude towards care robots has tended to be more negative compared to other uses of robots (e.g. Eurobarometer, 2012; 2015). According to the most recent European-wide survey (Eurobarometer, 2017), less than half (45%) of the EU citizens felt at least moderately comfortable about having a robot to provide services and companionship when infirm or elderly. However, positive view about robots tends to correlate with personal experience of them (e.g. Eurobarometer, 2017; Hennala et al., 2017; Niemelä, 2016). The general negative attitude may just inform us that there are not useful, usable or fitting robotic products available yet.

[1] ISO 8373: https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en. Sometimes purely non-physical computer-based assistants – such as so-called virtual agents or artificial intelligence software solutions that perform routine assistive tasks on computers – are termed robots as well. Non-physical robots are beyond the scope of this paper.

Indeed, care robotics appear to be in an early phase on the supply side. Bedaf et al. (2015) identified 107 different care robots able to support independent living of the older people, but only six of them were commercial products. The rest were mainly for research or demonstration purposes. Two analyses of the Japanese care robot market (Kohlbacher & Rabe, 2015; Levsen, 2015) pointed out the explorative activity of technology companies in the field, indicating growing market opportunities. However, many care robots were still rather technology demonstrators than mature commercial products (or service solutions), prices were high, and there was no clarity of the target customer. Also Watanabe and colleagues (2017) have identified the immaturity of technology as a barrier to the adoption of robots in elderly care both in Finland and Japan.

The purchasing process of technological solutions also affects the possibility to acquire public customers for robot solutions. In Finland, the social welfare and health services are the responsibility of the public sector, mainly municipalities. This brings challenges in purchasing: municipal procurers may lack expertise either in care or in technologies, the procurement criteria is limited, and decision-making is fragmented (Jännes et al., 2014). A reform is, however, being planned, and the role of the public sector and thus municipalities concerning technology purchases may change in the future. In Europe, the approaches to public procurement of innovative solutions are Pre-commercial Procurement (PCP), Public Procurement of Innovative Solutions (PPI), and Innovation Partnerships (IP). PCP, defined in the EC Communication COM/2007/799, is a useful approach when near-to-the-market solutions do not exist and technologically demanding innovations and new R&D are acquired. The PPI approach is appropriate, when solutions are already or nearly on the market (not yet available on a large scale) and do not require any new R&D. IP, again, refers to a long-term partnership for the development and subsequent purchase of new innovative solutions and R&D. This approach enables solutions developed and tailored to specific needs of the public

acquirer. In practice, a more multi-disciplinary approach, strategic design and efficient use of public procurement are still needed. (Iossa et al., 2018.)

The market and business area of care robots is continually growing: a recent analysis by Lehr of BCC Research (2016) estimated that the total elderly care market in the US, including products, services, housing and assistive technology, would increase to 513 billion USD in 2020. Frost & Sullivan (2016) estimated 36% average annual growth in the "Global care assistance and automation robots market" and the market of robots for assistance of older and disabled people is expected to increase substantially within the next 20 years (IFR, 2016). These forecasts do not automatically materialize. It is important to know how to support different actors in order to take part in the care robot ecosystem. Even companies already providing technology products for health and care may find it difficult to take new emerging technologies as part of their business. Especially small technology companies may have challenges such as lack of knowledge and entrepreneurial skills, limited sharing of knowledge and lack of cooperation, similarly to small heating and security home system installer companies that consider taking part in the smart home and smart living business (Keijzer-Broers & de Reuver, 2018).

In this paper, we have a business focus. More precisely, we focus on how companies operating in the field of health and care technology perceive the potential of care robotics, and what kind of drivers and barriers they see in related business and ecosystem growth. We study these issues by using qualitative interview data from 10 company managers and supplementary quantitive data from an online survey (13 companies). We use a framework of the service ecosystem perspective for illustrating enablers related to technologies, markets and business models in a care robotics context. This study is a part of a project "Robots and the

Future of Welfare Services" (ROSE)[2] that investigates the potential of care robots in the Finnish context.

Service ecosystem perspective

The on-going service revolution involves a reorientation towards service in individual companies, economies, and research (Wieland et al., 2017). On the company level, this means that during recent years, technology companies have shifted their focus from product and technology orientation towards a more customer- and service-orientated focus (Baines et al., 2009; Hakanen & Murtonen, 2015). Wieland et al. (2017) also introduced the perspective that service is the basis of all exchange, and can also be provided directly as well as through the product (goods). Thus, when the service business orientation is adopted, the importance of products and technology will not necessarily diminish, but the customer knowledge and interaction should be deepened. It is essential to understand that customers and also other stakeholders have a fundamental role in service-for-service exchange, value creation and evaluation of value (Prahalad & Ramaswamy, 2004; Vargo & Lush, 2004). According to Prahalad and Ramaswamy (2004), co-creation comprises the joint creation of value by the company and the customer, when the customer is able to co-construct a personal service experience. In order to involve customers in value co-creation, service providers need to learn to thoroughly understand their customers' context, operations and needs (Grönroos, 1990; Johnston & Clark, 2008; Vargo & Lusch, 2004). Focusing on customer development and relationships, and the fit of a company's value proposition with customer needs, is highly important for the success of a business (Osterwalder et al., 2005). Early and ongoing user involvement have been recognised as being particularly important in health information technology (Cresswell & Sheikh, 2013; Martikainen et al., 2014; on the need for in-depth

[2] http://roseproject.aalto.fi/en/

understanding of user needs, see also the Concluding discussion).

Ecosystems are networks gathering complementary resources to co-create value (Moore, 1996). At the same time, they involve cooperation, competition and interdependence (Adner & Kapoor, 2010). Valkokari (2015) distinguished three different types of interconnected economic ecosystems: business ecosystems (also including industrial and service ecosystems), innovation ecosystems and knowledge ecosystems (including research institutes and innovators). Whereas business ecosystems focus more on present customer value creation, knowledge ecosystems focus on the generation of new knowledge. Innovation ecosystems can be considered as integrators that combine exploration of new knowledge and the exploitation of this knowledge for value co-creation in business ecosystems (Valkokari, 2015). Of these, this article adopts the service ecosystem perspective, highlighting present customer value creation.

In the ecosystem context, value creation is not limited only to the company and customer relationship, but more actors are involved in joint creation of value. Considering the value for the entire ecosystem, many actors are involved and the value itself is multidimensional (social, cultural and economic) (Ben Letaifa, 2014). In addition to companies, the ecosystem involves actors such as individuals, universities, associations, unions, governments, competitors, investors and other entities not usually belonging to traditional supply chains (Ben Letaifa, 2014). The success of a company's business model is ultimately dependent on broad sets of actors and market practices (Wieland et al., 2017). An ecosystem perspective (Fig. 1) provides a comprehensive social and institutional framework to describe business and non-business relationships (Wieland et al., 2012; Ben Letaifa, 2014), and is thus important for understanding the performative nature of markets, technologies and business models (Wieland et al., 2017).

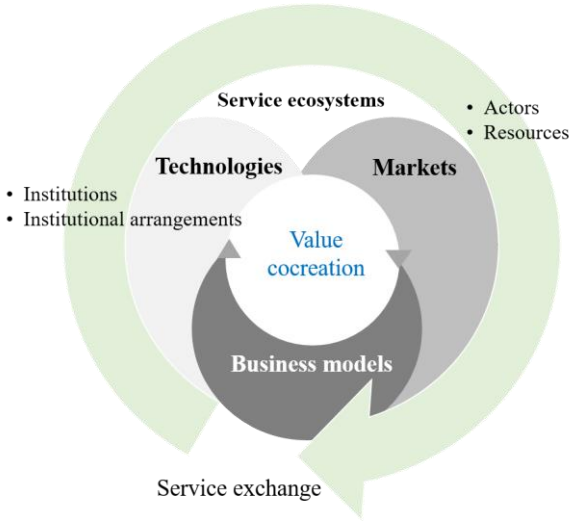

Fig. 1. Service ecosystem perspective adapted from Wieland et al. (2017) and Vargo & Lush (2016).

As Wieland et al. (2012) summarized, "a service ecosystem is composed of heterogeneous entities, interacting with each other to achieve shared goals". Interactions and perceptions of what problem the actors need to solve can be expressed through a collaborative framework. The framework also highlights dynamic processes, including the collaboration and competition shaping institutional organization (Wieland et al., 2017). The new market will not only arise because of the introduction of new technology, but also through the institutionalization of solutions (Vargo et al, 2015). Markets are also continually formed through the activities and interaction of various social and economic actors (Kjellberg & Helgesson, 2007). In service ecosystems, technology both influences and is influenced by several actors (Akaka & Vargo, 2013). In the business model, the company outlines business activities and describes how the value is actually delivered to the customer and converted into an economic value for the company (Chesbrough & Rosenbloom, 2002; Magretta, 2002; Baden-Fuller & Morgan, 2010). The business model also communicates strategic choices (Richardson, 2008), and a company strategy must address how the company will handle competition (Magretta, 2002; George & Bock, 2011). The ability to make innovative and dynamic changes to business models has also been demonstrated to be important

(Chesbrough, 2010; Achtenhagen et al., 2013). More broadly, on a service ecosystem level, a business model illustrates an understanding of how all the actors can best serve themselves through service to other stakeholders (Wieland et al., 2017).

Instead of focusing on the best practices of a company, the service ecosystem shifts attention to how institutions are reformed. Institutional processes, such as the maintenance, disruption and change of rules, norms, meanings and symbols, are considered to be fundamental to technologies, markets and business models, and to enabling and constraining resource integration and value co-creation processes. As Wieland et al. (2017) expressed, "multiple actors cocreate institutions iteratively, by competing and collaborating, until shared meanings and uses of technologies, business models and market practices form". (Wieland et al., 2017) The service ecosystem perspective and framework presented in Figure 1 will guide the following empirical part and be modified and complemented on the basis of the results.

Methods

Data collection

For this study, we interviewed managers of 10 companies in the health and care technology business in Finland. This qualitative interview data is supplemented by quantitative data from an online survey concerning perspectives of different stakeholders to care robots in Finland. This data includes results from 13 companies in the field of robotics or care.

Company interviews

The interviewees were selected on the basis of the fact that they worked closely with the issues of this study that were central to the research, and they occupied a leading position in the company. The companies included one importer of care robot products, one innovation hub company for startups, and eight companies providing technology solutions for safety, welbeing, independent life, care resource optimizing or telehealth (Table 1).

Table 1. Overview of the companies interviewed.

Case	Products and services	Company size	Customers	Informant
A	Import and maintenance of robot products (e.g. Paro the therapy robot seal)	SME	Consumers, care service providers	CEO
B	Medicine dispensing robot & service	SME	Homecare service providers (public), consumers, hospitals	CEO
C	Platforms, user interfaces for multiple services	Large	Residential service providers (private), public sector, hospitals	Business director
D	Innovation village for health tech startups	Owned by a large health technology company Hosted by SME	Target customers of startups: Public and private service providers	Village Chief
E	Monitoring and alert systems, nurse call system, localization (different service packages)	SME	Public and private care and residential service providers, consumers	CEO
F	Technological assistive tools to provide safety, alerts, camera solutions, IP-Based tools, GPS-Watch, nurse call systems	SME	Public and private care and residential service providers, consumers	CEO
G	Security systems, alert and call centre services, nurse call and personal safety systems	Large	Public and private care and residential service providers, hospitals	Business unit manager
H	Software, applications (e.g. for capacity management and resource optimizing)	SME (sold to private health care company)	Municipalities, large governmental areas for social and health services	Development manager
I	Smart solutions for the home care chain (e.g. smart phone, performance and well-being monitoring, alerts)	SME	Public and private homecare and residential service providers, hospitals and health service centres, consumers	CEO
J	Customized solutions for telehealth and telecare as a full service	SME	Public and private social and health care service producers	Business development manager

Altogether 10 informants attended the interviews and provided their perceptions concerning service business development, care robots and influential factors affecting markets, technologies and business models related to care robots. The semi-structured interviews included the following topics of discussion:

- the strategy of the company

- the core technologies utilised or sold by the company with regard to elderly care services
- overview on the current business field and expectations of future developments
- the possibilities and role of care robotics in elderly care and residential services and in supporting independent living of the older people
- the capability of the company to benefit from care robotics in the current business environment
- how the company could be supported by public institutions to advance integrating care robotics into the business

The face-to-face interviews lasted about 1.5-3 hours and they were conducted during February-March, 2017. The interviews were not recorded, due to the fact that some of the discussions were organized in public places. Instead, careful notes were documented. As a result, 25 single-spaced note pages were produced. In addition, during the interview the informants filled in a short Likert-type scale questionnaire about the importance of different application fields for care robotics. The five-level Likert items were: 1=Not at all important, 2=Not very important, 3=Neutral, 4=Quite important, 5=Very important. The other part of the interview was more like a guided conversation than a structured query, which enabled the informants to bring new views and the investigators to exploit naturally occurring data (Silverman, 2006).

Survey

An online survey about perceptions to care robots in Finland was conducted in February-March 2017. The survey addressees were collected from stakeholder groups that were

identified to be essentially involved in the development and societal take-up of care robots in welfare services. These stakeholder groups included members of Parliament, ministries, municipalities and hospital districts, enterprises in the field of robotics or care services, non-governmental organizations and research institutes in Finland. An electronic invitation including a link to the online questionnaire was sent to some one thousand email addresses. Altogether 250 respondents replied to the survey, thus the response rate was approximately 25%.

The survey consisted of over 50 questions including the following elements: background information, general questions about robotics, questions on robotics issues in welfare services, and questions related to care robots in particular. For this article, we concentrate on four questions concerning (1) the factors that limit or promote the introduction of robots (two questions) and (2) funding of the robots (two questions). The dataset includes those respondents who marked "entrepreneur" (in the field of robotics or care services) as their present profession. This subset consists of 13 respondents (6 female, 7 male).

Data analysis

The interview data was analysed by content analysis (Kohlbacher, 2006; Mayring, 2000). Adapting the technique described by Krippendorff (1980), the text was first divided into content areas according to specific topics in the interview; then the interviews were read through several times in order to obtain a sense of the whole text, and the text was divided into meaning units and labelled with codes. In this case thematic coding was used to identify patterns (i.e. themes) in the data (Braun & Clarke, 2006). Thematic coding facilitates the comparison of people's perceptions and experiences (Flick, 2009). After that the codes were compared and sorted, and finally categorized data were utilized in formulating a framework. The analysis started with the analysis of an individual interview script, and proceeded in searching for mentions and descriptions of expected benefits, challenges and suggestions

concerning care robots as a service.

The framework presenting the service ecosystem perspective (Wieland et al., 2007; Vargo & Lush, 2016) (Fig. 1) guided the data analysis and served as a 'lens' through which the service ecosystem perspective was applied in the field of care robotics. The tentative framework enabled filtering the essential data for the purpose of the study, and management and utilization of the data in a condensed form (Kohlbacher, 2006; Mayring, 2000). The themes that emerged from empirical data and reflected perceived market drivers and challenges were collected into Table 2 from each case company interviewed. In order to draw conclusions on service ecosystem in the context of care robots, these findings of the interview analysis, as well as those of the online survey, were compared with the service ecosystem perspective (Fig. 3).

Findings from the interviews

General themes that arose from the empirical data were used for structuring the analysis of interview notes. Table 2 presents briefly the informants' perceptions relating to end-users; potential of care robots; co-creation and collaboration; demonstrating benefits and societal and operational framework. All the themes have a strong link to value creation and the perspective of service ecosystems: interactions of markets, technologies and business models. The main findings are also described in the following sub-sections, named after the themes in Table 2.

Table 2. Data analysis of the companies interviewed (Cases).

Theme	**Perceptions briefly** + mainly promoting OR – currently hindering value co-creation *(→ link to summative Figure 3)*	**Case**
Perceptions related to end-users	+ A new market opportunity exists. The number of older people is considered to be growing and a positive attitude towards technology has increased. (B, E, I) + Especially for health technology companies, the group of older people often merges into a wider end-user group, which results in fewer solutions being developed solely to cater for older people's needs. (D) ○ From a usability perspective, the older people are demanding user groups. (C, J) ➔ *Figure 3: End-user needs and attitudes; Consumer markets.*	B-E, I, J
Perceived potential of care robots	+ Potential was identified in many areas of application: especially in safety and security (e.g. alarm) solutions. (ALL) + The potential is linked to technological maturity, affordability and ease of use. (A, B, G, I) + Possibilities for preventing illnesses and injuries as well as cost saving opportunities related to independent living affect the attractiveness and demand of solutions. (B, G, H, I, J) + It is important to exploit care robot solutions precisely in those activities to which they are best suited and in the problems they best solve. (B, D, F, I) + The service business perspective is required, "care robot as a service". (B, C, D, E, G, J, I) + The potential was identified for solutions that increase older people's self-determination and improve the ability of the older people to act independently and to be socially active. (D, G, J) ○ When human contact plays a major role in the action, the care robot solution should only have an assistive role, not being a substitute for a caring person. (C, D, J) ➔ *Figure 3: Technologies: maturity, purpose, image; Service perspective as a whole; Co-creating value; Targeted to the problems robotics best solves (named suitability scanning); Understanding end-user and customer needs.*	A-J
Demonstra-ting benefits	+ Demo rooms and living labs are one opportunity to demonstrate the functionality of the solutions. (B, G) – Implementation of pilot projects is currently too fragmented. Demonstration of benefits and impacts requires more persistent, long-term and scientifically high quality and reliable, cost-effective and validated research on health and cost effects. (B, F, I, J) – Reliable information is needed to convince buyers in international and domestic markets. (B, D, I) – Free pilot projects do not lead to desired contracts (although the benefits are successfully addressed) and no willingness to develop free pilots exists among technology providers. (D, J) ➔ *Figure 3: Demonstrating benefits: Scientific research for assessing the impact (health, cost), New ways for demonstrating; Integrating technology to customers' operations and services.*	B, D, F, G, I, J
Co-creation, collaboration	+ Customer perspective must be understood thoroughly (e.g. needs and operations). (H, I, J) + Co-operation creates opportunities (e.g. platforms and application development). (A,B,C, E, F, G, H, I, J) – However, conflicts of interest also occur. (D, E, F, G, H, J) – The business field is fragmented, and technologies and activities are not combined in a way which is supportive for service ecosystems. (A, C, E, G, J) – Public purchasers' technology expertise and understanding of long-term benefits should be improved. (B, D, F, I, J) – Finding a payer for technology solutions targeted to the older people is difficult. (C, D, F, J) ➔ *Figure 3: Effective collaboration, Co-creating services; Service ecosystem; Value co-creation; Customer relationship: Facilitating the acquisition, Integrating technology to customers' operations and services; Learning from experiences; Technological and service know-how.*	A-J
Societal and operational framework	+ The brand of the Finnish health technology is good for customer trust. (B, D) + Reform of the governance model of social and health care structures and services may simplify public procurement of care technology (e.g. finding the payer; expertise of the buyer). (D, I) + The procurement criteria (related to tender) should include scientific evidence of the benefits, and the wider level impact evaluation (health benefits and cost effects). (E, F, I, J) + The business environment in Finland should be maintained and further developed (e.g. the level of education, attractiveness to international players: employees and investors). (D, E) – Requiring scientific proof of benefits may hinder the development and market entry of new technologies. (D, H) – Centralization of procurement can lead to concentration of procurement only to large companies and to long service times, which is not advantageous for SMEs. (H, I, J) – No more regulation for evidence-based purchasing was desired. (D, G, H, J) ○ Standardization work and cyber security are affecting the business environment. (F, I, J) ➔ *Figure 3: Facilitating the acquisition; Trust; Creating an attractive business environment, Technological and service know-how, Requirements, recommendations for purchasing.*	B, D-J

Perceived potential of care robots

Although the informants recognized the megatrend of the ageing population and the related market potential, they also described challenges in designing the usability of solutions targeted at older people; for example, end-users' reluctance to use modern technology, deterioration of sensory and cognitive functions, and high demands for clarity and ease bring challenges to design. However, for some companies this created an opportunity to specialize in user-driven design and ease of use. Challenges in finding a payer for the solution were also mentioned. The buying customer for care technology is often a municipality or a public or private service provider, but finding a responsible person for this kind of acquisitions was difficult. Interviewees considered that development of the consumer market is linked to public-sector markets in Finland. A profitable business is based on acquisitions by public and private organizations, but some of the solutions can also be served directly to consumers (e.g. via an online shop). A small consumer market already exists. One company reported the experience that when commercializing robotic solutions to the consumer market, it is advisable to express the benefit for the end-user as maintaining a standard of living, not as an aid or assistive help. According to McCreadie and Tinker (2005), from the end-user's point of view the acceptability of assistive technology depends on the perceived need for assistance, access to and availability of the assistive technology (including information, delivery systems, and payment), and the related attributes, e.g. efficiency, reliability, simplicity, safety and aesthetics). However, the image effect of the purpose of technology also seems to be relevant. For the companies, market entry is an essential phase for success, and mistakes are difficult to correct afterwards.

Suitability of care robot solutions for the activities in question should be carefully assessed and targeted based on that assessment. One interviewee expressed that the most important question when considering the exploitation of care robots is "What is the problem

that robotics best solves?" Based on the results of the interview, health protection and promotion via enabling social activity for older people and facilitating independent living was considered to be important. The potential was identified for solutions that increase older people's self-determination and improve their ability to act independently. Cost savings linked especially to hazard and illness prevention, health protection and health promotion were often mentioned. One example of this was the medicine dispensing robot, which helps to avoid health hazards and hospital expenses via reducing human errors in medicine dispensing.

Based on the short Likert-type scale questionnaire the interviewees expressed that care robot solutions related to safety and security (e.g. alarming) are *very important* (Average 4.7, on the scale 1=Not at all important, 2=Not very important, 3=Neutral, 4=Quite important, 5=Very important). However, some of the interviewees mentioned that a feeling of security as well as producing joy for the end-user should be in balance in all care technology solutions. On average, the interviewees also considered the importance of care robot solutions to be *quite important* in the following operations: cleaning, assisted lifting and getting up, physical support for movement (at home), e-health and e-care, outdoor navigation, transportation, communication and rehabilitation.

Demonstrating benefits

The interviewees mentioned difficulties in demonstrating the benefits of the technology. In a case in which society as a whole benefits from well-being and cost savings from a technology solution, the administrative unit responsible for procurement (acting on its own budget) does not necessarily appreciate that benefits are also directed to their organisation. In this case, the unit's willingness to pay may be lower and the contract might not be obtained. For this reason, some companies suggest that research evidence of any solution's societal benefits (e.g. protecting and promoting health, reducing indirect costs at the state level) should be mandatory in public procurement. However, some of the companies were worried that this

kind of emphasis would mainly favour older and most researched technological solutions, thus hindering adoption of the latest technological solutions. In the worst case this could cause problems for start-up companies; they would be unable to start their business based on the newer technology. Especially companies emphasizing agility and fast adaption of new technologies proposed less regulation of the market. One suggestion was that the state should set targets for cost savings at the organizational level and subsequently rewards for achievement of the goals.

Some interviewees also revealed that much effort has already been made for the pilots without leading to public purchase. For demonstrating benefits achieved by using new technology, customers sometimes expect free pilot projects. However, currently companies are not willing to participate in pilots if the customers do not participate in the costs, at least the material costs. The way in which the pilot projects were typically planned and implemented was also criticized as being too limited (only a few users) and of too short duration be able to demonstrate the real benefits. Problems related to goals and testing conditions were also mentioned. A pilot organisation will not necessarily change its old mode of operation for the pilot, as a result of which the benefits of the new technology may not be revealed. Without clear goals and indicators set by the pilot organisation and the technology provider together, success of the pilot project and analysis of the results were difficult to achieve. On the other hand, it is relevant to plan the changes together in such a way that the customer does not have to abandon well-functioning processes when introducing new technology. This approach was highlighted especially in companies in which customer and service orientation and expertise in care processes were considered to be success factors for the technology provider. From the perspective of the technology provider, frustration was experienced when pilot projects did not lead to desired contracts even though the goals set

with the customer were achieved and the benefits were demonstrated. Instead of pilots, demo rooms and living labs were also suggested for demonstrating the functionality of the solutions.

Most of the companies perceived that the role of the research should be strengthened in assessing the benefits and the impact of care technology. Some interviewees also suggested improvements to nationally funded research projects. More systematic comparison of different technologies, a longer period under review, more end-users for testing, regional comparison and more efficient execution of the projects were proposed. Not all the actors were willing to study the effects themselves, because this required resources and slowed down technology and product development. Research institutes were expected to take care of the impact assessment. However, impact assessment generally receives little academic attention despite its societal role; regular human impact assessment of novel technologies at individual and community levels may stimulate their adoption by consumers and professional care-givers (Melkas, 2011).

Co-creation and collaboration

As the interview results described above reveal, cooperation between a technology provider, a customer and research institutes was considered to be important in demonstrating technology and reviewing the impact achieved. The importance of the service perspective was also clearly expressed in the answers. Both technology providers and customers need to understand how new technology solutions and customers' current operations and services are integrated. Furthermore, care technology is often produced as a service, which should already be noted in the planning of acquisition. Technology as a service perspective also requires understanding of value co-creation. However, the interviewees considered value co-creation, especially with the public service provider (buyer), to be insufficient. They saw serious shortcomings in the buyer's technology-related know-how, understanding of value creation and appreciation of the long-term benefits. Public purchasers were considered to be cautious

and unable to take into account life-cycle costs and benefits of technology solutions. Similar problems were earlier identified by Jännes et al. (2014). When the benefits will not be directly attributed to the customer organisation, even high impact on a wider societal level (health and cost savings) is ignored in technology selection. However, some informants also understood the customer's problems in the procurement of technology. Bad experiences with the introduction of poorly functioning early-stage technology have had an impact on attitudes. Organisations were also working with their own budget when taking into account the wider social interests outside the unit was limited in the procurement. One suggestion from the companies was that the information and experiences related to new technologies should be more efficiently exchanged between different organisations and municipalities. This could improve understanding of the implementing processes as well as the benefits and the impacts that can be achieved.

In Finland, an active innovation hub is promoting robotics, artificial intelligence and automation. However, according to the interviewees, cooperation among the companies is still episodic and related only to certain research projects. The objectives in many co-projects were described as being scattered, and common business interests were hard to find. The exchange of information and experience between local authorities, decision-makers and organisations using care technology was considered to be of great importance in enhancing technology utilization and supporting decision-making. Cooperation opportunities for business were recognized (for example, with regard to application development), but conflicts of interest were also mentioned. Coopetition (cooperation and competition) was experienced as a discomfort. By contrast, collaboration among technology developers and retailers was considered to enable the concentration of expertise.

Societal and operational framework

Some interviewees mentioned that they have recently noted positive progress in their

customers' ability to adapt technology to care processes. In some cases, the coming reform of the Finnish governance model of social and health care structures and services was noted to confuse customers, who were now waiting for new instructions before embarking on acquisitions. However, from the perspective of technology providers the reform was expected to simplify public procurement of care technology in the future. After the centralization of care technology procurement, finding the right buyer and contact person for technology purchasing was assumed to become easier. The interviewees also expected that in the future, the buyer can more easily bring technology expertise to the procurement process. Some of the companies expressed dissatisfaction with the current procurement legislation, but some experienced that the current law is adequate and considered that customer acquisition skills (application of the law) play a more prominent role in successful technology purchasing. The criticism focused mainly on the facts that it is not obligatory to take into account the wider impact of technology on a societal level; research results are not strictly required; and quality criteria are not emphasised sufficiently.

According to the companies, the state can best support companies for creating and maintaining a business environment by ensuring that the level of professional education remains high and by attracting international experts and investors. This leads to greater experience and innovativeness. From the perspective of start-up companies, the lack of capital support for business development and growth created challenges, especially immediately after the technology development phase. For these companies, attracting investors was essential. Mutual trust was considered to be a prerequisite in operating any health sector business. The companies emphasized that the brand of Finnish health technology and long-term, scientifically high quality and reliable, cost-effective and well-executed (scientific) research on health and cost impacts would be enablers for creating high trust for Finnish care technology solutions and companies on an international level. Some of the companies also

expected state representatives to participate actively in standardization work and in the harmonizing of health technology assessment on the EU-level. Cyber security challenges were also recognized to be a matter that need to be resolved partly through wider cooperation on the state level.

In the following, we move on to presenting the results of the survey concerning factors that hinder or promote the introduction of robots and funding issues related to robots.

Findings from the survey

Creating attractive business environment: Hindering and promoting factors

Both hindering and promoting factors are active when considering an attractive business environment for the companies. The survey respondents were asked to give their opinions concerning factors hindering or promoting the introduction of robots in Finnish welfare services. For both of the options, the respondents were allowed to give as many responses as they wished (out of 26 or 25 given options, for promoting factors or hindering factors, respectively). On average, they marked 6.75 and 6.63 options for hindering and promoting factors, respectively. The main results are presented in Figure 2.

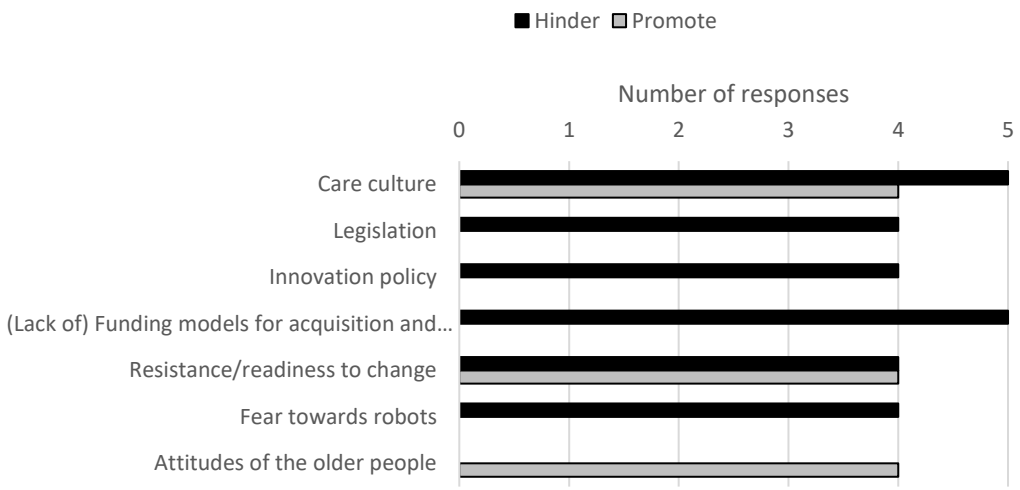

Fig. 2. Factors hindering or promoting the introduction of robots: the most often selected options.

Figure 2 shows the most often selected options. Care culture, lack of funding models, legislation, innovation policy, resistance to change and fear towards robots were the most often selected hindering factors. Care culture, again, readiness to change and attitudes of the older people were the most often selected promoting factors.

Other factors that were selected less often as hindering the introduction of robots were social structure, lack of domestic robot technology development, service structures and attitudes towards older people. Other factors that were selected less often as promoting the introduction of robots were innovation politics, domestic business in robotics, service structures, interest towards technology, readiness of workplaces for technology introduction (e.g. orientation), and professional and continuing education.

Interestingly, care culture was selected both as a hindering and as a promoting factor. This may be related to the long history of elderly care services in Finland, constituting a strong basis for development of the services, but, on the other hand, possibly leading to resistance to change. However, readiness for change was mentioned as a promoting factor. Funding models that were mentioned as a hindering factor are further discussed in the following. At the individual user level there were also contradictory views, for example the attitudes of older people were seen to promote the introduction of robots, although there was also some level of fear.

Business models and markets: Funding options of robots and facilitation of acquisitions

Funding options of robots are a key issue in robot acquisition and use, both from the viewpoints of users and stakeholders as well as those of business models and markets (and thus also the creation of an attractive business environment). In the survey, funding options were investigated with two open questions. The results of the survey are presented in the following.

Robot acquisitions to public welfare services

The respondents were asked to give their opinions concerning a situation in which a care robot is to be purchased for public welfare services. They were asked what kind of suggestions they would have for organizing the funding of such a robot acquisition. Who should pay? Three alternatives for funding robot acquisitions for public welfare services were identified: 1) service provider, 2) society and 3) consumer.

In the service provider alternative, the robot was seen as an investment; a care robot does not differ from other expenses – whether they are investments in new devices or hiring a new staff member. Every unit that provides a service should cover its funding in its own way. It was suggested that the service provider should conduct the investment calculation rather like in the industry, in which the cost of the service per customer is assessed based on the repayment period. In the society alternative, it was suggested that the robot should be funded via taxes. It was also mentioned that different levels of society (state, region and municipality) should take part in the costs equally. In the consumer alternative, it was mentioned that the society should move from a service provider model to a consumer-based model so that the person who wished to acquire a care robot would fund it her-/himself. It was also suggested that for robots to be widely adopted, society should consider the effects, rather than only efficiency and costs.

Robot acquisitions to private households

The respondents were asked to give their opinions concerning a situation in which a care robot is to be purchased for a private household. How should it be organized; who should pay? Four alternatives were identified for a private household to acquire a care robot: 1) the household itself pays, 2) financial aid, 3) service provider and 4) society. It was also suggested that categories 1) and 2) could be combined, so that financial aid could cover 70%,

and the rest would be covered by the household in question. Another suggestion was that the service provider generating the services of which the robot is a part should also fund the robot. The robot was seen to be on the same level as (other) home care services and medication. Alternatively, society as a whole (state, region or municipality) should take part in the funding.

Integrating the findings: Service business enablers in the care robot context

The interview and survey results highlight some important issues affecting business opportunities of care robots. The five themes of the organized interview data presented in Table 2 (perceptions related to end-users; potential of care robots; co-creation and collaboration; demonstrating benefits; and societal and operational framework) revealed a link to value creation and the perspective of service ecosystems: interactions of markets, technologies and business models (see Fig. 1). The results of the survey also supported the interview findings considering perspective of service ecosystems by emphasizing the relation of the societal framework and markets: funding models, legislation and innovation policy. In order to understand service business enablers in the care robot context, the interview results (opinions of the stakeholders) were sorted based on the promoting and hindering effects to value co-creation (see Tab. 2). In the survey, care culture, lack of funding models, legislation, innovation policy, resistance to change and fear towards robots were the most often selected hindering factors for the introduction of robots in Finnish welfare services. In a similar manner, care culture (again), readiness to change and attitudes of the older people were the most often selected promoting factors.

As a summary of the findings, Figure 3 presents enabling factors affecting opportunities and challenges from the perspective of the service ecosystem. When opinions of the stakeholders (interview data) referred to promoting the co-creation of value and/or have a connection to the service ecosystem perspective (see Fig. 1), they were taken into account

when forming the framework of service business enablers presented in Figure 3. The factors which were considered to be currently hindering the co-creation of the value or having an influence in both ways (hindering, in some circumstances, or promoting, in others) were also taken into account when forming the framework. For example, the perceptions described in Table 2 via the sentence "public purchasers' technology expertise and understanding of long-term benefits should be improved" supported several enablers in the framework: integrating technology to customers' operations; effective collaboration; learning from experiences; as well as technological and service know-how. In general, the link between the summarizing figure (Fig. 3) and stakeholders' opinions are presented in Table 2. In addition, care culture, readiness for change and attitudes were also included in the framework because, based on the survey results, they were considered to promote (or hinder) the creation of an attractive business environment for care robotics.

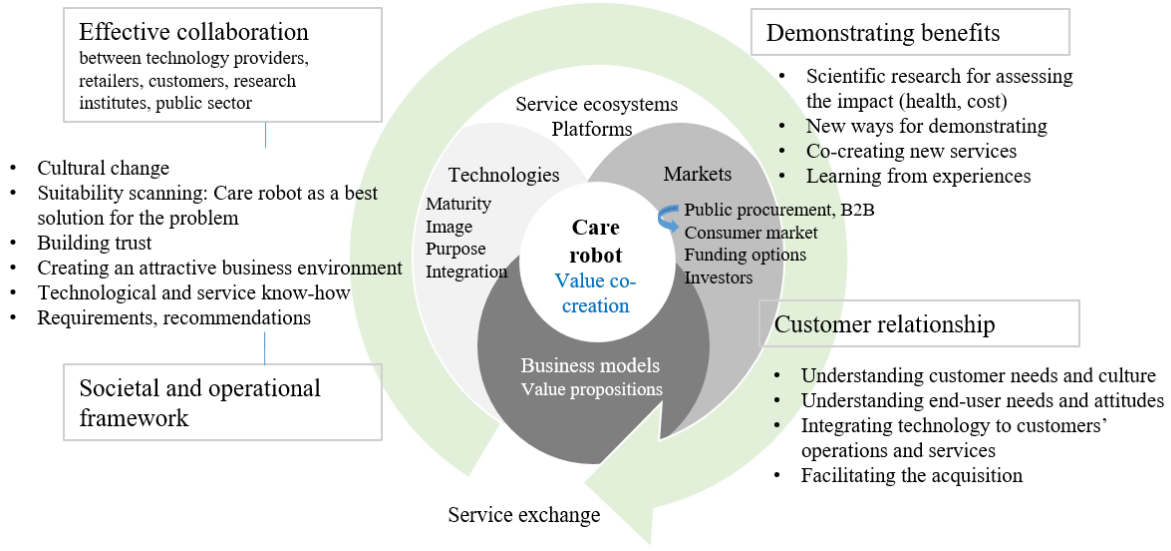

Fig. 3. Service business enablers in the care robot context.

Real service ecosystems related to care robotics were not found, despite the fact that some collaboration and projects exist between the technology companies, customers, retailers and research institutes. However, service providers recognized the need for business-based

collaboration in order to reach the international markets. Interest was targeted especially to platforms that allow a connection between different applications and services. Deeper collaboration with the customers was also needed for understanding their needs and for realization of successful acquisition and implementation of technology. Collaboration with the research institutes in turn would enable more reliable demonstration of benefits and impact assessment. The role of the state (societal framework) was highlighted in creating an attractive business environment, building trust and enabling high-level professional education, and in ensuring adequate technological expertise of public customers. For some actors stricter requirements relating to evidence of the benefits and impact were welcome, but others did not support strict regulation of the market. Instead, they were worried that regulation would hinder the introduction of new technology to the market. The same issues could be discerned from the survey results; legislation was one of the most often selected hindering factors. Interestingly, innovation policy was also one of the most often selected hindering factors, whereas it should – as part of the role of the state – be essential as an enabler, e.g. in creating an attractive business environment.

Maturity of the technology, clear purpose and opportunities for integration (technological and operational) were rated as important in the context of business to business (B2B) and public procurement. Procurement issues, problems in integration and lack of holistic views have been brought up in earlier studies concerning other types of well-being technology (Melkas, 2013; Melkas & Pekkarinen, 2014; see also Jännes et al., 2014). The current situation is similar, but technologies are rapidly developing and becoming more varied, further highlighting the urgent need to deal with these issues. The image effect for the end-user was also important in the marketing of technology targeted to consumers. However, the consumer market growth was considered to be dependent especially on the vitality of the public-sector market, which should be noted when funding is planned. Online survey results

also revealed that a lack of funding models for acquisition and innovation was considered to be hindering the introduction of robots. On the other hand, some respondents emphasized the fact that in terms of funding, robots are no different from other technologies used in patient care. They are still expensive, but we cannot know how well the respondents knew the prices of different types of robots when responding.

Concluding discussion

The exploitation of care robots is widely discussed, and the maturity of the technology already enables some solutions. The forecasts show high expectations of market growth, but sales figures of care robots are still quite moderate. In order to understand the perspective of companies with a potential to bring care robots into the market, interviews of 10 Finnish technology companies related to health and care were executed during the spring of 2017, supported by data of 13 companies from an online survey about perceptions to care robots. The data of the study included the informants' expectations, experiences and suggestions considering the opportunities, challenges, enablers and other factors relating to their business and to the care robotics market. In interpreting and utilizing the results, the relatively small number and size of the interviewed companies must be taken into account. The study was also limited to companies operating in Finland, and currently were mostly selling other technology than robotics.

According to the interviews, the business potential of care robots was recognized especially in care robots supporting older people's independent living, and in tasks in which human contact was not substituted by technology. Care robot solutions related to safety and security (e.g. alarm systems were considered to be very important, and some other application fields were considered quite important: cleaning, assisted lifting and getting up, physical support for movement (at home), e-health and e-care, outdoor navigation, transportation, communication and rehabilitation. The companies were most interested in robot technologies

that are mature and cost-effective, enabling cheap solutions. The care robotics was mainly perceived as a part of health technology and a wide range of care robot applications were recognized, ranging from software robots to transport, support and social robots. Although the service opportunities targeted to older people were identified, the development of robots not necessarily focused solely on this target group. In some companies, high demands for usability of this target group reduced the interest, while others saw opportunities in focusing on ease of use, which was mentioned to be important for other target groups as well (e.g. care workers).

Despite the potential of care robotics, and the generally positive attitude towards new technology, most of the interviewees were rather cautious about the new market. Care technology and care quality confrontation were seen to be hampering the development of solutions that would benefit the various parties involved (older people, their friends and relatives, care-givers, companies, society). Care culture was seen both as a hindering and as a promoting factor. Opportunities for business-related cooperation were recognized, for example with regard to platforms and application development. An individual company and its applications and solutions were considered to be rather limited in the international market if there is no service ecosystem involved. On the other hand, genuine cooperation between the companies had been difficult to achieve during previous joint research projects. Coopetition (co-operation and competition) was considered to be rather limited, and in the future, cooperation was preferred with those offering complementary solutions. Research institutes were considered to have a strong role in demonstrating the impacts and verifying the benefits of care technology solutions. This activity has an important effect in generating trust within the market. This result is in line with care robot market analyses in Japan and e.g. in Denmark that emphasize the important role of public actors and public funding in supporting both the

development and the adoption of robots in care services (Kohlbacher & Rabe, 2015; Levsen, 2015).

Some challenges were identified in the construction of business and the market. First, difficulty in finding the right payer due to the current complexity of the public administration and lack of public customers' technological know-how were recognized. This was assumed to limit purchasing of the care technology and to hinder the growth of the public-sector market, which also contributes to the consumer market. The coming reform of the Finnish governance model of social and health care structures and services was expected to provide more clarity to procurement, and to support the renewal of care practices and operational models towards utilizing care technology. A more bold and competent utilization of care technology in public and private healthcare services would probably boost the market growth. However, customer experiences of technology affect the levels of interest and caution. Information exchange and idea-building between municipalities and user organizations was considered to be important for identifying and prioritizing the problems that care robots can best solve, providing better understanding of the implementation and of the benefits that care technology can offer. The state was expected to affect the attractiveness of the business environment by enabling a high level of professional education, ensuring adequate technological expertise for the public sector and for planning funding options for care technology acquisitions. Robots were seen as relatively equal with other technologies in terms of funding options, and their effects should be considered rather than only their costs. Growth of the consumer market was considered to be rather low, even though some of the solutions focusing mainly on B2B and the public-sector market can also be served directly to consumers (e.g. via an online shop).

The second challenge was related to demonstration of the benefits. Companies needed wider-scale scientific research evidence of impact in order to justify technology solutions and build trust in the international market. Current pilot projects for demonstration were

considered to be too fragmented, small and inadequate. Future innovation policy could play a role in streamlining pilot projects. Lack of objective evidence of the benefits was assumed to hinder penetration into international markets. More systematic comparison of different technologies, longer period under review, more end-users for testing, regional comparison and more efficient execution of the projects were proposed. Some of the companies even considered that the state should require scientific evidence of the societal impact of technology (health and cost effects) in public procurement. However, this was considered mainly to favour older and most researched technological solutions, while hindering the adoption of the latest technology.

Third, the business field was fragmented, and the companies were rather small and pursuing their own advantage. This was a challenge for the formation of a service ecosystem that would have more potential in the international markets. Value co-creation with the customers was not very deep, although some companies emphasized the service perspective and good understanding of the customers' needs, operations and culture. Again, this is an issue in which innovation policy could play a role in the future; facilitating co-creation with the customers, but also with the consumers, whose attitudes were found to be a promoting factor in the introduction of robots. Particularly for start-ups, but also for other companies, finding investors was a challenge. According to Rydehell and Isaksson (2016), companies operating in the IT-sector were usually more eager to find investors than firms operating in the medical technology industry, which might impact their growth rates during start-up. This could also affect the growth and survival of new technology-based firms. The companies hoped that the state will constantly make an effort to create an attractive business environment to attract international experts and investors into the Finnish service ecosystem of care robotics.

However, care technology providers should also improve their customer and service orientation in order to understand the pure value of the solution. The potential of the care technology needs to be redeemed by creating business models including the value proposition targeted on improving customers' current operation and services and providing an opportunity for the customer to create new services. The technology provider is always serving the customer's "end customer" as well. Understanding the change in an operating process needs to be developed together in such a way that the value is co-created.

Finally, the user focus is of utmost importance in this theme. Whilst a detailed discussion of the diversity of users, diversity of technologies, or a general discussion on ageing or care (including care culture) are beyond the scope of this paper, we raise some central issues here. The field of health and care technology use involves the end-user and her/his family and other close ones; care staff; technology producers; service procurers, and implementation, maintenance and assessment of technology in private homes, supported homes or long time care facilities. Sometimes the end-user may be a family member or professional care worker (on primary and secondary users, see e.g. Khakurel, Porras & Melkas, 2019). Producers and providers of health and care technology need to understand the terrain they are entering, and how they understand, navigate and negotiate the transition from no or few technologies to some or many technologies is of major interest (e.g. Pekkarinen & Melkas, 2019). Older technology users are often viewed stereotypically or represented by assumptions or static identities, without cultural and historical constructions (Östlund et al., 2015). If diversity in users is incorporated at all, it is usually only age and gender differences (Flandorfer, 2012). Assumptions that lay at the heart of technology design and implementation are often resistant to change; technology designers and producers may construct their end-user in ways that do not match the real life user (e.g. Johansson Pajala et al., 2019) – a concern that should be increasingly focused on in future research. Users of

health and care technology are of all ages, and being old does not automatically imply needs of technology or care (Neven, 2010; see also Hennala, Melkas & Pekkarinen, 2011). For these reasons, a systematic involvement of different types of end-users in the service ecosystem's development is necessary to unleash the full potential of care robotics and related business.

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Indication of figures and tables

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