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A Digital Collaborative Platform to Facilitate Innovative Solutions for the Silver Economy

Sidra Azmat Butt

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Declaration:
Hereby, I declare that this doctoral thesis submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any academic degree elsewhere, and it is my original investigation and achievement.

Sidra Azmat Butt

signature

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Digitaalne koostööplatvorm hõlbustamaks uuenduslikke lahendusi hõbemajanduses

SIDRA AZMAT BUTT

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Contents

List of Publications

The present Ph.D. thesis consists of the following collection of publications:

I Sidra A. Butt, Ingrid Pappel, and Enn Õunapuu. Potential for increasing the ICT adaption and identifying technology readiness in the silver economy: Case of Estonia. In *Proceedings of EGOSE 2020 – the 7th International Conference on Electronic Governance and Open Society: Challenges in Eurasia*, pages 139–155. Springer International Publishing, 2020.

II Sidra A. Butt, Emna A. Elhadjamor, Ingrid Pappel, Enn Õunapuu, and Dirk Draheim. A knowledge map for ICT integration in the silver economy. In *Proceedings of CENTERIS 2020 – the 8th International Conference on Enterprise Information Systems*, volume 181 of *Procedia Computer Science*, pages 693–701. Elsevier, 2020.

III Sidra A. Butt and Dirk Draheim. Ethical challenges of ICT for the silver economy. In *Proceeding of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 152–155. IEEE, 2021.

IV Sidra A. Butt, Karin Rava, Taivo Kangilaski, Ingrid Pappel, and Dirk Draheim. Designing a digital collaborative platform for the silver economy: Inception and conceptualization. In *Proceedings of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 47–54. IEEE, 2021.

V Sidra A. Butt, Ingrid Pappel, and Dirk Draheim. Digital Silver Hub: User dialogue model technical document. *IEEE TechRxiv. Preprint*, pages 1–49, 2022.

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X Sidra A. Butt, Taivo Kangilaski, and Dirk Draheim. Lessons learned from a multi-national project on developing a platform for the silver economy. In *Proceedings of Projman 2023 - the 7th International Conference on Project Management*, Procedia Computer Science. Elsevier, 2023.

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Author's Contributions to the Publications

I I was the main author of this article (first author and corresponding author), and I was responsible for the article content, writing the manuscript, conducting a literature review, collecting and analyzing data, interpreting the results, constructing the discussion, formulating the future plan and proofreading.

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XII I was the second author of this article, and I was responsible for writing parts of the manuscript, collecting and analyzing data, and proofreading.

Abbreviations

ICT	Information and Communication Technology
IT	Information Technology
ADR	Action Design Research
CI	Collective Intelligence
AI	Artificial Intelligence
IoT	Internet of Things
HCI	Human-Computer Interaction
BSR	Baltic Sea Region
EU	European Union
DSH	Digital Silver Hub
UX	User Experience
UI	User Interface
SSL	Smart Silver Lab
SSF	Smart Silver Framework
UML	Unified Modelling Language
OSIRIS	Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth

Terms

Agile Methodology	An approach to software development that involves a collection of practices centered around incremental and iterative development. It emphasizes the values of collaboration, communication, feedback, and adaptation to change.[1] See publication IV on pp. 108 and publication V on pp. 129.
Attitude towards using the Technology (AT)	An overall sense that a user develops regarding a technology, which is influenced by how useful they perceive it to be and how easy they think it is to use [155]. See publication IX on pp. 233.
Co-creation	A collaborative process that involves businesses working together with their customers to generate value. It is a mutually beneficial approach that allows businesses to gain a deeper understanding of their customers' needs and preferences while giving customers an opportunity to contribute their ideas and feedback to the development of products and services [117].
Collaboration Tools	Software and hardware applications that facilitate collaboration, among teams of individuals, for project or task completion [84]. See publication V on pp. 150.
Collective Intelligence	The phenomenon in which a group's interactions lead to an ability to solve problems, make decisions, and produce ideas that surpass the capabilities of any individual working alone [90, 147].
Collective Intelligence Platform	A platform that enables the gathering and analysis of information and knowledge from a community to generate insights and solutions that surpass individual capabilities [53]. See publication VI on pp.175.
Competition	A process where individuals or groups exert their efforts to attain a shared objective by surpassing each other [116]. See publication V on pp. 156.
Conceptualization	A vital step in the creative process involving generating or evolving an idea based on a particular object or concept.[2] See publication IV on pp. 109.
Content Administration	The process of creating, organizing, storing, retrieving, publishing, and distributing digital or physical content [60].
Crowdsourcing Platform	A digital platform that allows organizations to delegate tasks to a pool of individuals on a freelance or voluntary basis [26].

[1] https://agilemanifesto.org/iso/en/manifesto.html
[2] https://dictionary.cambridge.org/dictionary/english/conceptualization

Customer Journeys	"The path of interactions an individual has with the brand, product, and/or services. It describes both direct interactions, such as contacting a customer service team, to indirect interactions, such as hearing about a brand at an event."[3] See publication X on pp. 251.
Digital Inclusion	The capability of individuals or groups to utilize technologies to engage in aspects of society, economy, culture, and democracy. This includes accessing, comprehending, and effectively utilizing these technologies.[4]
Digital Transformation	The use of technology to develop and enhance business processes, culture, and customer experiences in order to adapt to evolving business and market needs [127].
Digital Platform	A technological infrastructure that allows individuals to engage with one another and, with suppliers of products and services [6].
Digital Collaborative Platform	A web-based or mobile-based platform that enables users to work together on tasks, projects, and documents. These platforms typically offer a wide range of functions, such as file sharing, communication tools, discussion forums, and task management tools [159].
Digital Silver Hub	"An environment where different stakeholders can collaborate in innovation processes using a methodology based on knowledge exchange, co-creation/co-production techniques, and participatory methods to generate new innovative solutions to tackle aging challenges and exploit silver economy opportunities [133]." See publication VII on pp. 202.
Discussion Forum	A web-based platform that allows individuals to exchange messages and engage in discussions on various topics in real-time[27]. See publication V on pp. 148.
e-Service	"The use of electronic technology by an organization to provide services to its customers".[5]
Events	Occurrences that take place at a designated time and location usually involving individuals coming together for a purpose [119]. See publication V on pp. 155.
Financing Mechanism	"Specific tools portfolio that has the purpose of bridging the financing needs of innovation actors, particularly of private and public companies, with the financiers' services and requirements in order to speed up market commercialization of innovative solutions."[6] See publication VII on pp. 204.
Functionality	The platform's ability to provide users with the necessary tools and resources to achieve their intended objectives [165].

[3] https://www.bynder.com/en/glossary/customer-journey/
[4] https://e-estonia.com/digital-inclusion/
[5] https://www.collinsdictionary.com/dictionary/english/e-service
[6] https://silverhub.eu/et/c/10064

Generic Collective Intelligence Model	A comprehensive framework to facilitate the design and implementation of Collective Intelligence systems that are not bound by domain-specific requirements. This framework considers various elements such as staffing, processes, goals, and motivation to foster collaboration and bring together the interests and expertise of individuals towards achieving shared objectives [146]. See publication VI on pp. 180.
Idea Lab	The repository for all the ideas that have been shared, given feedback on and concluded as well as the new and upcoming ideas. See publication V on pp. 143.
Inception	The process of coming up with a creative concept that effectively addresses user problems.[7] See publication IV on pp.103.
Information and Communication Technology	The vast array of technologies used to gather, analyze, store, transmit, and share information. It includes hardware, software, and networks, all constantly evolving to improve how we communicate and work.[8]
Information Library	A compilation of information materials arranged in an order to facilitate searching and accessing usually found in either digital or physical formats [97]. See publication V on pp. 156.
Innovation	The introduction of new concepts, practices, or objects into a system. It is a dynamic process that encompasses the generation, spread, and adoption of new ideas [121].
Innovation Supporting Tools	Software and hardware applications in supporting innovators and teams by aiding them in generating, analyzing, and implementing ideas. These tools enable collaboration, effective communication, and informed decision-making, ultimately mitigating the risks and uncertainties often involved in the innovation process. See publication VII on pp. 204.
IT Architecture	The structure of an IT system, including its various elements, connections, and guiding principles. The elements of an IT system refer to the different components that contribute to its functionality, such as hardware, software, and data [14]. See publication XII on pp. 298.
Knowledge Diffusion Toolkit	"Comprises different communication channels, instruments, and knowledge transfer methods to improve the capacity of innovation actors to learn, transfer, and exploit knowledge resources."[9] See publication VII on pp. 204.
Knowledge Map	A visual representation of an organization's knowledge assets that is utilized to identify, communicate, distribute, and exchange knowledge [47]. See publication II on pp. 91.

[7] https://dictionary.cambridge.org/dictionary/english/inception
[8] https://unesdoc.unesco.org/ark:/48223/pf0000156769
[9] https://silverhub.eu/et/c/10284

Knowledge Hub	A digital platform where people can access and contribute to a pool of online knowledge and information, fostering learning and sharing within a community [56].
Market Research	Analyzing the market for a product or service involving gathering and examining data to uncover opportunities and obstacles [88]. See publication V on pp. 154.
Networking and Collaboration Opportunities	Potential for individuals and organizations to unite and work together towards common goals.[10] See publication VII on pp. 205.
Older Adults	Population in old age, "usually associated with declining faculties, both mental and physical, and a reduction in social commitments."[11]
Open Innovation Toolkit	"A set of open innovation tools and methodologies that serve innovation actors in knowledge creation, transformation, and reuse. It provides support for generating innovative solutions, prototyping, market uptake, and building strong partnerships."[12] See publication VII on pp. 204.
Partner Search	The process of identifying and building relationships with potential collaborators for projects, research, or other ventures [28]. See publication V on pp. 149.
Perceived Usefulness	The perception of usefulness as to how users believe a system can enhance their job performance [48]. See publication IX on pp. 233.
Perceived Ease of Use	The extent to which a user thinks that utilizing a system would require effort [48]. See publication IX on pp. 233.
Platform Evaluation	The systematic assessment of the performance, usability, and influence of a platform [102]. See publication IX on pp.227, publication VII on pp.197 and publication XI on pp.255.
Process Documentation	"The steps necessary to complete a task or process. It is an internal, ongoing documentation of the process while it is occurring."[13] See publication XII on pp. 296.
Project Management	"The application of processes, methods, skills, knowledge and experience to achieve specific project objectives according to the project acceptance criteria within agreed parameters."[14] See publication X on pp.243.
Quadruple Helix Model	A concept emphasizing broad collaboration in innovation between government, academia, industry, and civil society [5].

[10] https://www.oecd.org/sti/inno/2754490.pdf
[11] https://www.oxfordreference.com/display/10.1093/acref/9780198568506.001.0001/acref-9780198568506-e-4834?rskey=7F4W2cresult=4834
[12] https://silverhub.eu/ww/c/10054
[13] https://www.lucidchart.com/pages/tutorial/process-documentation
[14] https://www.apm.org.uk/resources/what-is-project-management/

Silver Economy	Economic opportunities and challenges related to an aging population encompassing all economic activities related to the production and consumption of goods and services by older adults [54].
Silver Generation	Population of older adults who are more than 50 years of age [80].
Smart Silver Framework	"A theoretical pilot model for increasing quadruple helix innovation actor's capacity to generate economic growth by using smart specialization approaches."[15] See publication VII on pp. 203.
Smart Silver Labs	A regional open innovation ecosystem that has an innovative multi-level structure developed using a quadruple helix approach to connect, coordinate, and support collaboration between researchers, product and service developers, financiers, local authorities, and user organizations, who are innovation actors, in generating new market-viable products and services.[16] See publication VII on pp. 203.
Silver Market Characteristics	"Characteristics of a regional business or market environment including all the factors, forces, and institutions that have direct or indirect influence over the interactions between various innovation actors."[17] See publication VII on pp. 206.
Social Media Platform	A digital platform that allows individuals to generate and distribute content, engage with others, and establish connections [68].
Technology Adoption	The incorporation of new technologies into existing practices by individuals, organizations, or societies [121].
Technology Acceptance Model	A theoretical model that explains the process through which individuals adopt and make use of a technology [48]. This model focuses on two factors: Perceived usefulness and Perceived ease of use. See publication IX on pp. 233.
Technology Readiness	The capacity of people to adopt, accept, and effectively utilize technologies [108]. See publication I on pp. 73.
Technological Ethics	The examination of the consequences associated with the advancement and utilization of technology. It involves evaluating the potential benefits, risks, and ethical implications of adopting and using new technologies [143]. See publication III on pp. 100.
Training	The process of providing instructions and engaging in activities to enhance the abilities of an individual or a group [20]. See publication V on pp. 157.
Transnational Cluster	"Clusters which involve actors from two or more countries in the same geographical area" [154].

[15] https://osiris-smartsilvereconomy.eu/smart-silver-framework/
[16] https://osiris-smartsilvereconomy.eu/smart-silver-lab/
[17] https://silverhub.eu/et/c/10100

Vertical Market	An industry or consumer segment that places an emphasis on specialization and catering to the unique requirements of its target market.[18]
Virtual Marketplace	A digital platform that allows individuals to connect and trade products and services without requiring them to be physically present [99].
User-Centred Evaluation	A structured approach to assess a system by engaging users in the evaluation process [66]. See publication XI on pp. 273.
User Dialogue Models	"An abstract model that is used to describe the structure of the dialogue between a user and an interactive computer system." [59] See publication V on pp. 139.
User Interface	The various components of a system that facilitate communication and engagement with users. This includes hardware elements like the screen, keyboard, and mouse as well as software software components such as the operating system, applications, and menus [65].
Utility Platform	A digital platform that offers free services to users and generates revenue through targeted advertising.[19]

[18] https://www.techtarget.com/searchitchannel/definition/vertical-market
[19] https://www.geeksforgeeks.org/types-of-software-platforms/

Summary

There is a major demographic shift in the world, with an increasing silver generation and a projected decrease in the percentage of working-age citizens. As a result, the working-age population will have to bear the brunt of the social expenditure on the aging population and related services.[20] It is expected that between 2021 and 2100, the number of older adults (those aged 80 years or above) will increase from 6% of the population to 14.6% [49]. Therefore, it is crucial to view this as an entrepreneurial opportunity instead of an economic threat.

This thesis emphasizes the importance of leveraging Information and Communication Technology (ICT) in providing innovative solutions for the silver generation, helping them lead active and independent lives. This thesis also identifies and addresses challenges and barriers to technology adoption by the silver generation and highlights how ICT can overcome these issues. As a design science effort [62], the thesis contributes significantly to the digital transformation of the silver economy by developing a digital collaborative collective intelligence platform called the Digital Silver Hub (DSH) that facilitates the design, development, and evaluation of innovative solutions to cater to the everyday problems faced by the silver generation the Baltic Sea Region (BSR).

Remark: In the thesis, all terminologies from the Terms Section are emphasized on the first occasion.

The thesis is written as a series of publications forming a single collection supplied with a summary article. Copies of the publications are appended.

This thesis summary is structured as follows. Section 1 lays out the research problem statement and motivation and explains the research objectives, along with research questions. Section 2 provides an overview of the relevant literature. Section 3 explains the research design. Section 4 reports the results of the research questions and demonstrates how these results were evaluated. Section 5 highlights the major contributions of this thesis, discusses the limitations and challenges of this work, and suggests some possible directions for future improvements. Finally, Section 6 is dedicated to concluding remarks.

[20] https://www.euromonitor.com/

1 Introduction

With the population aging and the evolution of *Information and Communication Technology (ICT)*, numerous challenges and opportunities are emerging for economies worldwide. The *silver generation*, also known as *older adults*, is proliferating in size, posing a threat to public finances and work dependency ratios [2]. It is imperative to develop strategies and adopt a perspective that views the silver generation as an opportunity for economic growth [76]. This phenomenon of population aging has been termed a strong market driver by the World Economic Forum [58]. The approach to underscore the economic and social opportunities accompanying this longevity revolution has led to the emergence of the concept of the *silver economy* [54]. The silver economy is described as “the new market opportunities that arise as a result of public and private spending in connection with the wishes, rights, needs, and requirements of the growing older population” [3]. ICT can enable the silver generation to be active and more independent and contribute to the economy [11].

1.1 Problem Relevance

It is important to recognize that a *vertical market* exists in the IT industry and the world of technology. A vertical market pertains to a segment or sector where companies meet the requirements and preferences of a particular group of customers, in this case, the silver generation [80]. In this context, the vertical market catering to the silver generation refers to a niche market that emphasizes creating and promoting technology-based products and services specifically tailored to meet the unique requirements of older adults. While older adults are becoming increasingly aware of the advantages of technology, they still face challenges and limitations when it comes to adopting new solutions that are available in the market [10]. These difficulties can make it challenging for them to find and use novel technological solutions, causing them to stick with conventional options and consequently, waste valuable resources.

1.1.1 Understanding the Silver Generation: Unique Challenges and Barriers

In recent times, there has been an increase in the number of people aged between 55-65 who are well-versed in technology [42]. They are capable of utilizing apps, e-services, and smart devices [148]. However, as they grow older and encounter age-related impairments and issues, their needs differ from those of older adults who are 80 years and above [86]. For these technologies to be effective, it is crucial to understand the unique needs and difficulties faced by the silver generation. According to the United Nations, individuals aged 60 years or older are considered to be older persons [152]. However, different organizations have categorized the silver generation into three groups: the "young-old" (ages 60-75), the "old-old" (ages 75-85), and the "very old" (ages over 85) [162]. The research community has varying perspectives on how to define this age group, with some considering individuals over 65 as older people [101, 163], and others regarding those over 60 years as elders [100, 125].[21] Additionally, some researchers define older adults differently, with some defining it as individuals above the age of 55 [19, 32, 44], while others consider those over 50 to be elderly people [71, 126]. For the purpose of this study, we have defined two groups within the silver generation: older adults aged 55 to 65 and those aged 65 and over [42]. These two age groups have distinct characteristics, requirements, and challenges that must be addressed when designing a platform for the silver economy. Although various studies have been conducted to identify the barriers and challenges faced

[21] `https://www.population-trends-asiapacific.org/mipaa`

by the silver generation when it comes to technology, only a few of them distinguish between different age groups within the silver generation. Furthermore, previous research becomes obsolete as more people enter the silver generation and technology evolves [83]. Digital literacy, technological abilities, *user experience* requirements, and unique challenges of the silver generation may change with time [15]. Therefore, it is crucial to conduct up-to-date research (primary or secondary) to identify the challenges and barriers faced by different groups within the silver generation when adopting technology.

As technology continues to evolve, ethical concerns are becoming increasingly important to consider [110]. Scams, phishing, identity theft, compromised integrity, social isolation, and other issues are on the rise [63]. With the advent of Artificial Intelligence (AI) powered homes and smart devices equipped with cameras, *technological ethical* implications arise [38]. Therefore, it is crucial to examine the ethical challenges that the silver generation faces in today's technological world. In addition to conducting new studies and research, it is also essential to identify and make use of existing knowledge resources [95]. This involves identifying the digital competencies of the silver generation, recognizing the potential advantages of smart living solutions, identifying potential barriers to accessing technology, and understanding the available IT infrastructure. By doing so, we can lay a foundation for further insights and innovative strategies to improve digital competencies, enhance user experience, increase accessibility, and tailor technological solutions to meet the diverse needs of different age groups within the silver generation.

1.1.2 Opportunities for Collaboration and Inclusivity in Technological Solutions

The silver economy requires the involvement of four major actors in the innovation systems identified in the *Quadruple Helix Model* of Innovation [123]. These actors include the academic sector (universities, research and development organizations, and vocational institutions), the private sector (private and public companies, incubator networks and digital labs, and business support services), the public sector (government and policymakers, municipality and cities) and end-users (in this case, older adults, associations, Voluntary NGOs & programs). To develop effective strategies for *co-creation* and innovative solutions, it is crucial to understand the motivations, incentives, perspectives, interests, and barriers of each actor [106]. This understanding helps to tailor the strategies for engagement to meet the unique needs and requirements of each actor. Additionally, exploring the dynamics of collaboration and partnership-building among these actors is critical, as each actor can adopt a different role in the co-creation process and take on different responsibilities. Therefore, it is essential to understand each actor's different roles and responsibilities [106].

Furthermore, it is important to establish effective communication channels and a collaborative culture to encourage diverse perspectives, competencies, and contributions [36]. Unfortunately, in many cases, only public, private, and academic actors are involved in the development process, leaving end-users on the back burner [123]. However, if solutions are targeted at the silver generation, it is highly imperative to involve them in the co-creation process [36]. They are the best people to understand what they need and want. However, creating technological solutions requires specific skills, so it is crucial to identify methodologies and approaches that facilitate meaningful partnerships and encourage active participation from the silver generation [164]. By doing so, we can create sustainable and impactful solutions that address the challenges of the silver generation and take advantage of the opportunities presented by the silver economy.

1.1.3 Challenges with Existing Digital Platforms

Digital platforms can play a significant role in empowering the silver generation to leverage their skills, knowledge, expertise, and experience and enable them to actively contribute to the economy [25]. There are several existing notable digital platforms in the market that help the silver generation in their daily routines. These platforms may provide opportunities to build social networks, reduce isolation, access information, avail different services, freelance and find remote work, offer their knowledge, and participate in different training programs.[22] However, only a very limited number of platforms actively involve the silver generation in the development and design of the platform itself and the solutions it offers [45, 158]. Furthermore, different platforms serve different purposes, such as Senior Planet[23] offers an online community and focuses on technology education, while Aging2.0[24] connects the silver generation with entrepreneurs and experts and hosts events, workshops, and challenges. Some digital platforms do not cater to accessibility issues, such as small font sizes or confusing navigation that could limit the ability of the silver generation to fully use the functionalities [35]. Moreover, older adults have diverse needs, especially among the two groups within the silver generation: older adults aged 55-65 and those aged 65 and over. They may have varying health conditions, cultural backgrounds, and technology literacy, which must be accounted for when developing solutions for this population segment and therefore lack a personalized experience [87]. Most of the solutions lack offline support, which should be integrated to enhance the effectiveness of the solutions for the silver generation [22]. In addition, some platforms do not offer privacy, security, and trust; therefore, the silver generation finds it challenging to use the platform with complete confidence [167]. Digital platforms for older adults should be designed using the user-centred approach [9, 77, 61, 66]. Digital platforms should address the barriers that the silver generation faces, such as age-related physical and cognitive impairments, digital literacy issues, accessibility problems, and social isolation [78]. Moreover, there are platforms like AGE Platform Europe[25] and AAL Programme[26] that integrate the quadruple helix actors; however, these platforms are more informative in nature, providing information on different projects, and also designing and development of such platforms are missing in scientific literature. Therefore, there is room for an improved *digital collaborative platform* which is called the *Digital Silver Hub (DSH)* that adopts user-centred design, addresses barriers and challenges of the silver generation, ensures *digital inclusion*, is dynamic, and continuously adapts to the rapidly changing technology and thus seeks user input and improves based on user feedback and changing needs [96].

1.2 Objectives

In order to fulfill the research gaps, the following research objectives are formulated:

- To understand the *technology readiness* of the current silver generation, and to investigate the barriers and challenges faced by the silver generation in adopting innovative technologies and explore strategies to overcome them.

- To analyze the existing digital platforms for the silver generation and identify their weaknesses, strengths, and areas of improvement and to assess the impact of the

[22] `https://www.un.org/en/un-chronicle/digital-technologies-can-help-older-persons-maintain-healthy-productive-lives`
[23] https://seniorplanet.org/
[24] https://www.aging2.com/
[25] https://www.age-platform.eu/
[26] https://www.aal-europe.eu/

digital collaborative platform on the well-being, digital and social inclusion, and empowerment of the silver generation.

- To conduct a needs assessment of the quadruple helix actors to identify their specific requirements, preferences, and expectations for a digital collaborative platform and to identify effective strategies to engage quadruple helix actors in the co-creation process.

- To investigate the role of *Collective Intelligence (CI)* systems in fostering collaboration, knowledge sharing, and *innovation* among quadruple helix actors.

- To investigate and evaluate the impact and effectiveness of the digital collaborative platform in facilitating the co-creation and uptake of innovative solutions, addressing aging challenges for the silver generation, and capturing silver economy opportunities.

1.3 Research Questions

To address research objectives, the following main research question and three sub-research questions were constructed:

- RQ: How to design a digital collaborative platform to facilitate the co-creation and uptake of innovative products and services in the context of the vertical market of the aging population?

  This question aims to explore features and functionalities required to develop a digital collaborative platform and to enable effective co-creation and collaboration among stakeholders to develop innovative solutions to cater to the challenges faced by the silver generation.

  - RQ.1 (Context): How is the context of the digital collaborative platform constituted in terms of technology readiness, available knowledge resources, and ethical concerns?

    This question aims to identify the technology readiness of the silver generation, including challenges and barriers to technology adoption and ethical concerns. It also aims to identify existing knowledge resources for ICT integration in the silver economy.

  - RQ.2 (Requirements): What are the requirements for the digital collaborative platform, in particular, in terms of collective intelligence (CI) systems?

    This question aims to determine the necessary features, functionalities, and infrastructure that the digital collaborative platform should support to facilitate co-creation and collaboration among diverse stakeholders and ensure that the platform enables the creation and uptake of innovative solutions in the vertical market of the silver population.

  - RQ.3 (Design and Evaluation): How does the elaborated design of the platform meet the goal and the requirements of the digital collaborative platform?

    This question aims to validate the elaborated design of the digital collaborative platform by evaluating its alignment with the goals and requirements identified and assessing its usability, effectiveness of functionalities, and user perception.

Table 1 *Publications and Associated Research Questions*

Research Questions	Publications
RQ	[I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII]
RQ.1	[I, II, III, VIII]
RQ.2	[IV, VI, XII]
RQ.3	[VII, IX, XI, V, X]

Table 1 shows the list of published articles that answer the aforementioned main and sub-research questions.

1.4 Brief Description of the Digital Silver Hub

The Digital Silver Hub (DSH) is a digital collaborative platform designed to foster innovation and collaboration amongst the quadruple helix actors (Figure 1.1 in publication V on pp. 125) to address the challenges faced by the silver generation. To begin with, the technology readiness of older adults was identified to determine their current status regarding the adoption of ICTs (see publication I on pp. 73). Ethical challenges that arise from technology were also identified (see publication III on pp. 100). The platform also compiled existing knowledge resources that can help integrate ICT into the economy (see publication II on pp. 91). Barriers and challenges that older adults face towards ICT adoption were also investigated, and recommendations were put forward (see publication VIII on pp. 222). Amongst many recommendations, involving older adults in the product design and development process, taking into consideration the unique needs of different age groups within the silver generation, engaging actors from all sectors, and the need for a unified digital solution were greatly emphasized.

Therefore, the concept of the DSH was coined (see publication IV on pp. 109), and functionalities were identified and developed based on the generic CI model by Shweta Suran et al. (see publication VI on pp. 190, and Figure 5.1 and 5.2 in publication V on pp. 135 and pp. 136). An *Agile (SCRUM) methodology* was used to develop the DSH, and components of the *platform's architecture* were outlined (see Figure 3.1 in publication V on pp. 129). These components included user management, country and role management, menu and category management, forum management, chat module, custom page management, information content management, alert module, information publishing and dashboard, mobile *User Interface*, and wiki module (see publication XII on pp. 298). The DSH is defined as an environment where different stakeholders can collaborate in innovation processes using a methodology based on knowledge exchange, co-creation/co-production techniques, and participatory methods to generate new innovative solutions to tackle aging challenges and exploit silver economy opportunities. See publication VII on pp. 202

The DSH operates within the *Smart Silver Framework*, which integrates quadruple helix actors, ensures efficient utilization of resources, and emphasizes collaboration. See Figure 6.1 in publication V on pp. 139. This framework consists of three layers: (i) quadruple helix actors, (ii) infrastructure focus areas for each helix actor, and (iii) classification and references.

The landing page of the Digital Silver Hub (DSH) consists of a main title, 'Digital Silver Hub,' along with introductory statements intended to familiarize the user with the main concept of the hub. The taskbar on the page displays three sections: 'About,' 'How it works?' and 'Login/Signup' as shown in Figure 6.2 in publication V on pp. 141. Additionally, the landing page offers the option to choose from different languages as shown in Table 6.1 in publication V on pp. 140. The landing page also includes a Help button and a FAQ page.

The platform requires users to signup, build a profile, and login before accessing some of the major functionalities where users make contributions in any form. The signup form is shown in Figure 6.4 in publication V on pp. 142; additional tabs will be shown depending on which role the user chooses from Figure 6.3 in publication V on pp. 142. For specific roles, the form will include the tabs shown in Table. 6.2 in publication V on pp. 143. After entering information and using the correct email address and password, the user is able to login as shown in Figure 6.5 in publication V on pp. 144 and view the home page. The home page consists of links leading to different platform features and functionalities, as shown in Figure 6.6 in publication V on pp. 145.

Smart Silver Labs, a multi-layered governance structure, employs the Smart Silver Framework and serves as an open innovation ecosystem, enabling innovation actors to connect, coordinate, and collaborate to develop innovative products and services for the silver generation in the BSR. See publication V on pp. 143 and publication VII on pp. 203. The Smart Silver Lab uses the DSH to communicate and establish collaborations amongst its first layer of governance, which is the quadruple helix actors, to identify new "*trajectories, which each region may need to acquire to access new forms of knowledge, create new recombinations of their resources, and move from path extension to new path-creation.*" The second layer of governance is the *Transnational Cluster*, which is composed of each regional Smart Silver Lab and supports innovation actors[27] as shown in Figure 6.6 in publication V on pp. 145.

There is also an *Idea Lab*, which will serve as the repository for all the ideas that have been shared, provided feedback on, and concluded, as well as the new and upcoming ideas. Innovation actors can provide feedback on the ideas through voting, commenting, or taking it to the discussion forum. To share an idea or give feedback, the user has to sign up and log in. See Figure 6.7 in publication V on pp. 147. In order to submit an idea, the user has to submit an idea proposal form as shown in Figure 6.8 in publication V on pp. 148.

On the DSH, innovation actors and teams can generate new ideas that must be analyzed for their feasibility and practicality as viable products and services using *innovation-supporting tools* (see publication VII on pp. 204). The toolkit is structured in accordance with the innovation development phases shown in Figure. 5.3 in publication V on pp. 137. These tools include:

- *Open Innovation Toolkit* is a curated collection of tools and services to support actors involved in the innovation process, including ideation, prototyping, market adoption, and partnerships. See publication V on pp. 137 and publication VII on pp. 204.
- *Financing Mechanism* acts as a bridge between innovation actors and different funding sources and investment organizations. It assists in project development and entrepreneurial opportunities. See publication V on pp. 137 and publication VII on pp. 204.
- *Knowledge Diffusion Toolkit* fosters the utilization and transfer of knowledge among innovation actors by highlighting best practices and benchmarks for efficient collaboration. See publication V on pp. 137 and publication VII on pp. 204.

[27] `https://osiris-smartsilvereconomy.eu/smart-silver-lab/`

The DSH provides *networking and collaboration opportunities* which include the *discussion forum* (see Figure 6.9 in publication V on pp. 149.) and *partner searching* (see Figure 6.11 in publication V on pp. 151). There are regional forums and an international forum on the DSH. Regional forums use the local language, and international forums are in English. Partner searching enables innovation actors to find potential collaborators for their projects and entrepreneurial ventures. In order to contact a partner, a form has to be filled out as shown in Figure 6.10 in publication V on pp. 150 and sent to the potential partner.

In addition, information about different *events*, including hackathons, conferences, workshops, and other 'innovation/technology-themed meetups, is published on the DSH (see publication V on pp. 157). News regarding other innovations for the silver economy will be displayed in the newsletter along with upcoming events, seminars, webinars, etc., organized in different regions of the BSR (see publication V on pp. 157. The DSH also publishes *silver market characteristics*, which are detailed information on regional business environments, facilitating market analysis and innovation development. See publication VII on pp. 206.

The DSH also provides *collaboration tools* to help innovation actors in different regions collaborate on ideas and work together as one team. See Figure 6.14 in publication V on pp.155. Adding a new project requires the user to fill out a form as shown in Figure 6.12 in publication V on pp.152 and choose which tabs they like on their project interface (see Figure 6.13 in publication V on pp.153). Given that the user allows for all the tabs on the new or existing project, the user should be able to use the following collaboration tools:

- Invite/add new partners
- Assign tasks
- Make agenda
- Build workflows
- Discussion forum
- Zoom meetings
- Schedule on the calendar
- Time deadlines
- Make notes
- Upload important files
- Archive project

Innovation actors can use the DSH to test their ideas and conduct *market research* (see publication V on pp. 154.). Testing can be conducted with older adults or other innovation actors to understand the market. The participants for market research can be accessed from the DSH and conduct one-on-one discussions, surveys, and focus group discussions.

Moreover, *competitions* can be held on the DSH on various themes related to the silver economy: healthcare, leisure, social life, living environment, safety, etc. This helps attract new users to the DSH and grow a community of like-minded people. See publication V on pp.156. In addition, the DSH serves as an *information library* that consists of all the existing services and products in the market for older adults (see publication V on pp.

156). Every region will have its list, and this helps older adults to find all related items in one place and choose the most appropriate one as shown in the example of taxi services in Estonia in Table 6.3 in publication V on pp. 157. The DSH also provides different *training* and mentoring programs for older adults. See publication V on pp. 157. This may include general IT skill classes, specific banking services classes, and even fitness training.

These functionalities were evaluated initially through information sessions where participants were given a comprehensive introduction to the core concept of the DSH and its various functionalities (see publication V on pp. 159). For evaluation sessions, the DSH introduction consisted of the following:

- A presentation of the system's documented *user dialogues* in terms of a form-oriented dialogue model [50, 8, 7]. See publication V on pp. 139;
- A demonstration of the recent web-based implementation of the Silverhub collaborative platform;[28]
- Scenario and *customer journeys* of the DSH (see publication X on pp. 251);
- Wireframes of the DSH.

The feedback regarding different functionalities was recorded and incorporated into the DSH. The DSH was then evaluated on the basis of dimensions of the *Technology Acceptance Model (TAM2)*, *perceived usefulness*, *perceived ease of use*, and *attitude towards using the technology*, along with dimensions of generic CI framework, staffing, processes, goals, and motivation to evaluate the DSH. See publication IX on pp. 235.

Furthermore, a *user-centred evaluation* was conducted by integrating the principles outlined in ISO 9241-210 [66] and provided practical implications for stakeholders designing digital collaborative platforms for older adults, emphasizing the importance of tailoring solutions to meet the specific needs of different age groups within the silver generation. See publication XI on pp. 273.

[28] `https://silverhub.eu/`

2 Relevant Studies

From 2019 to 2023, the author conducted a thorough analysis of the state of the art and continuously reflected on related work. The author searched Google Scholar, Scopus, IEEE Xplore, and the ACM Digital Library using relevant keywords.

This section presents an overview of the relevant information obtained from the related literature and explains how this thesis will contribute to the knowledge base [62]. It addresses current gaps in research questions presented in Section 1.3.

2.1 Silver Economy and ICT

The concern regarding the growing silver population is a significant issue, and it has implications for various markets and industries [129]. The European Commission defines the silver economy as activities that cater to the needs of older adults, including the production, utilization, and exchange of goods and services [150]. According to Cornet (2015), the silver economy is diverse and serves individuals with varying statuses, incomes, health conditions, and social and cultural backgrounds. This includes baby boomers, active retirees, and vulnerable older adults facing dependency risks or social isolation [41].

Recent research has shown that developed countries have a higher percentage of older adults compared to developing nations [150]. Projections indicate that by 2060, one-third of Europeans will be above 60 years old, resulting in a significant change in the ratio between retired and working citizens from 2:1 to 4:1 [170]. Furthermore, countries in the BSR are among the most rapidly aging areas globally [17], with an increase in the percentage of citizens aged 60 years or above.[29]

The changing demographics have become an indicator of prosperity within regions that have prompted policy development across sectors, particularly among EU nations. The silver economy has significant impacts on transportation, healthcare, social services, eHealth solutions, robotic assistance, and public services [170].

Insights from consultations by the Organisation for Economic Cooperation and Development (OECD) and Global Coalition on Aging (GCOA) are valuable sources for studying the silver economy.[30] Additionally, a background paper provided by the European Commission is crucial for understanding this phenomenon.[31] The OECD-GCOA perspective emphasizes that the silver economy focuses on individuals over 60 years old to enhance their active lifestyle, including work-life balance. On the other hand, the European Commission defines the economy more broadly as serving individuals over 50 years old.

One possible solution to meet citizens' needs is through ICT solutions.[32] The field of ICT presents opportunities for engagement and contribution to the environment. It encompasses sectors such as AHA (active and healthy aging), wellbeing, eHealth, senior tourism, age-friendly housing, and health and social care [170], all undergoing development processes [30]. Interactive platforms that connect individuals with developers of solutions are emerging as valuable tools [68]. ICT has a ranging impact as it includes technologies that enable access to information through telecommunications, such as Internet-of-Things (IoT), wireless networks, cell phones/smartphones, and other similar means of transmitting information [168, 171]. In the healthcare industry, ICT provides essential tools that support a wide range of functions, such as managing hospital equipment and devices, handling pharmaceuticals, facilitating medical procedures, and providing eHealth

[29] https://neweuropeaneconomy.com/fdi/digital-economy-estonia/
[30] https://apo.org.au/node/62476
[31] https://digital-strategy.ec.europa.eu/en/library/growing-silver-economy-background-paper
[32] https://neweuropeaneconomy.com/fdi/digital-economy-estonia/

services. These services include maintaining health records, issuing medicine prescriptions, monitoring patients' vitals in real-time, managing schedules, and much more [52]. In the development of homes, ICT provides smart solutions for individuals to live independently [52]. Moreover, integrating ICT innovations into autonomous transportation improves accessibility to public transport services for disabled individuals [52]. According to Il-Yeol Song et al. (2018), the concept of smart aging is gaining popularity because of its benefits, such as improved well-being and increased independence, consequently leading to lower healthcare costs [142]. ICT also promotes banking and e-banking services, making financial management more straightforward and accessible for older adults [52]. Lastly, in the tourism sector, entertainment and recreational activities tailored to retired citizens can be facilitated through ICT solutions [52]. Therefore, it is crucial to enhance digital literacy among the silver generation to overcome challenges associated with adopting ICT in the silver economy [103].

2.2 Digital Platforms for the Silver Economy

The silver economy has gained attention with the increase in the global aging population, focusing on products and services for individuals aged 50 and above [82]. With advancements in technology, digital platforms have emerged as tools to address the challenges faced by the silver generation [115]. In this literature review, various initiatives and projects in the BSR and beyond are explored, examining the concept of digital platforms for the silver economy.

Digital collaborative platforms play a crucial role in enhancing the quality of life of the silver population. These platforms are software-based systems that have a modular technological architecture, coordinate external actors that innovate and compete, and function as a central hub of an ecosystem where peripheral firms or individuals facilitate, complement, and connect via boundary resources [144]. Such platforms store information to optimize services that are specially tailored to the needs of the silver generation by incorporating advanced technologies like the Internet of Things (IoT), Big Data, and Machine Learning [115]. Some notable examples of such platforms include Gubbe, VideoVisit, and Fiksari in Finland, which provide home care services, healthcare assistance, and technology support for older adults.[33]

The EU has been actively involved in promoting research initiatives to support the silver economy. The Digital Agenda for Europe 2020 recognizes the importance of eHealth, addressing the needs of an aging population with a focus on ICT [3]. The GRUNDTVIG program aims to support the goal of life-long learning (LLP) for the silver population of Europe.[34] Through the EU Seventh Framework Programme (FP7), various projects have received funding to utilize ICT applications and develop solutions catered to the silver generation or disabled individuals [82]. One noteworthy project is OASIS[35], which leveraged technologies to provide benefits explicitly targeted at older adults.

There has been a rise in platforms that cater to the needs of older adults, offering services related to healthcare, socialization, housing, and more [1]. Examples include Aging-

[33] https://www.goodnewsfinland.com/en/articles/feature/2021/elderly-care-finds-solutions-in-digital/

[34] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Grundtvig_programme

[35] https://www.age-platform.eu/project/oasis-project-overview-and-conclusions

Care[36], Age UK[37], and American Association of Retired Persons (AARP)[38], which provide resources, advocacy efforts, and community support for older adults in regions. AgeTech Collaborative[39] also plays a role by fostering innovation and collaboration within the aging and technology domain [32]. Silvernest[40] is another platform that facilitates home-sharing arrangements by connecting aging homeowners with housemates as a means of addressing housing challenges faced by the silver generation. A complete list of digital platforms is given in the research paper XI.

However, despite their benefits, existing digital platforms encounter challenges and limitations [40, 16, 112].[41] Some platforms lack accessibility features such as unreadable font size or confusing navigation systems that may restrict their usability among the silver generation [35]. The personalization of experiences often falls short when serving older adults due to variations in their health conditions, technology literacy, and cultural backgrounds [87]. It is also important to consider support for older adults with accessibility issues, such as not having consistent internet access. In addition, older adults prioritize privacy, security, and trust when using platforms [167].

Therefore, it is crucial to adopt a user-centred approach to make digital platforms more effective for the silver generation [9, 77, 61, 66]. This means addressing challenges such as age-related impairments and lack of digital literacy and combating isolation to ensure inclusivity across all groups of the silver population. Platforms should continuously adapt to evolving technology and user needs by seeking user input and feedback. By integrating support, improving accessibility features, and prioritizing privacy and security measures, we can significantly enhance the user experience for older adults [78].

2.3 Technology Readiness of the Silver Generation

The increasing number of older adults in our society has highlighted the significance of technology in enhancing their quality of life [122]. Older adults encounter difficulties when it comes to accepting and utilizing ICTs [118]. This review examines various aspects related to the readiness of older adults to adopt technology, considering factors such as age, education, barriers to adoption, and inclusive design. Furthermore, we explore social considerations for implementing ICT for the silver population.

Several studies have shown that the use of the internet among older adults is closely related to factors such as age, gender, and employment status [109]. Within the silver population, we can identify two age groups: older adults aged 55-65 and those aged 65 and above [42]. Older adults aged 55-65 tend to be more familiar with technology and display a positive attitude towards embracing ICT solutions [109]. They are individuals who prioritize their health and often use technology for fitness tracking, nutrition management, and staying connected through social networks [124]. Nevertheless, incorporating technology into their work lives may present challenges, which could lead to resistance toward change [24]. Additionally, they may seek platforms that offer opportunities for online learning after retirement [85].

On the other hand, older adults aged 65 and over often face a variety of physical, cognitive, and sensory challenges that can make it difficult for them to learn and use new technology [157]. This, coupled with issues like lack of familiarity with technology and

[36]https://www.agingcare.com/
[37]https://www.ageuk.org.uk/
[38]https://www.aarp.org/
[39]https://www.aarp.org/home-family/personal-technology/info-2021/age-tech-collaborative.html
[40]https://info.silvernest.com/far
[41]`https://www.nia.nih.gov/about/aging-strategic-directions-research`

difficulty in usability, can make it harder for older adults to embrace advancements in technology [34]. Additionally, concerns about privacy [114, 107], social isolation [69], cost considerations, and limited access to technology and infrastructure [104, 158] greatly influence the willingness of older adults to adopt ICTs. For many older adults aged 65 and over, traditional non-digital tools are still preferred due to their familiarity and ease of use. [18].

While technology solutions have the potential to enhance the quality of life for the silver generation, it is crucial to address social concerns [75]. Relying heavily on technology may result in isolation and dependence on digital communication, diminishing real human interactions [75, 81]. Privacy becomes a concern with monitoring technologies that compromise the confidentiality of individuals [29]. Although AI and robotic assistants can simplify technology use, they may also lead to social connections by dehumanizing interactions [172]. Furthermore, ethical considerations include cybersecurity threats [70] and the affordability and accessibility of technology solutions [74].

To effectively implement technology solutions for the silver generation, it is necessary to have an understanding of their diverse needs, challenges, and preferences. Factors such as age, education level, and individual characteristics significantly influence their willingness to adopt ICTs [109]. Overcoming barriers to adoption, ensuring design practices, and addressing social concerns are all essential steps toward the successful implementation of technological solutions. The importance of allowing older adults to choose from a range of technology options that suit their preferences and convenience is emphasized in literature [118]. It is recommended that products designed for older adults be kept simple and unobtrusive with instructions and manuals for getting started [107]. Providing training, support, and easy access to helplines are vital for technology use [104]. As the population ages, it is crucial to prioritize a user-centred approach that appreciates connections and upholds the dignity and privacy of older adults [9, 77, 61]. This should be the foundation for developing and implementing ICTs tailored to this demographic.

2.4 Collective Intelligence

The concept of Collective Intelligence (CI), also referred to as *wisdom of the crowd* [57], has piqued the interest of researchers for several years. The central premise behind CI is that when individuals come together in groups, they can efficiently solve problems, make decisions, and achieve goals better than if they were working alone.[146] The Jury theorem is credited with laying the foundation for CI, as it observed that groups of individuals tend to make better decisions compared to individual members.[79] CI has since been widely applied across various research fields, including biology, sociology, psychology, social networks, computer science, human-computer interaction (HCI), organization, and management [146]. The popularity of CI concepts such as *crowdsourcing*, citizen science, open innovation, social norms, and collective behavior has grown across domains and continues to be relevant.

CI platforms have become powerful tools for problem-solving, idea generation, decision-making, outcome prediction, and information exchange [89]. These platforms offer benefits to both individuals and society. Examples of CI platforms include the first wiki, WikiWikiWeb [89], and GoldCorp [23], which utilized knowledge to identify new gold mining locations. With advancements in ICT technologies, such as the web, mass collaboration has been facilitated, leading to the emergence of novel CI platforms such as Wikipedia, Climate CoLab, Tippanee, InnoCentive, and Reddit [89, 111, 161].

Various researchers have proposed models and frameworks to understand how CI platforms function [91, 21, 156]. However, many of these models are specific to domains and use cases, which limits their applicability in diverse contexts [145]. Moreover, various metaphors have been used to explain these models, such as genes, system-specific elements, principles, attributes, requirements, or combinations thereof. This lack of a framework for collective intelligence creates obstacles in effectively developing new platforms [146, 145].

To address the need for a framework for CI, Shweta Suran et al. (2020) proposed an all-encompassing model that enables researchers and stakeholders to integrate different components and create novel platforms regardless of the domain [146], shown in Figure. 1. The *generic CI model* is based on four components: Staffing, i.e., *Who is performing the task?*, Goals i.e., *What is being accomplished?*, Processes i.e., *How is it being done?*, and Motivation i.e., *Why they are doing it?*; and these are again divided into *types*, *properties*, *and interactions*.

- The staffing of the generic CI framework refers to the users of CI platforms. These users can be divided into two categories based on their roles and responsibilities: contributors and beneficiaries. Contributors are individuals who use their knowledge and expertise to solve problems and generate new solutions. For example, on CI platforms like InnoCentive and OpenIDEO, users from different countries collaborate with each other to propose novel solutions, such as modifying engine oil to reduce transport to the combustion chamber or finding ways for businesses of all kinds to rapidly adapt to support the immediate needs of the COVID-19 response and enable a more just and resilient future. Contributors on CI platforms can be further categorized as hierarchy and crowd. Members of the hierarchy are mainly experts and administrators who manage work allocation, while members of the crowd are active contributors who submit new artifacts or information. Kaggle is a platform where both types of contributors can be seen: the crowd submits new machine-learning solutions or optimizes existing ones, while the hierarchy allocates resources or selects the best solution. [146]

  The generic CI model has some essential features that apply to the characteristics of the crowd. Firstly, the users should come from diverse backgrounds such as different cultures, and economic and social statuses. Secondly, the users should be independent of each other to maintain unbiased opinions. Lastly, the crowd should have a *critical mass*. A perfect example of such properties can be seen in Climate CoLab, where users come from different countries, have different expertise, and can work independently or in a group, but must follow some rules. Additionally, the crowd should trust and respect each other to promote co-creation among its members. Lastly, they should follow the SECI model (socialization, externalization, combination, and internalization) to convert tacit knowledge into explicit. [146]

- According to the proposal by Shweta Suran et al. (2020), goals can be classified as individual and community goals. Additionally, goals should be objective and well-defined. An example of this can be seen in InnoCentive, where individuals submit novel ideas in response to challenges. The community provides feedback in the form of comments, votes, likes, or dislikes, and ultimately selects the most innovative idea. The individuals learn from the feedback and can be rewarded for their submission. [146]

- The generic CI framework categorizes processes into different types and interactions. Processes can be classified as collection, collaboration, group decisions, and individual decisions. Collection activities are independent, where individuals create

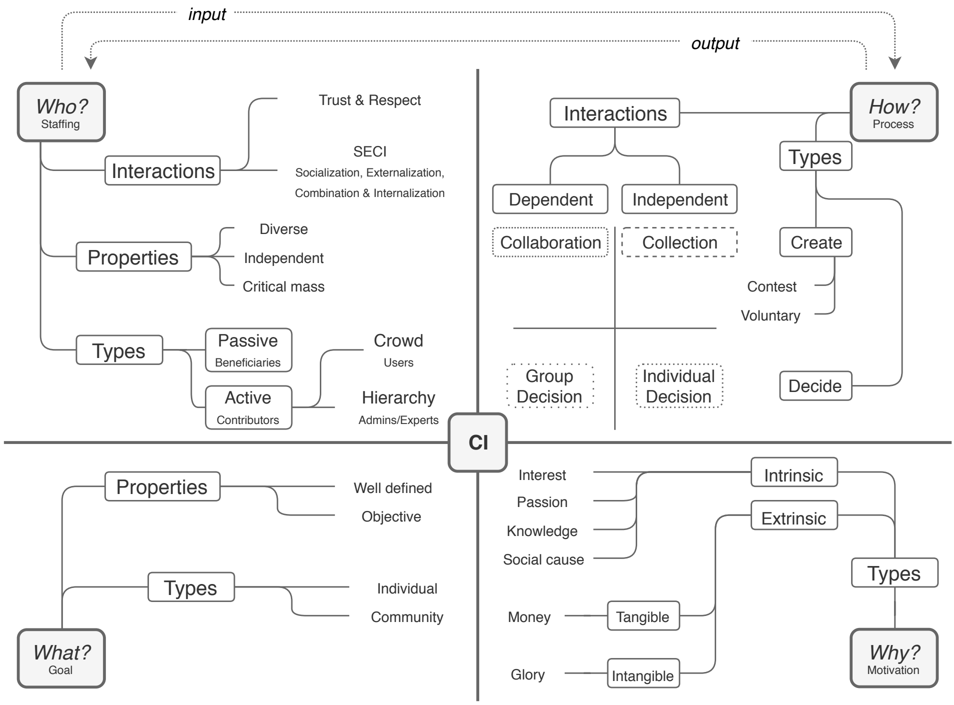

Figure 1: 'Generic' CI Model of Sweta Suran et al. [146]

new innovative solutions and solve problems without being part of any community. On the other hand, group tasks are a part of collaboration activities, where individuals come together on a platform to create new knowledge and solutions. Kaggle is an example of such collection and collaboration activities: an individual user posts the solution, and different communities can evaluate and improve it. [146]

Decisions can also be independent (individual decisions) or dependent (group decisions). For example, in Threadless, users can make individual decisions like selecting or rejecting T-shirt designs submitted by other users. On the other hand, in group decisions, multiple users as a community select or reject the designs. The end result of group decisions affects the entire community. [146]

- Collaboration among users is driven by intrinsic and extrinsic motivations. Intrinsic motivations, such as passion and interest, are present in platforms like Reddit and Stack Overflow, where users share new information on specific topics. Social causes also drive collaboration, as seen in platforms like HackAir and Climate CoLab, where users come up with innovative solutions to tackle global climate issues. On the other hand, extrinsic motivations include tangible rewards, as seen in platforms like InnoCentive and Goldcorp, where users receive cash prizes for submitting novel solutions. Intangible rewards, such as reputation and recognition, are present in platforms like WikiCrimes and Kaggle, where users earn a reputation based on their continuous contributions. [146]

CI benefits from diversity as it brings fresh ideas and viewpoints to a given topic [147, 23]. Homogeneous groups are more susceptible to group-level biases, whereas diverse groups outperform them on tasks that require collective intelligence [105]. Diversity adds perspectives and encourages the expression of opinions. Furthermore, communication patterns within a group are directly proportional to the level of collective intelligence [73]. More communication among group members leads to higher collective intelligence.

3 Research Design

A systematic and structured approach was adopted to design the digital collaborative platform, the Digital Silver Hub (DSH), which integrates theoretical insights and empirical findings [62]. An overview of the research design, along with publications and associated research questions, is presented in Figure 2.

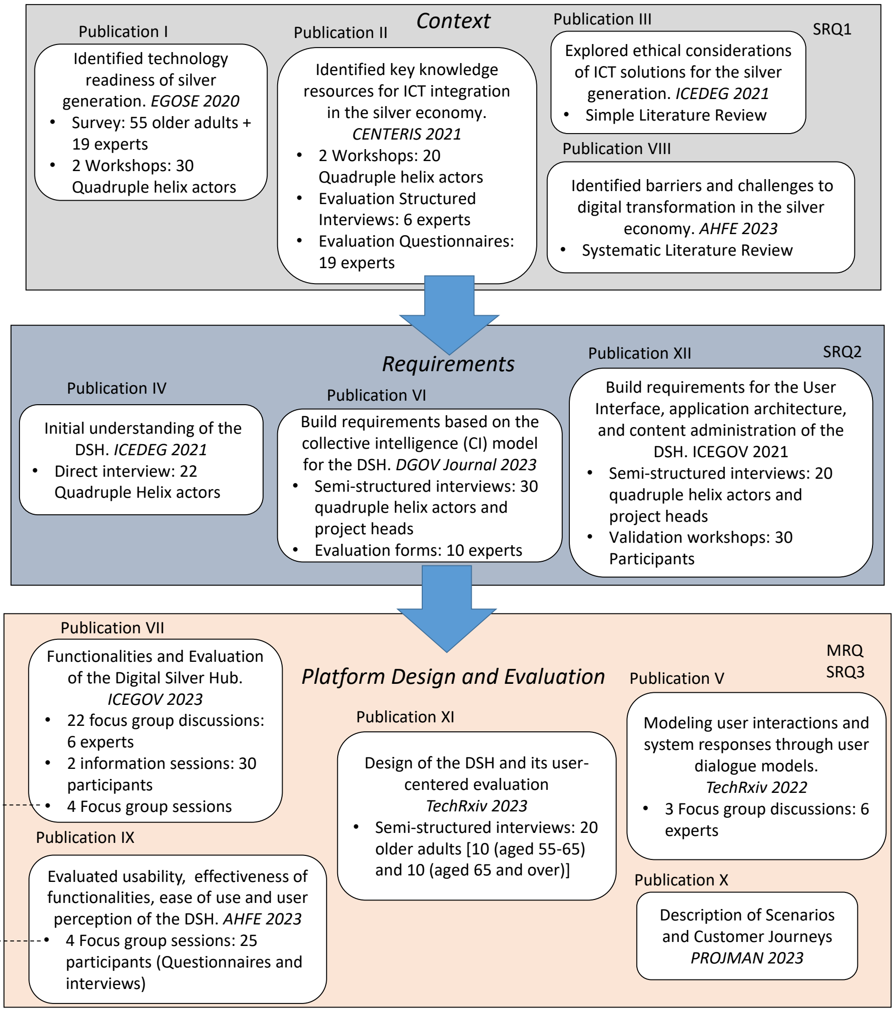

Figure 2: Research Design

For this research, the design science methodology [62, 113, 153, 92] was particularly suitable as it focuses on developing and evaluating artifacts, such as systems, models, or frameworks, to address practical and specific challenges and problems [113]. Design science provides an iterative approach to designing, implementing, and evaluating innovative solutions by combining rigorous research methodologies with practical design principles [62, 113, 153, 92]. Among design science methodologies, *action design research* (ADR) emphasizes iterative cycles of diagnosis, action, evaluation, and reflection, allowing for continuous feedback and adaptation [128, 98, 43, 46]. ADR emphasizes the practical application of research findings to real-world settings [128, 98, 43, 46].

This research adopts principles and practices of both design science and, in particular, ADR to ensure that the designed and developed artifact contributes to the silver economy and develops innovative solutions that cater to the challenges faced by the silver generation. To ensure the rigor and validity of the research, different qualitative and quantitative methods were employed in the design and evaluation of the platform.

The first step (Publication I) of the research involved identifying the technology readiness of the silver generation of Estonia and exploring the challenges and barriers they face when adopting ICT solutions. For this purpose, two survey questionnaires and two workshops were conducted. The first questionnaire targeted 55 older adults to understand their challenges to ICT adoption. The second questionnaire was targeted at 19 experts working in the IT field and developing solutions for the silver generation. The results of the questionnaires were presented as graphs and pie charts. The outcomes of the questionnaires were further validated and discussed in the two workshops with a total of 30 participants, including older adults aged 50+, as well as experts from the science, business, and government sectors.

Furthermore, a simple literature review was conducted to identify the existing ethical issues concerning the ICT solutions for the silver generation (Publication III). A simple literature review provides a comprehensive overview of existing knowledge and contextualizes the research regarding the current state of the art, and possible areas of further exploration [12]. These barriers, challenges, and ethical ramifications faced by the silver generation were further analyzed through a systematic literature review (Publication VIII). A systematic literature review provides comprehensive coverage and unbiased synthesis of existing knowledge, identifies knowledge gaps, and helps summarize and compare the results of various studies [72]. Eight hundred articles were skimmed to identify the nine most relevant studies using inclusion and quality criteria. These articles were further used to extract and synthesize data, which was analyzed through a tool-based thematic analysis [39] using NVivo [160]. Furthermore, existing knowledge resources were identified for ICT integration in Estonia (Publication II) through two workshops with a total of 20 quadruple helix actors, including businessmen, entrepreneurs, policymakers, researchers, professors, and older adults from Estonia. A *knowledge map* [94] was created using the Ontology model in Web Protégé to demonstrate the critical knowledge resources for ICT integration in the silver economy. The knowledge map was further validated through six structured interviews and 19 questionnaire responses from experts from different fields of IT, social sciences, and healthcare in Estonia.

The next step was to conceptualize the digital collaborative platform in terms of the platform's structure, goals, and initial requirements (Publication IV). For research purposes, the author was also part of a larger project called OSIRIS - 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth'.[42] In order to gather initial requirements for the DSH, 22 direct interviews were conducted with the quadruple helix actors involved in the OSIRIS project. The data collected through the interviews were analyzed through a tool-based thematic analysis using open-source qualitative data analysis software, RQDA [55]. The vision and mission statement of the DSH were established.

Moving forward, functionalities and features of the DSH were identified (Publication VI) through 30 semi-structured interviews with the partner heads of the OSIRIS project as well as quadruple helix actors from six regions in the BSR: Estonia, Latvia, Finland, Lithuania, Denmark, and Russia (St. Petersburg). Deductive thematic analysis [39] was

[42] https://osiris-smartsilvereconomy.eu/about-project/

conducted to analyze these functionalities in terms of collective intelligence (CI) components, staffing, processes, goals, and motivation based on a most recent generic CI model [146]. The functionalities were further evaluated by ten experts working in the field of science and technology in the silver economy through evaluation forms. In addition, a further 20 semi-structured interviews were conducted with project heads and quadruple helix actors from the BSR to identify the requirements for the User Interface (UI), application architecture, and content administration (Publication XII). These requirements were further validated in a workshop with 30 participants.

The functionalities and requirements were further subjected to a comprehensive analysis to refine and expand upon (Publication VII). Twenty-two focus group discussions were carried out with project partners and subject matter experts. Focus group discussions allow participants to share their experiences, opinions, and perspectives on a specific topic, which can lead to a deeper understanding of the topic [13]. These focus group discussions were conducted online and, on average, two hours long and comprised of semi-structured discussions. Combined with previous work, the outcomes of these discussions resulted in concrete functionalities, features, and processes of the DSH. Furthermore, three focus group discussions were carried out with six participants from the IT field. These participants included developers, back-end engineers, and front-end engineers. The outcome of the discussions was to identify the *system architecture* and the possible user interactions and system responses was mapped out through *User Dialogue Models* (Publication V) [51], which were generated using UML Activity Diagrams. In addition, scenarios and *customer journeys* were described (Publication X), wireframes were constructed, and a web-based implementation of the Silverhub[43] collaborative platform was established.

The DSH was evaluated initially in two information sessions with a total of 30 participants (Publication VII). Participants included the project members and quadruple helix actors from the six regions of the BSR participating in the OSIRIS project. The first information session was conducted online due to the pandemic, and the second was in person. Participants walked through the web implementation of the DSH and user dialogue models and evaluated them based on their first impressions of the platform and their overall opinions about different functionalities. Subsequently, four focus group sessions were conducted (Publication IX) with a total of 25 participants, including the quadruple helix actors from the six regions of the BSR. The participants were walked through the web implementation of the DSH, and user dialogue models were presented. Focus group discussions were divided into two parts; firstly, participants completed a closed-ended questionnaire and then participated in group interviews. The dimensions of the *Technology Acceptance Model (TAM2)* [48, 155]; perceived usefulness, perceived ease of use, and attitude towards using the technology, along with dimensions of generic CI framework [146]; staffing, processes, goals, and motivation were used to evaluate the DSH.

One core aspect of ADR is the reflection, which critically analyses and reflects on the actions taken, outcomes achieved, and implications of both practice and theory [128]. Therefore, as a further step, a *user-centred evaluation* is employed to design and evaluate the DSH (Publication XI) [37, 77, 61] by integrating the principles outlined in ISO 9241 210 [66]. Silver generation is divided into two groups: older adults aged 55-65 and those aged 65 and over. Semi-structured interviews were conducted with 10 older adults aged 55-65 and 10 older adults aged 65 and over, with a total of 20 participants. These participants belong to the six regions of the BSR. The interview with each participant was conducted in two parts, with the first part including a discussion about different barriers and challenges they face when adopting and using the technology. The second part involved showing the

[43]https://silverhub.eu/

platform wireframes, scenarios, and customer journeys [141] and web implementation of the SilverHub Platform to the participants to provide a visual representation of the functionalities and features of the DSH. The participants then discussed the possible ways the DSH can help overcome some of the challenges they face when using technology, provided their feedback, gave suggestions, and provided valuable insights to the DSH. The data collected from the interviews were then transcribed, and a tool-based thematic analysis [39] was conducted using NVivo [160].

The context, results, and evaluation of the DSH are covered in the publications [I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII].

4 Results

This section summarizes the results of RQ1, RQ2 and RQ3 and how research has contributed to filling gaps in the state of the art.

4.1 RQ1 (Context)

Sub RQ1 (Context): How is the context of the digital collaborative platform constituted in terms of technology readiness, available knowledge resources, and ethical concerns?

4.1.1 Technology Readiness of the Silver Generation

In publication I, it was found that the majority of older adults in Estonia do not use smart devices or the internet due to a lack of knowledge and digital literacy. Older adults face challenges such as skepticism and resistance towards technology, fear of learning new digital skills, and complex online forms. Solutions proposed to increase technology readiness included creating awareness campaigns, conducting community-based workshops, establishing competence centers, providing specialized training, and making online forms more user-friendly. Further research should be conducted to identify varying needs among different age groups within the silver generation. For detailed results, see the publication I on pp.65.

4.1.2 Knowledge Map for ICT Integration

In publication II, existing knowledge resources were identified to integrate ICT into the silver economy of Estonia. The focus areas included smart living, digital competencies of older adults, medical help, IT and internet penetration, active lifestyle, and one size doesn't fit all. A holistic knowledge map was constructed to visually represent the knowledge resources for ICT integration, encompassing legal, infrastructure, service design, actors, promotion, and knowledge management aspects, as shown in Figure. 3. These knowledge resources were further evaluated, and it was found that the map lacks a critical aspect: interoperability. Moreover, particular challenges of the silver generation were highlighted, and the importance of tailored approaches to *technology adoption* to enhance ICT integration in the silver economy was emphasized. For detailed results, see the publication II on pp.85.

4.1.3 Ethical Challenges

In publication III, ethical challenges faced by the silver generation toward ICT adoption were explored. These challenges included the stigmatization of older adults by referring to them as the burden ratio, social isolation and technological dependency, privacy and integrity concerns, dehumanization of interaction, cybersecurity and data privacy, limited affordability and accessibility of ICT solutions, lack of inclusive solutions and empowering choices and lack of inter-generational communication. For detailed results, see the publication III on pp.97.

4.1.4 Barriers to Technology Adoption and Recommendations

In publication VIII, further barriers and challenges were identified, and recommendations were provided on how digital transformation can engage older adults in the economy by addressing the hindering factors to ICT adoption. Older adults find technology difficult to use and navigate, have limited knowledge and understanding of technology, are concerned about data management and privacy, and are influenced by social and cultural

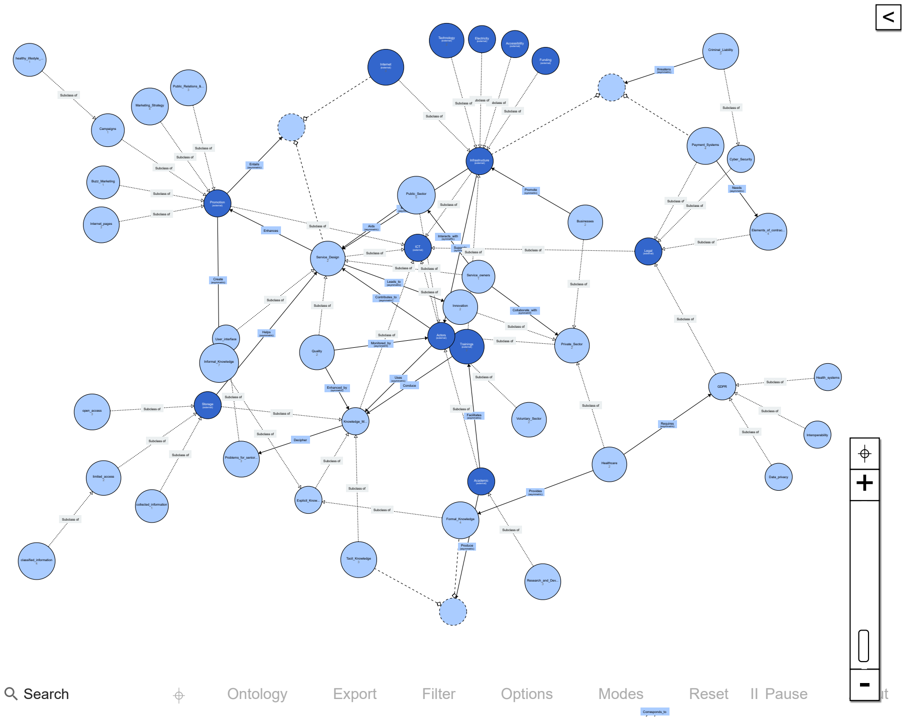

Figure 3: Knowledge Map

factors. In addition, lack of access to technology and infrastructure can be a significant barrier to ICT adoption for older adults.

To enhance technology use by older adults, it is important to design technology and digital solutions that are user-friendly and inclusive. This means that digital solutions should offer larger fonts, fewer buttons, speech-activated tools, and straightforward instructions and training. Additionally, solutions should ensure clear and transparent data collection and usage information, and take into account individual characteristics such as language and cultural support. Older adults should also be involved in the design and development process of the product or service concerning them. Various stakeholders from different sectors, including government and policymakers, should collaborate in funding, creating policies, and promoting public-private partnerships to support older adults' use of technology. For detailed results, see the publication VIII on pp.211. To this end, the Digital Silver Hub (DSH) was developed as a digital collaborative platform that fosters innovation and knowledge exchange through co-creation, co-production, and participatory methods. This platform aims to generate new innovative solutions to address aging challenges and exploit silver economy opportunities.

4.2 RQ2 (Requirements)

Sub RQ2 (Requirements): What are the requirements for the digital collaborative platform, in particular, in terms of collective intelligence (CI) systems?

4.2.1 Conceptualization of the Digital Collaborative Platform

In publication IV, the digital collaborative platform, the DSH, was conceptualized to understand the initial requirements of the stakeholders. It was imperative to understand if the DSH would serve as a virtual marketplace, utility platform, social media platform, crowdsourcing platform, or only as a *knowledge hub*. Different actors and their roles on the DSH were identified. In addition, focus areas of the DSH and barriers that may hinder the successful implementation of the DSH were discussed. The vision and mission statement of the DSH were also articulated. For detailed results, see the publication IV on pp.103.

4.2.2 Requirements and Functionalities of the Digital Collaborative Platform

In publication VI, functionalities of the digital collaborative platform, the DSH, were developed based on a recent generic CI model and in terms of its components, namely staffing, processes, goals, and motivation [146] shown in Figure 4, which were evaluated by experts. For detailed results, see the publication VI on pp.175.

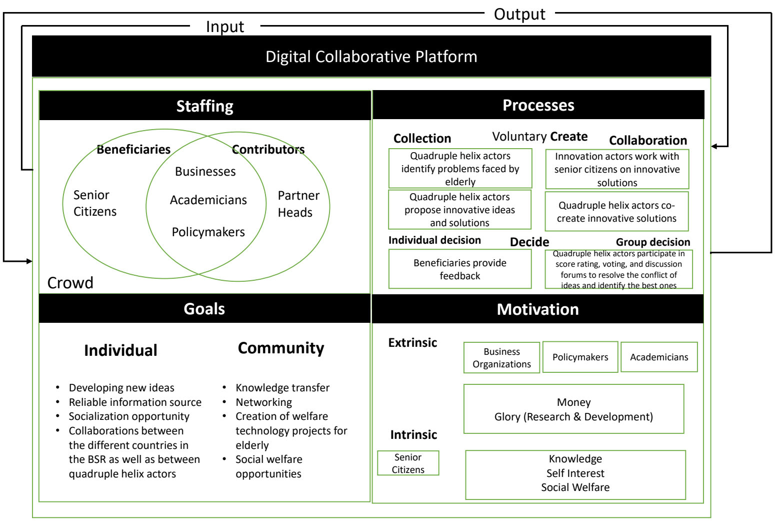

Figure 4: Components of the Digital Silver Hub [138] according to the Generic CI Model [146].

In publication XII, the DSH development process was discussed. Due to changing requirements and time constraints, the project employed an Agile (SCRUM) methodology. The components of the platform's architecture were discussed. For detailed results, see the publication XII on pp.293.

4.3 RQ3 (Design and Evaluation)

Sub RQ3 (Design and Evaluation): How does the elaborated design of the platform meet the goal and requirements of the digital collaborative platform?

In publication VII, the DSH functionalities were further expanded and named to add to the platform prototype. For detailed results, see the publication VII on pp.197. Moreover, a web implementation of the DSH[44] was created with basic functionalities, and user dialogue models were developed, which were presented to the project partners and quadruple helix actors. The DSH was evaluated in two feedback sessions and four focus group discussions. For detailed results, see the publication V on pp.113.

[44]https://silverhub.eu/

In publication IX, the DSH is evaluated based on dimensions of the TAM2 [48, 155]; perceived usefulness, perceived ease of use, and attitude towards using the technology along with dimensions of generic CI framework [146]; staffing, processes, goals, and motivation to evaluate the DSH. For detailed results, see the publication IX on pp.227.

4.3.1 User-Centred Evaluation

In publication XI, user-centred evaluation was employed and explored how the DSH helps address barriers and challenges faced by the silver generation. The results of the thematic analysis revealed the challenges faced by older adults aged 55 to 65 and those aged 65+, It also explored their expectations from a digital collaborative platform, the importance of a user-friendly interface for older adults, concerns about data privacy and security, and the potential impact of a digital collaborative platform on their quality of life. The study provided recommendations to address these challenges. For detailed results, see the publication XI on pp.255.

5 Discussion

5.1 Contributions

This section outlines the research contributions of the study. The design science methodology produces artifacts with the potential to provide three types of research contributions based on their novelty, generality, and significance [62].

5.1.1 Novelty

As the world's population ages, it becomes increasingly important to en-able the silver generation to contribute to the economy rather than become dependent [76]. ICT can help them achieve this by allowing them to work independently from their homes [33]. Therefore, there is a growing need to develop technology solutions that cater to the specific needs and challenges faced by the silver generation. By addressing this issue, the research provides valuable insights and practical implications for all the stakeholders involved in designing, developing, and implementing ICT solutions for the silver generation and availing silver economy opportunities. Older adults have vast expertise and valuable insights from years of professional experience, which is often untapped and can be considered a significant resource [166]. They can contribute to knowledge sharing, validating, testing, and mentorship for different entrepreneurial ventures and innovations [169]. This leads to a more inclusive and dynamic economy that benefits society as a whole and leads to the development of solutions that older adults actually need. However, to enable the participation of the silver generation, it is highly imperative that their barriers and challenges are addressed when using and accessing technology [4]. Therefore, the DSH can play a significant role in facilitating the active participation of older adults in the economy by creating opportunities for collaboration, entrepreneurship, and knowledge exchange. The DSH connects the silver generation to the relevant stakeholders, potential partners, and resources to foster an environment that promotes economic engagement and growth.

Furthermore, a contextual understanding surrounding the DSH has been established, identifying technology readiness, available knowledge resources, and ethical concerns of ICT adoption among the silver generation. The research sheds light on barriers and challenges faced by older adults toward ICT adoption and helps stakeholders understand the specific areas that need to be addressed to enhance technology readiness among the silver generation. In addition, identifying existing knowledge resources can help stakeholders gain insights into the existing information gaps and areas for improvement, the current landscape, and potential areas for collaboration [120]. Moreover, understanding the eth-ical ramifications of ICT integration in the silver economy is crucial to designing platforms and solutions that prioritize older adults' security, dignity, and well-being [75]. As a result, stakeholders can build an environment of trust, leading to the active participation of the silver generation.

Diverse perspectives emerged towards developing the silver economy by adopting a multi-disciplinary approach combining social sciences with IT. One such perspective is integrating the quadruple helix model of innovation [123] and the silver generation, emphasizing the importance of collaborative partnerships and co-creation towards knowledge exchange and digital inclusion of the silver generation [31]. This approach acknowledges that stakeholders from the public sector, private sector, academia, and end-users have unique roles and responsibilities and provides a framework for engaging them in designing the DSH to develop tailored solutions to the diverse needs of the silver generation.

5.1.2 Generality

The research contributes theoretically and provides practical implications and recommendations for the stakeholders involved in developing the silver economy. These implications have real-world applications that positively impact the lives of the silver population and the silver economy. The identified barriers and challenges older adults face toward ICT adoption offer concrete guidance to policymakers. This can lead to targeted initiatives and policies, such as tailored training programs for older adults or awareness campaigns to inform them about the advantages of using technology. Moreover, research recommendations can be used by industry professionals to design age-friendly and user-centred digital platforms. Smart Silver Framework[45] can be adopted as a cooperation model that uses a smart specialization approach to enable collaboration between stakeholders and increase their capacity to generate economic growth through innovation. Moreover, user dialogue models can be adapted per the use case, and functionalities can be replicated as a useful reference for developing similar collaborative platforms in other regions for the silver economy. In addition, the DSH as an artifact could serve as a template, starting point, and valuable reference for other digital platforms targeted to the silver generation.

The challenges and requirements of older adults towards using technology in the context of the BSR can serve as a reference for generalizing findings to older adults from other developed countries. Despite cultural, social, and economic differences, there are various similarities and shared characteristics faced by the silver generation towards ICT adoption, such as aging challenges, the digital divide, privacy concerns, the need for tailored solutions, and the use of digital platforms to foster technology adoption [151]. Therefore, the context-specific approach contributes to the broader knowledge base and highlights unique considerations relevant to other countries with similar socio-economic and demographic characteristics.

5.1.3 Significance

The research highlights that the silver generation should be divided further into age groups; older adults aged 55-65 and those aged 65 and over. This dis-tinction helps identify specific needs and challenges that may incur due to varying circumstances at different ages. This leads to a personalized and user-centred approach, ensuring that the DSH is designed to promote inclusivity and accessibility. This research offers practical implications for stakeholders designing digital collaborative platforms for the silver economy, emphasizing the importance of tailoring solutions to meet the specific needs of different age groups within the silver population. In addition, this study adds significantly to the literature as there is limited research that provides a distinction between different groups within the silver generation. In addition, ADR encourages communication and reflection on the research findings to enable continuous improvement and learning [128]. The results and findings from the research were communicated to the older adults, and the strengths, limitations, and implications of the designed solution were recorded using a user-centred evaluation in Publication XI.

Moreover, a generic CI framework was used for requirement elicitation [146]. Collective knowledge, expertise, and experience of quadruple helix actors are leveraged to identify the requirements and functionalities of the DSH. This leads to a more inclusive and participatory method of requirement building, ensuring that the platform meets the needs of the diverse group of stakeholders and increases the effectiveness of the plat-

[45] https://osiris-smartsilvereconomy.eu/smart-silver-framework/

form. The DSH, a CI platform, caters to a diverse range of perspectives and ideas to be shared from the quadruple helix actors, enables co-creation, fosters innovation and creativity, and allows for flexibility through continuous feedback and reflection. In addition, the use of CI systems for building requirements can be applied to other digital platforms by adapting and replicating the methodology for different target groups and domains.

5.2 Limitations

It is imperative to acknowledge certain limitations that may affect the generalizability and scope of the research findings.

The sample for conducting research mainly relied on quadruple helix actors from the BSR only. Although the research and findings may be insightful for the BSR, they are not fully representative of the different perspectives and experiences of quadruple helix actors from other regions of the world. Therefore, generalizing findings to regions with different social, cultural, economic, and technological contexts can be challenging. Moreover, due to the different languages in different BSR countries, mostly those participants who could communicate in English were chosen for conducting primary research. Therefore, diverse perspectives from local communities of quadruple helix actors may have been limited.

Most importantly, older adults who also speak English may have more exposure and are digitally literate and may not represent the characteristics of a local villager. However, the author ensured that local language-speaking older adults were included in the research by conducting translated written interviews. The research was somewhat limited, and in-depth interviews were not possible; therefore, mainly English-speaking older adults were targeted for research. Due to language barriers, the author could only partially capture diverse experiences from different regions in the BSR. This may also lead to representation bias as the author may have underrepresented a certain group within the silver generation, such as older adults with limited secondary or higher education or those facing significant health impairments.

Furthermore, ethical considerations were identified for ICT integration in the silver economy; however, these were more generic in nature. It is essential to understand the potential ethical challenges, such as privacy and security concerns of the DSH. This calls for further exploration that can help identify ethical ramifications caused by the DSH and, consequently, lead to mitigation strategies. Additionally, one of the barriers identified towards ICT adoption of the silver generation was access to technology, and in those re-gions with limited digital access and internet penetration, the application of the DSH may be compromised. This needs to be further investigated as one of the most important goals of the DSH is to enable older adults to use technology and contribute to the economy.

In addition, technology is ever-changing, and the DSH should be dynamic and adaptable to accommodate any changes. The research currently considers the need to provide up-to-date information to the users. However, it does not fully consider the external factors that can influence the successful implementation and adoption of the DSH, such as ever-evolving technology, changes in government-level policies, and stakeholder en-gagement strategies. Thus, the research does not fully address the concern of long-term sustainability.

5.3 Future Work

There is a need to perform comparative analysis across different regions and countries to understand the unique characteristics, such as socio-cultural and economic factors. These factors help identify factors influencing ICT adoption and integration among the silver generation. Consequently, the researcher can tailor strategies and solutions for the specific needs of the silver generation in different regions and identify patterns and common characteristics. Moreover, the user experience (UX) aspect of different platforms should be explored in-depth to help optimize the design and features for a more user-friendly experience. These features can be integrated into the DSH to increase its usability and accessibility to older adults in different regions.

Future research can focus on the crucial aspect of inclusive design, especially concern-ing the silver population. This includes exploring design strategies that cater to a range of physical and cognitive abilities. The use of emerging technologies such as voice recognition and gesture-based interactions can significantly contribute to creating platforms that are more accessible for older adults.

Understanding how to effectively engage older adults on digital platforms is crucial for maintaining and improving user engagement. To achieve this, future studies can explore techniques such as gamification, personalized content recommendations, and incentives that align with older adults' preferences and motivations. The advancements in technology, such as IoT devices and virtual reality, provide possibilities for enhancing the digital experiences of older adults. Future research can investigate how these innovations can be integrated into platforms such as the DSH to address challenges faced by older adults more effectively.

Moreover, the concern of the long-term sustainability of the DSH has to be addressed whereby factors such as funding, governance, and stakeholder engagement strategies have to be analyzed and implemented. To ensure the DSH's sustainability and main-tainability, policies, daily practices, and user workflows should be made flexible and au-tonomous. Interoperability is also fundamental to ensure service ordering capability and secure cross-border data exchange. This helps to increase the collaborative capacity of organizations to provide innovative solutions. This requires further research and deeper investigation to develop a transnational multi-stakeholder network focused on the silver economy to raise the DSH's capacity to support cross-border data exchange and innova-tive solutions [67].

Currently, the deployment of the DSH involves a standard solution and has no scientific value. However, blockchain technology can be used in the future, and a novel way of deploying the DSH can be explored.

6 Conclusion

The world population is aging; therefore, there is a dire need to develop strategies to enable the silver generation to actively contribute to the economy and society. With the silver generation growing, concerns regarding a skewed working-retired ratio also arise. However, this research encourages to perceive the growing silver population as an entrepreneurial opportunity rather than an economic threat. This research integrates ICT in the silver economy of the BSR and investigates its implications. A comprehensive contextual study is conducted to explore the technology readiness, existing knowledge resources, barriers towards ICT adoption, and ethical considerations of ICT integration among the silver generation.

Furthermore, the research identifies the importance of digital platforms in enabling older adults to use e-services and online applications and become more independent. Consequently, the research designs a digital collaborative platform, DSH, to serve as an ecosystem to develop and accelerate the uptake of innovative solutions to the challenges faced by the silver generation. Quadruple helix actors are the main users of the platform and engage in co-creation and knowledge exchange on the DSH. A generic CI framework is used to develop requirements of the DSH, which are developed into concrete functionalities and features. The DSH is evaluated based on its usability, the effectiveness of its functionalities, ease of use, and user perception to validate that the platform requirements match the derived results. The findings of this research help to understand the importance of digital transformation in the silver economy to help the silver generation become more active and independent and enable them to contribute to the economy.

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References

[1] W. Aalst, O. Hinz, and C. Weinhardt. Big digital platforms: Growth, impact, and challenges. *Business & Information Systems Engineering*, 61(2):645–648, 2019.

[2] T. Abeysinghe. Old-age dependency: Is it really increasing in aging populations? *Applied Economics Letters*, 26(13):1111–1117, 2019.

[3] P. Anderberg. Gerontechnology, digitalization, and the silver economy. *XRDS: Crossroads, the ACM Magazine for Students*, 26(3):46–49, 2020.

[4] A. Antonio and D. Tuffley. Bridging the age-based digital divide. *International Journal of Digital Literacy and Digital Competence*, 6(3):1–15, 2015.

[5] R. Arnkil, A. Järvensivu, P. Koski, and T. Piirainen. Exploring quadruple helix. Outlining user-oriented innovation models. Technical Report Working Paper No 85, Work Research Center, University of Tampere, 2010.

[6] A. Asadullah, I. Faik, and A. Kankanhalli. Digital platforms: A review and future directions. In *Proceedings of PACIS 2018 – the 22nd Pacific Asia Conference on Information Systems*. Association for Information Systems (AIS), 2018.

[7] C. Atkinson, D. Draheim, and V. Geist. Typed business process specification. In *Proceedings of EDOC'2010 – the 14th IEEE International Enterprise Computing Conference*, pages 69–78. IEEE, 2010.

[8] D. Auer, D. Draheim, and V. Geist. Extending BPMN with submit/response-style user interaction modeling. In *Proceedings of BPMN Workshop, CEC'09 – the 11th IEEE Conference on Commerce and Enterprise Computing*, pages 368–374. IEEE, 2009.

[9] S. Balakrishnan, S. Salim, and J. Hong. User centered design approach for elderly people in using website. In *Proceedings of ACSAT 2012 - the 2012 International Conference on Advanced Computer Science Applications and Technologies*, pages 382–387. IEEE, 2012.

[10] Y. Barnard, M. Bradley, F. Hodgson, and A. Lloyd. Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability. *Computers in Human Behavior*, 29(4):1715–1724, 2013.

[11] C. Barroso, M. Sánchez-Valle, and M. Abad. The role of the internet in later life autonomy: Silver surfers in Spain. *Humanities and Social Sciences Communications*, 10(56):56, 2023.

[12] E. Barry, J. Merkebu, and L. Varpio. State-of-the-art literature review methodology: A six-step approach for knowledge synthesis. *Perspectives on Medical Education*, 11(5):281–288, 2022.

[13] H. Basnet. Focus group discussion: A tool for qualitative inquiry. *Researcher: A Research Journal of Culture and Society*, 3(3):81, 2018.

[14] L. Bass, P. Clements, and R. Kazman. *Software architecture in practice*. Addison-Wesley Professional, 3rd edition, 2012.

[15] C. Bélisle. Literacy and the digital knowledge revolution. In A. Martin and D. Madigan, editors, *Digital Literacies for Learning*, pages 51–67. Facet Publishing, 2006.

[16] C. Berridge and T. F. Wetle. Why older adults and their children disagree about in-home surveillance technology, sensors, and tracking. *The Gerontologist*, 60(5):926–934, 2020.

[17] A. Berzins and P. Zvidrins. Depopulation in the Baltic States. *Lithuanian Journal of Statistics*, 50(1):39–48, 2011.

[18] C. Bianchi. Exploring how internet services can enhance elderly well-being. *Journal of Services Marketing*, 35(5):585–603, 2021.

[19] R. H. Binstock. *Handbook of aging and the social sciences*. Academic Press, San Diego, CA, 2010.

[20] B. D. Blume, J. K. Ford, T. T. Baldwin, and J. L. Huang. Transfer of training: A meta-analytic review. *Journal of Management*, 36(4):1065–1105, 2010.

[21] A. Boder. Collective intelligence: A keystone in knowledge management. *Journal of Knowledge Management*, 10(1):81–93, 2006.

[22] F. Boll and P. Brune. Online support for the elderly? Why service and social network platforms should be integrated. *Procedia Computer Science*, 98(1):395–400, 2016.

[23] E. Bonabeau. Decisions 2.0: The power of collective intelligence. *MIT Sloan Management Review*, 50(2):45–52, 2009.

[24] L. Borghans and B. Weel. *Do older workers have more trouble using a computer than younger workers?*, volume 21, pages 139–173. Emerald Group Publishing Limited, 2002.

[25] K. J. Boudreau and A. Hagiu. Platform rules: Multi-sided platforms as regulators. In A. Gawer, editor, *Platforms, Markets and Innovation*, chapter 7, page 29. Edward Elgar Publishing, United Kingdom, 2009.

[26] D. C. Brabham. *Crowdsourcing*. Wiley-Blackwell, March 2017.

[27] F. Buckley. Online discussion forums. *European Political Science*, 10(3):402–415, 2011.

[28] R. Bunduchi. Trust, partner selection and innovation outcome in collaborative new product development. *Production Planning & Control*, 24(2-3):145–157, 2012.

[29] K. E. Caine, A. D. Fisk, and W. A. Rogers. Benefits and privacy concerns of a home equipped with a visual sensing system: A perspective from older adults. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, pages 55–60. SAGE Publications, 2006.

[30] L. M. Camarinha-Matos, H. Afsarmanesh, F. Ferrada, A. I. Oliveira, and J. Rosas. A comprehensive research roadmap for ICT and ageing. *Studies in Informatics and Control*, 22(2):233–254, 2013.

[31] E. Carayannis and D. Campbell. ‘Mode 3’ and ’Quadruple Helix’: Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, 46(3-4):201–234, 2009.

[32] S. A. Caro, F. G. Bass and Y. P. Chen. *The elderly in America: A statistical portrait*. ABC-CLIO, Santa Barbara, CA, 1993.

[33] A. M. Carrillo. Ageing in a digital world – from vulnerable to valuable. Technical Report 978-92-61-33601-1, International Telecommunication Union, 2021.

[34] A. Caspi, M. Daniel, and G. Kavé. Technology makes older adults feel older. *Aging and Mental Health*, 23(8):1025–1030, 2018.

[35] D. Castilla, A. Garcia-Palacios, N. Miralles, J. Bretón-López, E. Parra, S. Rodriguez-Berges, and C. Botella. Effect of web navigation style in elderly users. *Computers in Human Behavior*, 55(B):909–920, 2016.

[36] A. Chaipunyathat and N. Bhumpenpein. Communication, culture, competency, and stakeholder that contribute to requirement elicitation effectiveness. *International Journal of Electrical and Computer Engineering*, 12(6):6472–6485, 2022.

[37] A. Chammas, M. Quaresma, and C. Mont'Alvão. A closer look on the user-centred design. *Procedia Manufacturing*, 3(1):5397–5404, 2015.

[38] V. Chang, Z. Wang, Q. A. Xu, L. Golightly, B. S. Liu, and M. Arami. Smart home based on Internet of Things and ethical issues. In *Proceedings of FEMIB 2021 – the 3rd International Conference on Finance, Economics, Management and IT Business*, pages 57–64. SCITEPRESS – Science and Technology Publications, 2021.

[39] V. Clarke and V. Braun. *Thematic Analysis*, pages 1947–1952. Springer New York, New York, NY, 2014.

[40] E. Cook, G. Randhawa, C. Sharp, and et al. Exploring the factors that influence the decision to adopt and engage with an integrated assistive telehealth and telecare service in Cambridgeshire, UK: A nested qualitative study of patient 'users' and 'non-users'. *BMC Health Services Research*, 16(1):137, 2016.

[41] G. Cornet. Europe silver economy: A potential source for economic growth? *Gerontechnology*, 13(3):319–321, 2014.

[42] M. Coto, F. Lizano, S. Mora, and J. Fuentes. Social media and elderly people: Research trends. In G. Meiselwitz, editor, *Proceedings of SCSM 2017 – the International Conference on Social Computing and Social Media*, pages 65–81, Cham, 2017. Springer International Publishing.

[43] S. Cronholm and H. Göbel. Action design research: integration of method support. *International Journal of Managing Projects in Business*, 15(8):19–47, 2022.

[44] S. J. Cutler and L. G. Hodgson. *Measuring aging*. Springer, Cham, Switzerland, 2001.

[45] S. Czaja, W. Boot, N. Charness, W. Rogers, and J. Sharit. Technology and older adults: Opportunities and design challenges. *Innovation in Aging*, 2(suppl 1):213–213, 2018.

[46] S. Danneels, L.and Viaene. Identifying digital transformation paradoxes: A design perspective. *Business and Information Systems Engineering*, 64(4):483–500, 2022.

[47] T. H. Davenport and L. Prusak. *Working knowledge: How organizations manage what they know*. Harvard Business School Press, Boston, MA, 1998.

[48] F. D. Davis. Perceived usefulness, perceived ease of use, and user acceptance of Information Technology. *MIS Quarterly*, 13(3):319–340, 1989.

[49] Directorate-General for Economic and Financial Affairs. The 2021 ageing report: Economic & budgetary projections for the EU member states (2019-2070). Technical Report Institutional Paper 142, European Commission, 2021.

[50] D. Draheim and G. Weber. Modeling submit/response style systems with form charts and dialogue constraints. In *On The Move to Meaningful Internet Systems 2003: OTM 2003 Workshops*, pages 267–278. Springer, 2003.

[51] D. Draheim and G. Weber. Modeling form-based interfaces with bipartite state machines. *Interacting with computers*, 17(2):207–228, 2005.

[52] D. Eatock. The silver economy: Opportunities from ageing. Technical Report 20.500.12592/wmj4x0., European Parliamentary Research Service, 2015.

[53] G. Elia and A. Margherita. *A collective intelligence platform for developing technology entrepreneurship ecosystems*, pages 195–220. Palgrave Macmillan, London, 2016.

[54] A. Erceg and I. Barkovic Bojanic. Silver economy: Demographic change and economic opportunity. In *Proceedings of IMR 2017 – the 8th International Conference on Interdisciplinary Management Research*, pages 123–130. IEEE Computer Society, 2017.

[55] S. Estrada. Qualitative analysis using R: A free analytic tool. *The Qualitative Report*, 22(4):956–968, 2017.

[56] H. Evers, S. Gerke, and T. Menkhoff. Knowledge hubs and knowledge clusters: A knowledge architecture for development. *Beyond the Knowledge Trap*, 1(1):27–45, 2011.

[57] F. Galton. The wisdom of crowds (Vox Populi). *Nature*, 75(1):450–451, 1907.

[58] C. Gordon. *A Silver Economy: The Value of Living Longer*. SUPA-NZ, 2017.

[59] M. Green. A survey of three dialogue models. *ACM Transactions on Graphics*, 5(3):244–275, 1986.

[60] H. Gsell and K. Thoben. Administration and operation of product-related content. *International Journal of Product Development*, 8(2):211–223, 2009.

[61] J. Gulliksen, B. Göransson, I. Boivie, S. Blomkvist, J. Persson, and A. Cajander. Key principles for user-centered systems design. *Behaviour & Information Technology*, 22(6):397–409, 2003.

[62] A. R. Hevner, S. T. March, J. Park, and S. Ram. Design science in information systems research. *MIS Quarterly: Management Information Systems*, 28(1):75–105, 2004.

[63] M. Hussain, S. Siddiqui, and N. Islam. Social engineering and data privacy. In *Fraud Prevention, Confidentiality, and Data Security for Modern Businesses*, pages 183–197. IGI Global, 2023.

[64] Ingrid Pappel, Sidra A. Butt, Ingmar Pappel, and Dirk Draheim. On the specific role of Electronic Document and Record Management Systems in enterprise integration. In *Proceedings of ICICT 2021 – the 5th International Congress on Information and Communication Technology*, pages 37–51. Springer Singapore, 2021.

[65] International Organization for Standardization. *Ergonomics of human-system interaction – Part 11: Usability: Definitions and concepts*. 9241-11. International Organization for Standardization, 2018.

[66] International Organization for Standardization. *Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems*. 9241-210. International Organization for Standardization, 2019.

[67] E. B. Jackson, P. Kivimäki, I. Pappel, and S. Ben Yahia. Exploring EU e-delivery integration for enabling interregional innovation through the silverhub platform. In *Proceedings of DGO 2023 – the 24th Annual International Conference on Digital Government Research*, page 172–179. Association for Computing Machinery, 2023.

[68] L. Jin, A. Psarrou, S. Cao, and Y. Chen. Trends on interactive platforms for social media through web2.0. In *Proceedings of MASS '09 – the International Conference on Management and Service Science*, pages 1–6. IEEE Xplore, 2009.

[69] A. Joinson. Looking at, looking up or keeping up with people?: Motives and use of Facebook. In *Proceeding of SIGCHI 2008 - the 26th Annual Conference on Human factors in Computing Systems*, pages 1027–1036. ACM, 2008.

[70] P. Juusu and S. Savenstedt. Ethical issues in the use of ICT as support for vulnerable older people to live longer in their homes – A review of literature. Technical report, Luleå University of Technology, 2017.

[71] K. Kinsella and W. He. An aging world: 2008. Technical Report P95/09-1, U.S. Census Bureau, 2009.

[72] B. A. Kitchenham and S. Charters. Guidelines for performing systematic literature reviews in software engineering. Technical Report EBSE 2007-001, Keele University and Durham University Joint Report, 2007.

[73] A. Kittur, E. H. Chi, and B. Suh. He says, she says: Conflict and coordination in wikipedia. In *Proceedings of GROUP07 – the 3rd International Conference on Supporting Group Work*, pages 61–70. ACM, 2007.

[74] A. Klimczuk. Supporting the development of gerontechnology as part of silver economy building. *Ad Alta: Journal of Interdisciplinary Research*, 2(2):52–56, 2012.

[75] G. Krzyminiewska. Ethical dilemmas of the silver economy. *Economics and Law*, 19(1):61–71, 2020.

[76] G. Krzyminiewska. Innovative technologies in the process of development of the silver economy. In K. Nermend and M. Łatuszyńska, editors, *Experimental and Quantitative Methods in Contemporary Economics*, pages 17–28, Cham, 2020. Springer International Publishing.

[77] T. Kühme. A user-centered approach to adaptive interfaces. *Knowledge-Based Systems*, 6(4):239–248, 1993.

[78] S. Kumar, L. Ureel, and C. Wallace. Lessons from our elders: Identifying obstacles to digital literacy through direct engagement. In *Proceedings of PETRA 2013 – the 6th International Conference on PErvasive Technologies Related to Assistive Environments*, pages 1–8. ACM, 2013.

[79] H. Landemore and J. Elster. *Collective wisdom: Principles and mechanisms*. Cambridge University Press, Cambridge, 2012.

[80] A. Laskowska and J. Laskowski. Silver generation at work — Implications for sustainable human capital management in the industry 5.0 era. *Sustainability*, 15(1):194, 2022.

[81] J. Leikas, A. Sigfrids, J. Stenvall, and M. Nieminen. Good life ecosystems – Ethics and responsibility in the silver market. In M. Rauterberg, editor, *Proceedings of HCII 2020 – the 8th International Conference on Culture and Computing*, Lecture Notes in Computer Science, pages 105–122. Springer, 2020.

[82] S. Linz and S. Stula. Demographic change in Europe - An overview. Technical Report Working paper no. 4, Observatory for Sociopolitical Developments in Europe, 2010.

[83] E. Loos and L. Ivan. Not only people are getting old, the new media are too: Technology generations and the changes in new media use. *New Media & Society*, 0(0):1–26, 2022.

[84] I. Lopes, A. Oliveira, and C. J. Costa. Tools for online collaboration: Do they contribute to improve teamwork? *Mediterranean Journal of Social Sciences*, 6(6 S4):511–522, 2015.

[85] B. Lyons, J. Wessel, Y. Tai, and A. Ryan. Strategies of job seekers related to age-related stereotypes. *Journal of Managerial Psychology*, 29(8):1009–1027, 2014.

[86] Q. Ma, A. Chan, and P. Teh. Bridging the digital divide for older adults via observational training: Effects of model identity from a generational perspective. *Sustainability*, 12(11):4555, 2020.

[87] Q. Ma, A. Chan, and P. Teh. Bridging the digital divide for older adults via observational training: Effects of model identity from a generational perspective. *Sustainability*, 12(11):4555, 06 2020.

[88] N. K. Malhotra, D. Nunan, and D. F. Birks. *Marketing research: An applied approach*. Trans-Atlantic Publications, Inc., 5 edition, 2017.

[89] T. W. Malone and M. Bernstein. *Handbook of Collective Intelligence*. MIT Press, 2015.

[90] T. W. Malone, R. Laubacher, and C. Dellarocas. The collective intelligence genome. *EEE Engineering Management Review*, 38(3):38–52, 2010.

[91] T. W. Malone, R. Laubacher, and C. N. Dellarocas. Harnessing crowds: Mapping the genome of collective intelligence. *SSRN Electronic Journal*, 1(4732-09):21, 2009.

[92] S. T. March and G. F. Smith. Design and natural science research on information technology. *Decision Support Systems*, 15(4):251–266, 1995.

[93] Markko Liutkevicius, Karl I. Pappel, Sidra A. Butt, and Ingrid Pappel. Automatization of cross-border customs declaration: Potential and challenges: A case study of the Estonian Customs Authority. In *Proceesings of EGOV 2020 – the 19th International Conference on Electronic Government*, volume 12219 of *Lecture Notes in Computer Science*, pages 96–109. Springer, 2020.

[94] R. McAdam and S. McCreedy. A critical review of knowledge management models. *The Learning Organization*, 6(3):91–101, 1999.

[95] H. McGuirk, A. C. Lenihan, and N. Lenihan. Awareness and potential of the silver economy for enterprises: A European regional level study. *Small Enterprise Research*, 29(1):6–19, 2021.

[96] J. Morato, S. Sanchez-Cuadrado, A. Iglesias, A. Campillo, and C. Fernández Panadero. Sustainable technologies for older adults. *Sustainability*, 13(15):8465, 2021.

[97] P. Morville and L. Rosenfeld. *Information architecture for the world wide web: Designing large-scale web sites*. O'Reilly Media, Inc., 3rd edition, 2007.

[98] M. T. Mullarkey and A. R. Hevner. Entering action design research. In *Procceding of DESRIST 2015– the International Conference on Design Science Research in Information Systems*, pages 121–134, Cham, 2015. Springer International Publishing.

[99] V. K. Murthy, N. Shi, C. Hwee Ng, S. Guan, and F. Zhu. *Virtual marketplace for agent-based electronic commerce*. Idea Group Publishing, 2003.

[100] National Center for Health Statistics (US). Health, United States, 2011. Technical Report 76–641496, Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics (NCHS), 2011.

[101] National Institute on Aging. Global health and aging. Technical Report no. 11-7737, World Health Organization, 2017.

[102] National Research Council. Design and evaluation: A review of the state-of-the-art. *D-Lib Magazine*, 4(7,8):1–167, 1998.

[103] M. Nedeljko, D. Bogataj, and B. Kaučič. The use of ICT in older adults strengthens their social network and reduces social isolation: Literature review and research agenda. *IFAC-PapersOnLine*, 54(13):645–650, 2021.

[104] B. Neves, F. Amaro, and J. Fonseca. Coming of (old) age in the digital age: ICT usage and non-usage among older adults. *Sociological Research Online*, 18(2):22–35, 2013.

[105] S. E. Page. *The difference: How the power of diversity creates better groups, firms, schools, and societies*. Princeton University Press, illustrated edition, 2007.

[106] F. C. Palma, S. Trimi, and S. Hong. Motivation triggers for customer participation in value co-creation. *Service Business*, 13(3):557–580, 2019.

[107] C. Pang, Z. C. Wang, J. McGrenere, R. Leung, and J. Dai. Technology adoption and learning preferences for older adults: Evolving perceptions, ongoing challenges, and emerging design opportunities. In *Proceedings of CHI 2021 – the Conference on Human Factors in Computing Systems*, page 1–13. ACM, 2021.

[108] A. Parasuraman. Technology readiness index (TRI): A multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research*, 2(4):408–421, 2000.

[109] A. Pargaonkar, W. Mishra, and S. Kadam. A study on elderly individuals' attitude towards ICTs. In A. Chakrabarti, editor, *Proceedings of ICoRD 2019 – the 7th International Conference on Research into Design*, pages 723–734, Singapore, 2019. Springer Singapore.

[110] M. Paska. The aspect of ethics determined by technological impact. In *Proceedings of HED 2021 - the 19th International scientific conference om Hradec Economic Days*, pages 1–19. University of Hradec Kralove, 2021.

[111] V. Pattanaik, S. Suran, and D. Draheim. Enabling social information exchange via dynamically robust annotations. In *Proceedings of IIWAS 2019 – the 21st International Conference on Information Integration and Web-Based Applications and Services*, page 176–184. ACM, 2019.

[112] S. T. M. Peek, E. J. M. Wouters, J. van Hoof, K. G. Luijkx, H. R. Boeije, and H. J. M. Vrijhoef. Factors influencing acceptance of technology for aging in place: A systematic review. *International Journal of Medical Informatics*, 83(4):235–248, 2014.

[113] K. Peffers, T. Tuunanen, M. Rothenberger, and S. Chatterjee. A design science research methodology for information systems research. *Journal of Management Information Systems*, 24(3):45–77, 2007.

[114] J. Pirhonen, L. Lolich, K. Tuominen, O. Jolanki, and V. Timonen. These devices have not been made for older people's needs – older adults' perceptions of digital technologies in Finland and Ireland. *Technology in Society*, 62(1):101287, 2020.

[115] M. Plaza-Hernandez, I. Sittón-Candanedo, R. S. Alonso, L. C. Martínez-de I., J. Prieto, K. Kravari, and J. M. Corchado. Edge computing and Internet of Things based platform to improve the quality of life of the silver economy on leisure cruise ships. In *Proceedings of ISCSIC 2021 – the 5th International Symposium on Computer Science and Intelligent Controls*, pages 159–163. IEEE, 2021.

[116] M. E. Porter. *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press, 1980.

[117] C. K. Prahalad and V. Ramaswamy. Co-creation experiences: The next practice in value creation. *Journal of Interactive Marketing*, 18(3):5–14, 2004.

[118] A. Quan-Haase, K. Martin, and K. Schreurs. Interviews with digital seniors: ICT use in the context of everyday life. *Information, Communication & Society*, 19(5):691–707, 2016.

[119] G. A. Radvansky and J. Zacks. *The importance of events*, pages 1–15. Oxford Academic, 2014.

[120] A. Riege and N. Lindsay. Knowledge management in the public sector: Stakeholder partnerships in the public policy development. *Journal of Knowledge Management*, 10(3):24–39, 2006.

[121] E. M. Rogers. *Diffusion of innovations*. Free Press, New York, NY, 5th edition, 2003.

[122] W. A. Rogers and E. D. Mynatt. *How can technology contribute to the quality of life of older adults?*, pages 22–30. Illinois Institute of Technology, 2003.

[123] M. Roman, H. Varga, V. Cvijanovic, and A. Reid. Quadruple helix models for sustainable regional innovation: Engaging and facilitating civil society participation. *Economies*, 8(2):48, 2020.

[124] A. Rosales and M. Fernández-Ardèvol. Beyond WhatsApp: Older people and smartphones. *Romanian Journal of Communication and Public Relations*, 18(1):27–47, 2016.

[125] J. W. Rowe and R. L. Kahn. Successful aging. *The Gerontologist*, 37(4):433–440, 1997.

[126] J. W. Rowe and R. L. Kahn. Successful aging and disease prevention. *Advances in Renal Replacement Therapy*, 7(1):70–77, 2000.

[127] S. Schneider and O. Kokshagina. Digital transformation: What we have learned (thus far) and what is next. *Creativity and Innovation Management*, 30(2):384–411, 2021.

[128] M. Sein, O. Henfridsson, S. Purao, M. Rossi, and R. Lindgren. Action design research. *MIS Quarterly*, 35(1):37–56, 2011.

[129] F. Shaw. Is the ageing population the problem it is made out to be? *Foresight*, 4(3):4–11, 2002.

[130] Sidra A. Butt and Dirk Draheim. Ethical challenges of ICT for the silver economy. In *Proceeding of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 152–155. IEEE, 2021.

[131] Sidra A. Butt, Emna A. Elhadjamor, Ingrid Pappel, Enn Õunapuu, and Dirk Draheim. A knowledge map for ICT integration in the silver economy. In *Proceedings of CENTERIS 2020 – the 8th International Conference on Enterprise Information Systems*, volume 181 of *Procedia Computer Science*, pages 693–701. Elsevier, 2020.

[132] Sidra A. Butt, Ingrid Pappel, and Dirk Draheim. Digital Silver Hub: User dialogue model technical document. *IEEE TechRxiv. Preprint*, pages 1–49, 2022.

[133] Sidra A. Butt, Ingrid Pappel, and Dirk Draheim. Exploring the functionalities and evaluation of the Digital Silver Hub: A collaborative platform for innovative solutions in the silver economy. In *Proceedings of ICEGOV 2023 - the 16th International Conference on Theory and Practice of Electronic Governance*. Association for Computing Machinery, 2023.

[134] Sidra A. Butt, Ingrid Pappel, and Enn Õunapuu. Potential for increasing the ICT adaption and identifying technology readiness in the silver economy: Case of Estonia. In *Proceedings of EGOSE 2020 – the 7th International Conference on Electronic Governance and Open Society: Challenges in Eurasia*, pages 139–155. Springer International Publishing, 2020.

[135] Sidra A. Butt, Ingrid Pappel, and Karin Oolu. Implementation of Electronic Records Management Systems: Potential and challenges a case study of the Water and Power Development Authority (WAPDA) in Pakistan. In *Proceedings of ICT4SD2021 – the 6th International Conference on ICT Analysis and Applications*, pages 629–639. Springer Singapore, 2021.

[136] Sidra A. Butt, Karin Rava, Taivo Kangilaski, Ingrid Pappel, and Dirk Draheim. Designing a digital collaborative platform for the silver economy: Inception and conceptualization. In *Proceedings of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 47–54. IEEE, 2021.

[137] Sidra A. Butt, Marina Weck, Ingrid Pappel, and Dirk Draheim. Multifaceted evaluation of the Digital Silver Hub to validate the platform requirements. In *Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics*, pages 164–177. Springer, 2023.

[138] Sidra A. Butt, Shweta Suran, Ingrid Pappel, Michael Smærup, Robert Krimmer, and Dirk Draheim. A digital collaborative platform for the silver economy: Functionalities required by stakeholders in a multinational Baltic Sea Region project. *Digital Government: Research and Practice*, 4(2):1–20, 2023.

[139] Sidra A. Butt, Shweta Suran, Marina Weck, Ingrid Pappel, and Dirk Draheim. Design of a collective intelligence platform for facilitating the silver economy: An exhaustive user-centered evaluation. *IEEE TechRxiv. Preprint*, pages 1–37, 2023.

[140] Sidra A. Butt, Silvia Lips, Rahul Sharma, Ingrid Pappel, and Dirk Draheim. Barriers to digital transformation of the silver economy: Challenges to adopting digital skills by the silver generation. In *Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics*, volume 97, pages 151–163. Springer, 2023.

[141] Sidra A. Butt, Taivo Kangilaski, and Dirk Draheim. Lessons learned from a multinational project on developing a platform for the silver economy. In *Proceedings of Projman 2023 - the 7th International Conference on Project Management*, Procedia Computer Science. Elsevier, 2023.

[142] I. Y. Song, M. Song, T. Timakum, S. Ryu, and H. Lee. The landscape of smart aging: Topics, applications, and agenda. *Data and Knowledge Engineering*, 115(1):68–79, 2018.

[143] B. C. Stahl. From computer ethics and the ethics of AI towards an ethics of digital ecosystems. *AI and Ethics*, 2(2):65–77, 2022.

[144] N. Staub, K. Haki, S. Aier, and R. Winter. Taxonomy of digital platforms: A business model perspective. In *Proceedings of HICSS 2021 – the 54th Hawaii International Conference on System Sciences*, pages 4348–4357. IEEE, 2021.

[145] S. Suran, V. Pattanaik, S. Ben Yahia, and D. Draheim. Exploratory analysis of collective intelligence projects developed within the EU Horizon 2020 framework. In *Proceedings of ICCCI 2019 – the 11th International Conference on Computational Collective Intelligence*, LNAI 11684, pages 285–296. Springer, 2019.

[146] S. Suran, V. Pattanaik, and D. Draheim. Frameworks for collective intelligence: A systematic literature review. *ACM Computing Surveys*, 53(1):1–36, 2020.

[147] J. Surowiecki. *The Wisdom of Crowds*. Anchor, 1st edition, 2004.

[148] S. Taipale and R. Hänninen. More years, more technologies: Aging in the digital era. *Human Technology*, 14(3):258–263, 2018.

[149] Taivo Kangilaski, Sidra A. Butt, Ingrid Pappel, and Erik Kangilaski. Overcoming challenges in the silver economy by connecting services in the Silver Hub: The tool to provide the basis for the innovative solutions. In *Proceedings of ICEGOV 2021 – the 14th International Conference on Theory and Practice of Electronic Governance*, pages 231––237. Association for Computing Machinery, 2021.

[150] Technopolis Group and Oxford Economics. The silver economy. Technical Report 2015/0038, Publications Office of the European Union, 2018.

[151] F. Thomas, L. Haddon, R. Gilligan, P. Heinzmann, and C. Gournay. Cultural factors shaping the experience of ICTs: An exploratory review. *International collaborative research: Cross-cultural differences and cultures of research*, 25(1):15–30, 2005.

[152] United Nations Department of Economic and Social Affairs. World population ageing 2020 highlights. Technical Report ST/ESA/SER.A/451, United Nations, 2020.

[153] A. van der Merwe, A. Gerber, and H. Smuts. Guidelines for conducting design science research in information systems. In *Proceedings of SACLA 2019 – the Annual Conference of the Southern African Computer Lecturers' Association*, volume 1136 CCIS, pages 163–178. Springer, 2019.

[154] C. van Lierop and D. Wagner. Transnational clusters and the Danube macro-regional strategy. Technical Report PE 635.587, European Parliamentary Research Service, 2019.

[155] V. Venkatesh and F. D. Davis. A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46(2):186–204, 2000.

[156] D. J. Vergados, I. Lykourentzou, and E. Kapetanios. A resource allocation framework for collective intelligence system engineering. In *Proceedings of MEDES 2010 – the 2nd International Conference on Management of Emergent Digital Ecosystems*, pages 182–188. ACM, 2010.

[157] S. Wallace, C. Graham, and A. Saraceno. Older adults' use of technology. *Perspectives on Gerontology*, 18(2):50–59, 2013.

[158] S. Wang, K. Bolling, W. Mao, J. Reichstadt, D. Jeste, H. Kim, and C. Nebeker. Technology to support aging in place: Older adults' perspectives. *Healthcare*, 7(2):60, 2019.

[159] D. Wegner, A. B. da Silveira, D. Marconatto, and M. Mitrega. A systematic review of collaborative digital platforms: Structuring the domain and research agenda. *Review of Managerial Science*, 17(4):1–41, 2023.

[160] E. Welsh. Dealing with data: Using NVivo in the qualitative data analysis process. *Forum: Qualitative Social Research*, 3(2):1–9, 05 2002.

[161] T. Weninger. An exploration of submissions and discussions in social news: Mining collective intelligence of Reddit. *Social Network Analysis and Mining*, 4(1):173, 2014.

[162] World Health Organization. Active ageing: A policy framework. Technical Report WHO/NMH/NPH/02.8, World Health Organization, 2002.

[163] World Health Organization. World report on ageing and health. Technical Report 978 92 4 156504 2, World Health Organization, 2015.

[164] B. Xie, A. Druin, J. Fails, S. Massey, E. Golub, S. Franckel, and K. Schneider. Connecting generations: Developing co-design methods for older adults and children. *Behaviour & Information Technology*, 31(4):413–423, 2012.

[165] T. Yudina and I. Z. Geliskhanov. Features of digital platforms functioning in information-digital economy. In *Proceedings of IOP 2019 – the International Conference Series on Materials Science and Engineering*, page 012104. IOP Publishing, 2019.

[166] S. Zedlewski and B. Butrica. Are we taking full advantage of older adults' potential? *Aging & Society*, 35(1):11–36, 2007.

[167] E. Zeissig, C. Lidynia, L. Vervier, A. Gadeib, and M. Ziefle. Online privacy perceptions of older adults. In J. Zhou and G. Salvendy, editors, *Proceedings of ITAP 2017 - the 3rd International Conference on Human Aspects of IT for the Aged Population. Applications, Services and Contexts*, pages 181–200, Cham, 2017. Springer International Publishing.

[168] Y. Zhang, S. Aikman, and L. Sun. ICTs as tools for older adults' well-being: Current issues and research directions. *Information Technology and People*, 21(2):173–190, 2008.

[169] Y. Zhu, A. Collins, Z. X. Xu, D. Sardana, and S. Cavusgil. Achieving aging well through senior entrepreneurship: A three-country empirical study. *Small Business Economics*, 59(2):665––689, 2022.

[170] M. Zsarnoczky. Innovation challenges of the silver economy. *Vadyba Journal of Management*, 28(1):105–109, 2016.

[171] C. M. Zuppo. Defining ICT in a boundaryless world: The development of a working hierarchy. *International Journal of Managing Information Technology*, 4(3):13–22, 2012.

[172] S. Zwijsen, A. Niemeijer, and C. Hertogh. Ethics of using assistive technology in the care for community-dwelling elderly people: An overview of the literature. *Aging & Mental Health*, 15(4):419–427, 2011.

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Abstract

A Digital Collaborative Platform to Facilitate Innovative Solutions for the Silver Economy

As the population ages, it is crucial to facilitate the active participation of the silver generation in the economy. This study explores the integration of Information and Communication Technology (ICT) into the silver economy, enabling older adults to engage in economic activities. The research assesses technology readiness, available knowledge resources, and ethical concerns related to ICT adoption among the silver generation. The study also highlights barriers that hinder older adults' adoption of technology, such as lack of digital literacy, privacy concerns, and insufficient access to resources. To address these barriers, the study provides practical recommendations considering the distinctive needs of the two groups within the silver population: older adults aged 55-65 and those aged 65 and over.

This research is a design science effort that aims to address the needs and challenges faced by the silver generation. To achieve this, a digital collaborative platform called the Digital Silver Hub was developed, using a generic Collective Intelligence (CI) framework for requirement elicitation. The co-creation process involved interviewing the quadruple helix actors, comprising academia, government, industry, and civil society of the six regions of the Baltic Sea Region: Estonia, Finland, Denmark, Latvia, Lithuania, and Russia (St. Petersburg). Moreover, semi-structured interviews were conducted with quadruple helix actors from the Baltic Sea Region to identify the requirements for the User Interface, application architecture, and content administration. All the requirements were validated by experts. The functionalities and requirements were further subjected to a comprehensive analysis to refine and expand upon through focus group discussions. The possible user interactions and system responses were mapped out through User Dialogue Models, customer journeys were described, wireframes were constructed, and a web-based implementation of the Silverhub collaborative platform was established. The Digital Silver Hub was evaluated to ensure that the platform meets the goals and requirements of stakeholders. The platform was evaluated through two information sessions and four focus group sessions. Further, a user-centred evaluation was employed to design and evaluate the Digital Silver Hub by integrating the principles outlined in ISO 9241-210.

The Digital Silver Hub serves as an ecosystem to develop and accelerate the uptake of innovative solutions to the challenges faced by the silver generation. The findings of this study have important implications for policymakers, industry experts, and service providers involved in designing and implementing ICT solutions for the silver generation. The Digital Silver Hub serves as a template for other digital platforms targeting the silver generation. The primary objective is to enhance participation and encourage social and digital inclusion of the silver population. By linking theory with practical applications, this research contributes to the applicability and influence of ICT solutions, leading to the growth of the silver economy.

Kokkuvõte
Digitaalne koostööplatvorm hõlbustamaks uuenduslikke lahendusi hõbemajanduses

Rahvastiku vananedes on ülioluline tagada hõbepõlvkonna aktiivne osalemine majanduses. Käesolev uurimustöö keskendub info- ja kommunikatsioonitehnoloogia (IKT) integreerimisele hõbemajandusse, võimaldades eakatel inimestel osaleda majandustegevuses. Uurimuses hinnatakse hõbepõlvkonna tehnoloogilist valmisolekut, olemasolevat teadmust ja IKT kasutuselevõtuga seotud eetilisi probleeme. Uuring toob välja ka takistused, mis pidurdavad tehnoloogia kasutuselevõttu eakate kodanike poolt, nagu digitaalse kirjaoskuse puudumine, privaatsusprobleemid ja ebapiisav juurdepääs ressurssidele. Uuring annab praktilisi soovitusi nende takistuste kõrvaldamiseks, võttes arvesse kahe hõbepopulatsiooni rühma erivajadusi: nooremad täiskasvanud vanuses 55–65 ja vanemad täiskasvanud vanuses 65+.

See uurimus põhineb disainiteadusel (design science), mille eesmärk on käsitleda hõbepõlvkonna vajadusi ja väljakutseid. Selle saavutamiseks töötati välja digitaalne koostööplatvorm nimega Digital Silver Hub, mis kasutab nõuete väljaselgitamiseks üldist kollektiivse intelligentsuse (CI) raamistikku. Koosloomeprotsess hõlmas neljatahulise mudeli osapoolte intervjueerimist, kuhu kuulusid Läänemere regiooni kuue piirkonna – Eesti, Soome, Taani, Läti, Leedu ja Venemaa (Peterburi) – akadeemilised ringkonnad, valitsus, tööstus ja kodanikuühiskond. Lisaks viidi läbi osaliselt struktureeritud intervjuud Läänemere piirkonna projektijuhtide ja neljatahulise mudeli osapooltega, et selgitada välja nõuded kasutajaliidesele, rakenduste arhitektuurile ja sisuhaldusele. Kõik nõuded valideeriti ekspertide poolt. Funktsionaalsusi ja nõudeid analüüsiti veelgi, et täpsustada ja laiendada neid fookusgrupi arutelude kaudu. Kasutajate dialoogimudelite abil kaardistati kasutajate võimalikud interaktsioonid ja süsteemi vastused, kirjeldati klienditeekondi, konstrueeriti põhiraamistik ja loodi Silverhubi koostööplatvormi veebipõhine rakendus. Digital Silver Hubi hinnati, et tagada platvormi vastavus sidusrühmade eesmärkidele ja nõuetele. Platvormi hinnati kahe infotunni ja nelja fookusgrupiseansi kaudu. Lisaks kasutati Digital Silver Hubi väljatöötamiseks ja hindamiseks kasutajakeskset hindamist, integreerides standardis ISO 9241-210 kirjeldatud põhimõtted.

Digital Silver Hub toimib ökosüsteemina, et arendada ja kiirendada uuenduslike lahenduste kasutuselevõttu hõbepõlvkonna väljakutsetele. Selle uuringu tulemused avaldavad olulist mõju poliitikakujundajatele, valdkonnaekspertidele ja teenusepakkujatele, kes on seotud hõbepõlvkonna IKT-lahenduste kavandamise ja rakendamisega. Digital Silver Hub on näidiseks teistele hõbepõlvkonnale suunatud digitaalplatvormidele. Peamine eesmärk on suurendada osalust ning soodustada hõbeelanikkonna sotsiaalset ja digitaalset kaasamist. Sidudes teooria praktiliste rakendustega, aitab käesolev uurimus kaasa IKT-lahenduste rakendatavuse ja mõju suurendamisele, mis viib hõbemajanduse kasvule.

Appendix I

[I]

Sidra A. Butt, Ingrid Pappel, and Enn Õunapuu. Potential for increasing the ICT adaption and identifying technology readiness in the silver economy: Case of Estonia. In *Proceedings of EGOSE 2020 – the 7th International Conference on Electronic Governance and Open Society: Challenges in Eurasia*, pages 139–155. Springer International Publishing, 2020

Potential for Increasing the ICT Adaption and Identifying Technology Readiness in the Silver Economy: Case of Estonia

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Abstract. Silver economy is dedicated to catering to the needs of the ageing population with innovative and technological solutions. The paper encompasses a de-tailed overview of the technology readiness and challenges of the silver generation towards ICT adaption. A hybrid approach is employed using the questionnaires and workshops to collect data. The main outcome creates the understanding of the hindering factors to ICT adaption for elderly people which if addressed can serve as the basis for new entrepreneurial opportunities. The present case is part of a larger set of research activities that will be conducted throughout the entire Baltic Sea Region in the coming years. The results of the research activities are aimed to be scale-able to serve the needs and requirements of other interested regions that are tackling similar matters regarding the ageing society.

Keywords: Silver economy · Silver generation · Technological readiness · ICT

1 Introduction

Silver economy is dedicated to the ageing population with production, distribution and consumption of goods and services targeted to the elderly people according to their purchasing power to satisfy their living and health needs. It is the third-largest economy in the world, which generates the biggest opportunities in public and consumer markets. The silvery economy is referred to as "the sum of all economic activity serving the needs of over 50 and including both the products and services they purchase directly and the further economic activity this spending generates" [1]. It has been estimated that by 2060, one out of three Europeans will be over the age of 65 which poses a threat to economic growth [2]. It is, therefore, imperative to ensure that elderly people lead a healthy and active lifestyle for them to contribute back to society. It is possible to increase their productivity by enabling the ageing population to manage their own health which will not only boost their confidence but also help them lead a quality life [30]. European Commission has already devised an action plan that incorporates ICT solutions at the workplace, in society and at home to increase their productivity, reduce isolation and maintain their independence respectively [31]. However, it leads us to the question: how do we make it possible?

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There are numerous e-services, digital portals, e-health platforms, smart devices, etc. already existing in the market to help the elderly people in their daily routines but adaption to these ICT solutions remains low. For instance, a research conducted in the US found out that only 42% of the elderly population over 65 own a smartphone and 32% own a computer while a whopping 49% does not have a broadband connection at home [36]. This leads us to our main concern: what are the factors that hinder the ICT adaption among elderly people?

ICT plays a significant role in the modern world which has revolutionized the way of living. Paperless management [35], X-road [3], eID [4], digital signature [4], e-voting [5], e-invoicing [6], e-prescriptions [7], e-tax [8], e-school [9], and e-residency [10] are some of the examples of ICT based services that have completely changed the dynamics of the fast-paced society in developed countries such as Estonia. Communication, socialization as well as information retrieval and archival are only a few clicks now. ICT infrastructure is already in place and well established, in these developed countries. Cyber security and cyber hygiene are religiously practiced as it "is inextricably linked to the development and management of state information systems and data" [32]. It has, therefore, become essential to use these resources in order to facilitate the major part of the country's population. ICT, without any doubt, can help develop systems that provide limitless benefits for the silver economy. ICT integration in the silver economy, however, may face several barriers mainly because this segment of the population is the last one to adapt to changes and are more likely to be dependent on others both physically and emotionally [11].

There have been limited research conducted on the silver economy and it is witnessed that innovative technology is being created for the masses especially youth who are tech-savvy and well-equipped with ICT knowledge. However, this research identifies the main obstacles that are faced by the elderly people with respect to technology adaption so that these can be addressed and future projects can bring innovation and technology solutions specifically for the elderly people to help them live an independent and comfortable life.

For research purposes, this study is a part of a larger project called 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth' – OSIRIS. The project consortium is made up of partners from Latvia, Lithuania, Estonia, Denmark, Russia and Finland representing the business, governmental and academic actors of the Triple Helix model for economic growth and regional development. This transnational partnership unites expertise, resources, and knowledge to share practices and learning on how to apply the smart specialization approach for exploiting silver economy opportunities in the Baltic Sea Region.

1.1 Methodology

The main objective of this paper is to explore the main problems that the silver generation faces when adapting to ICT solutions. In order to cater to the purpose of the study, a hybrid approach was applied which employs two survey questionnaires and two workshops.

First questionnaire was targeted to the elderly people to understand the problems they face when adapting to the ICT solutions. On the basis of the outcomes, second questionnaire was designed which was targeted to the experts who deal with IT solutions for the elderly people. To validate the results derived from the questionnaires, two carefully designed workshops were conducted that involved experts from various walks of life.

As the first step of the research, a survey was conducted by sending out questionnaires to 55 members of the elderly population in Estonia. All the candidates were selected randomly and were aged above 50 belonging to diverse segments of the population in Estonia. The questionnaire was designed to integrate closed-ended and objective questions keeping in mind the convenience of the aged candidates. The questions were aimed at understanding the mindset of the elderly population regarding technology solutions to everyday living. Therefore, the questionnaire included questions like if they were willing to use IT solutions in their daily routines, if they needed help in using smart devices, if they would chose a smart service over a traditional one etc. This helped in creating a better understanding of where elderly people struggled with technology, if either it was difficult to use, or expensive or if they just have a wrong perception about technology altogether.

The second questionnaire was sent to 19 experts working in the following organizations:

– Tallinn University of Technology.
– Tallinn University.
– Ministry of Social Affairs (Sotsiaalministeerium).
– Estonian Association of Pensioners' Societies (Eesti Pensionäride Ühenduste Liit).
– NGO Estonian Village Movement Kodukant.

Questionnaire included a combination of both, open as well as close ended questions to get an even deeper understanding of the obstacles faced by the elderly people when using technology solutions. IT experts who deal with elderly people were contacted because of their experience and understanding of the silver generation. They were asked more in-depth questions like the reasons behind elderly people unwillingness to adapt IT solutions, how pro-active services can help elderly people and which existing services can be transformed to proactive services etc. These experts had already conducted years of research to innovate IT solutions to help elderly population live an independent and comfortable life therefore, their valuable input aided in developing a thorough understanding of the problems and causes behind silver generation's low technology adaption rate.

The data thus gathered contributed towards the quantitative analysis of the responses from the candidates. Quantitative research methods enhance the objectivity of the study and are a form of empirical studies that require statistical analysis to understand various variables in research design [25].

The second phase of the research consisted of two workshops. These workshops encouraged the participation of field experts from the quadruple helix sectors of Estonia to further the research aims and objectives. These sectors include the four domains of ICT stakeholders comprising of the private sector, public sector, academic institutions and the end-users. Qualitative research designs in the social sciences stem from traditions in anthropology and sociology; where the philosophy emphasizes the phenomenological basis of a study, the elaborate description of the "meaning" of phenomena for the people or culture under examination [16]. For this particular phase of the study, the qualitative techniques were applied to understand the belief systems, behavioral aspects, and general attitudes of the population under consideration.

The initial workshop was fashioned in a manner to address the validity of the survey results of the first phase. Experts from the quadruple helix sectors contributed to determining the problems associated with e-solutions for the elderly. Through rigorous discussions and analyses, the experts identified their version of factors hindering ICT adaption. The second workshop attempted to undertake the task of devising recommendations to address the problems identified in the first workshop. The first workshop consisted of 12 participants including end users which were elderly people aged 50+ as well as experts from science, business and government sectors. The workshop was initiated with an introduction to the subject at hand with briefings on silver economy and ICT integration. Participants were then divided into 4 groups and were asked to have an open discussion within the groups about the main factors that hinder the ICT adaption in the silver economy. The second work-shop was dedicated to address the issues faced by the silver generation for ICT adaption identified in the first workshop. There were 18 participants again from the quadruple helix sectors and lasted for a fair three hours. The same format as first work-shop was used with dividing the participants into 6 groups this time and discussing the possible solutions and measures that can be taken to increase the technological readiness of the elderly people. The workshops ended in open discussions and the results and findings were completed.

The main advantages of a hybrid approach to research include a high level of detailed analysis, and the ability to combine both the objective and the subjective data to gain a thorough understanding of the subject [26].

The remainder of the paper is organized as follows. In the next section, we provide a literature review. In Sect. 3, we provide the results which are discussed along with recommendations in Sect. 4. We proceed with a possible future direction in Sect. 5 and we finish the paper with a conclusion in Sect. 6.

2 Literature Review

2.1 The Silver Economy

The term silver economy is used to identify the needs of the ageing population as an economic opportunity. Silver Economy in today's world is not just a market but across "economy", where it caters to the elderly population of the society. It is imperative to understand that the ageing process of the population is a genuine issue and has real impacts on the markets and industry [12]. The European Commission describes the silver economy as a set of economic activities pertaining to older people that incorporate the production, utilization and exchange of related goods and services [1]. Cornet (2015) considers the Silver Economy to encompass a great diversity of individuals concerning status, income, health, social and cultural context. He suggests that it includes the "50+ markets for wealthy baby boomers, active retirees, as well as poor and frail older adults, mostly lonely women at risk of dependency and social isolation" [13]. It also includes the challenges and opportunities that arise with catering to the requirements of the" greying" generation [13].

The developed countries especially the European region is witnessing a profound demographic change in terms of the ages of its population. Research shows that the proportion of older people is higher in developed countries as compared to the developing countries [1]. This is one of the reasons why in developed countries such as Estonia it is of eminent importance to take into serious consideration the support and welfare of elderly people. It is estimated that by 2060, one out of three Europeans would be above 60 years of age. The ratio of inactive to working citizens is also expected to change from 2:1 today to 4:1 in 2060 [14]. Other studies suggest that by 2025, the percentage of citizens above 60 years of age in the Baltic Sea countries would increase from 25% to 50% [2]. Many consider the evolution of the ageing society as an indicator of prosperity in a region [13]. This has impacted strategic policy development across several sectors especially in the EU nations. The Silver Economy is a cross economy that influences markets such as transport, healthcare, social services, e-health solutions, home accommodation, robotic assistance, public services, and many more [14]. Research suggests that the ICT sector has the potential to cater to the dependency needs of the elderly to support healthy and active ageing [15].

2.2 Existing ICT Services in Estonia

Estonia is an active member of the European Union with strong digital foundations. ICT is a distinguishing feature of the country, sometimes also referred to as "e-Estonia" [15]. It encompasses a wide array of realms including e-health, e-governance, data analytics, cybersecurity, and many more. Research suggests that over the past 20 years Estonia has thrived to become one of the most technologically developed countries in the world [2]. Tambur states that digital public services are a part of everyday life in Estonia. It ranks third in the index of Economic Freedom in the EU and second in Internet Freedom [2]. Internet access is declared as a human right with highly developed telecommunications and the fastest broadband networks all across the country [1]. The country also ranks amongst the top five countries in the cybersecurity index [16]. The ICT infrastructure is quite advanced in the country since the leadership in Estonia had assessed the value of a strong digital base at the beginning of this century. Therefore, it is already on its way towards a paperless and technologically advanced society [34]. For efficiency and security reasons, Estonia has conducted technical [37], policy and legal [38] environment analysis for e-government services migration to cloud servers.

According to Smart City Hub, almost all schools (97%) in Estonia had an online presence in 1997. All the inhabited areas have had a publicly constructed Wi-Fi network since 2002. All the citizens have a state-issued digital identity accessible through the Estonian ID card. They have had digital access to voting since 2007 and can file their taxes and sign documents online [17]. Furthermore, they can get prescriptions from the comfort of their homes with e-health services and almost 100% of bank transfers happen online. By 2017, Estonian citizens could file their taxes digitally in just three minutes [15]. Estonia is home to Skype and TransferWise with advanced digital support for entrepreneurs. Businesses can register online in less than 18 min through the online portal [18].

A country report by Empirica for the European Commission states: "Estonia is number one in the world concerning the use of e-services based on e-identity cards: Estonia holds a leadership position in using, developing and adopting of electronic ID in Europe and sports a center of competence in this field. The Estonian educational system makes strong use of ICT; e-tools and e-learning tools are becoming very common and at least 40% of the working-age population have participated in ICT training/retraining." [18] In 2011, the Estonian Government launched its Competitiveness Strategy for 2020. Its vision was to proactively raise the competitiveness of the economy through effective implementation of ICT across all sectors of the economy with participation from all population groups [19].

2.3 Obstacles for ICT Adaption in the Silver Generation

E-solutions can be of great use for the elderly as there are many belonging to the group who may have issues and inconvenience in being mobile and moving from one place to another easily [14]. Literature suggests that senior citizens face certain inhibitions in accepting and adopting the latest technologies, as compared to the younger generation [20]. Buccoliero et al. (2013) imply that the elderly have been wrongly considered a homogeneous segment and very little efforts have been put in understanding their needs according to their unique characteristics [21]. They believe that the silver generation needs to be evaluated based on their health conditions, financial situation, family status, education and skills into several target segments. These factors can predict their acceptance of ICT innovations. The ICT solutions can be tailored according to the requirements of each target segment [21]. There has been a lot of research to gain perspective into the factors that influence ICT adaption with reference to the elderly. Choudrie et al. (2014) investigated that observability, compatibility, social influence, facilitating conditions, effort expectancy and enjoyment are significant factors in ensuring the adaption of new technologies like smartphones within the silver generation [22]. Other literature highlights the role of individual external variables in developing attitudes of senior citizens towards technology adaption. Social norms, perception of usefulness and the perception of ease are some of the factors that may impact ICT implementation for the elderly [19].

Jensen & Mahan (2008) conducted a study and they have attempted to go beyond physical access to technology or the legal and regulatory framework to include factors like political will, affordability, human capacities, local content and trust in technology to consider for ICT adaption frameworks [23]. Although a large number of ICT solutions are available for a transition towards a digital economy, the adaption of these solutions needs serious thought and effort [20]. It is imperative to mold the technology according to the needs of the elderly to bridge digital divide and disseminate technology skills to the silver surfers [24].

3 Results

3.1 Results from Questionnaires

A total of 55 elderly people were randomly chosen in the age bracket of 50–85 years old and were asked to fill in the questionnaire to help understand the main problems that hinders the ICT adaption in their daily life routines. Majority of the respondents claimed that they did not use computer nor internet mainly because they did not have the required knowledge or skills for using them. When they were asked if they'd be willing to learn IT skills, a whopping 90.9% of respondents mainly above 85 years of age showed unwillingness. The same response was witnessed when they were asked if they'd be willing to use smart services over traditional services such as booking an appointment online. Most of the respondents claimed that they took help from their kids and were mainly dependent on their peers for caretaking. Majority of the respondents also complained about feeling isolated mainly because of the lack of communication.

On the basis of these outcomes, the second questionnaire was designed for experts who deal, communicate, research and/or provide services to the elderly people. Their experiences with elderly people provide a detailed insight to the factors that may hinder ICT adaption in the silver generation. 63.2% (12) of the respondents stated that the elderly people usually find the ICT services difficult to use with 31.6% stating that elderly have privacy concerns and that the websites for these e-services usually have misleading information as shown in Fig. 1. Moreover, 58% also claimed that silver generation did not have the means of using these e-services, such lack of internet-connected devices also contributes to low technology readiness amongst the elderly people. However, when asked about which digital devices elderly people used, 94.7% (18) confirmed that they owned a smart phone and 63.2% also used desktop computers. While the popularity of smart watches (26.3%) and tablets (42.1%) remained low, 8 respondents stated that elderly used laptops, indicating that they preferred using digital devices at the comforts of their homes and unlikely to use them on the go. When asked how often elderly were concerned about privacy when using ICT services, 31.6% agreed that they often did not trust the websites while only 5.2% of them were able to maintain cyber hygiene.

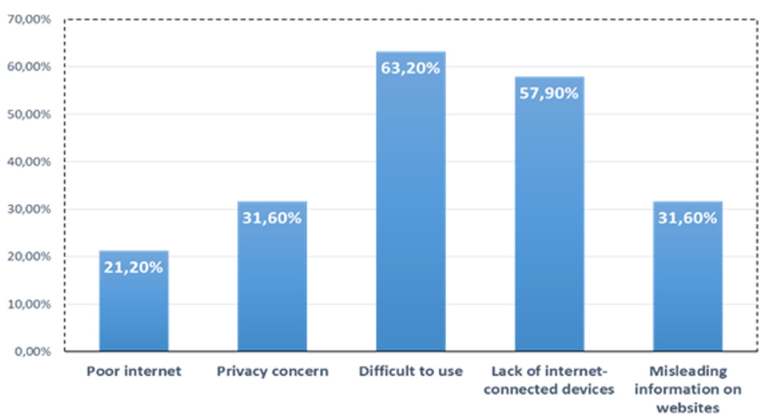

Fig. 1. Challenge when using ICT services.

Experts were asked which services could be turned into proactive services[1] meaning that the state already has the necessary information and provide predictive services to the elderly people. 73.7% stated population registry and 63.2% medical prescription and job search can be made proactive services which will not only save time for elderly but also optimize costs for the service providers. If elderly people were given an option of choosing either consulting an online doctor or physically visiting a doctor, 21.1% of the respondents that they are likely to choose the latter elaborating that they felt more comfortable and confident that they were being heard out in the face-to-face communication. When they were asked how likely are elderly people to be comfortable to use innovative technology over the traditional methods in their daily routine, for e.g. using a smart device for checking blood pressure and pulse rate, only a 10.5% of them chose the former option for the elderly people (see Fig. 2) as the rest of them stated that elderly believe that the digital methods are not always accurate neither convenient.

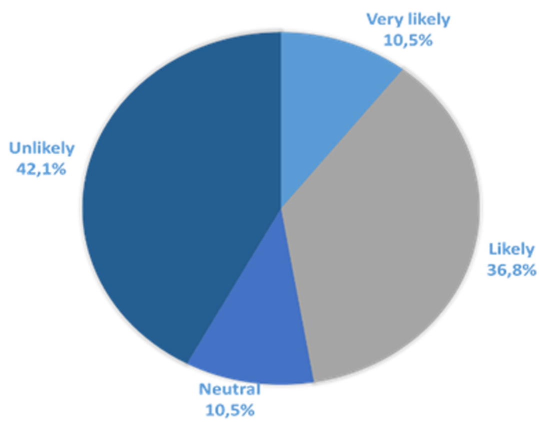

Fig. 2. Likely to use smart device over traditional methods.

When experts were asked how the elderly population can be trained to use digital devices to avail e-services, they pointed out that training workshops (73.7%), community tutoring (84.2%) and peer teaching (63.2%) are the best possible solutions. Moreover, to create awareness amongst the ageing population, 63.2% agreed that print advertising is the most suitable mean of promotion. Lastly, when respondents were asked what are the main limitations associated with the introduction of smart technology in the homes of older people who may be experiencing declining health due to age related conditions, 52.6% stated that elderly dislike using technology because of the lack of confidence and fear of making mistakes, 42.1% confirmed that silver generation could not afford to continue to maintain or replace the technology so they did not want to get dependent on it and 78.9% stated that elderly people were happy with the traditional ways and did not want to adapt to new technology as it was difficult to use.

[1] https://e-estonia.com/proactive-services-estonia/.

3.2 Results from Workshops

The results from both the questionnaires were then validated in two workshops which included group activities and open discussions. Silver generation and the obstacles they face in ICT adaption were discussed in immense detail and subsequently, appropriate solutions were provided as shown in Table 1.

Table 1. Results from workshops.

Problem	Description	Solution
Internet penetration	Unfamiliar with using the internet or might not even have it available to their premises	Awareness creation Internet subsidiary packages for elderly
Internet-connected devices	Elderly might not have means to use the internet for e.g., smart phones, tablets, laptops etc.	Peer teaching
Digital incompetency	Elderly population might be fearful and incompetent to learn new things compared with the younger population	Competence centre for digital skills Customer support involvement
Structure of digital application forms	Illogically structured. Lack of easy user experience that is necessary for the elderly users	Review existing forms Pre-filled forms
Lack of awareness	Aware of the existence of the e-service such as e-health but might not be aware of how it could make their lives easy	Community-based workshops Print advertising
Security	Lack of understanding of how to be safe online and how to maintain cyber hygiene	Cyber-security practices: • Notifications • Warnings
Lack of experts	Lack of specialists and trainers particularly for elderly people to cooperate with them and teach them ICT skills	Unified Platform Special training sessions
Inability to learn	Weak cognitive skills and capabilities at an elderly age leading to prolonged learning cycle requiring more repetition regularly	Chatbots One-size-doesn't-fit-all solution

Different age-groups have different needs which requires further research. If there is a logical cooperation between RIA (Information System Authority) and subsequently, solutions are created, it wouldn't have to duplicate systems that we already have.

This means that Estonia already has various training centers that help build digital competencies but for them to be useful for the silver generation, they should know where to find them and how to access them. Moreover, teaching digital skills requires user to already have some basic knowledge and skills. This can be achieved by involving peers and caretakers in the process just to give it a push start. It was suggested that we should follow the 'Hierarchy of skills' model[2] when teaching digital skills to the elderly people (see Fig. 3).

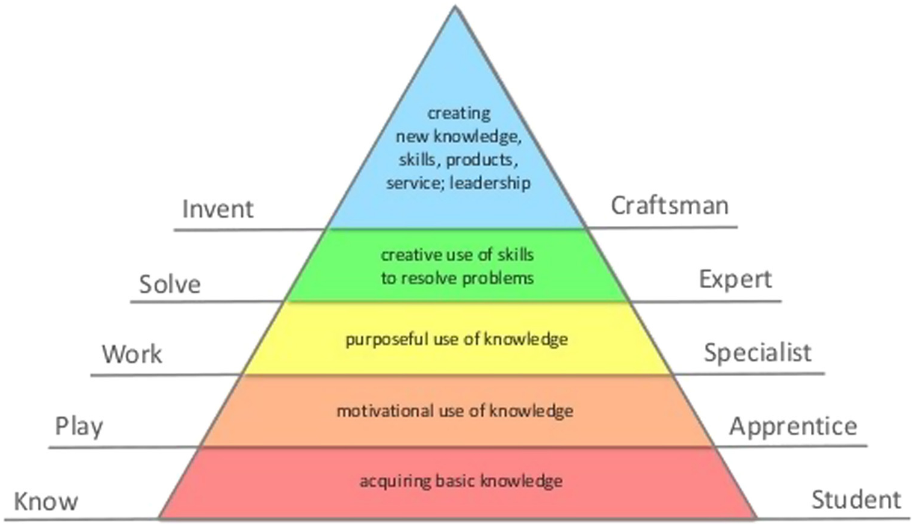

Fig. 3. Hierarchy of Skills.

We always need to keep in mind that automatic solutions are not able to replace real human contact that becomes vital the older we get. Elderly people need more explaining and have questions that programs are just not able to solve so we always need to involve customer support who can also help. Moreover, to create something new or maybe adding them to Facebook elderly-group doesn't mean that they are going to use it. Elderly people are using the same platforms like younger people (they are the ones who teach them how to use it). Therefore, we need to create solutions on a unified platform that are suitable and accessible to as many as possible. Existing application/e-services forms are also needed to be reviewed, we need to make the interface easy-to-use or silver generation will continue to use the traditional ways e.g. call their doctor to make an appointment. When elderly people are using computer and new pop-up windows of information open they can get easily distracted. We need to critically review all existing templates and forms and analyze if it could be possible to automate their execution. State already has all the information and 'once-only' principle can be very beneficial for the elderly people when they have to fill in applications online. This will help them realize that online forms are more convenient and less time consuming and eventually, increase motivation.

Digital guidance on how to use these platform such as "point and click" principle is not suitable for elderly people because this will distract their attention. The ability to pay attention decreases with age therefore, we should make more targeted and

[2] I. Kokcharov: Hierarchy of Skills © 2015 Craftsman Expert Specialist Apprentice Student.

personalized videos and use tools that are modern like chatbots which can guide them and help them stay focused. In addition to this, notifications about risks should be in different places (e.g. flashing) and warnings should be displayed. However, it should be done in a way that it doesn't create fear for the elderly people as they would then not be willing to use the digital devices or e-services.

We need more physical tutors who have gone through special training about how to teach elderly and should be community-based. Family members and peers should be included initially in the training process to make the elderly people feel more comfortable. Measure should be taken to increase awareness about ICT solutions and their benefits to the elderly people. E-mails, news, via local government, newspaper and direct mail are some of the best possible ways to distribute information to this age group. Elderly people need information on paper therefore the most effective way is to send a direct mail into their mailboxes. In addition to this, word-of-mouth is also considered useful to create awareness about e-services and ICT solutions as they find it more reliable when they are informed by their acquaintances.

Lastly, one-size-fits-all solution does not seem plausible for the needs of different elderly age groups, for example the groups of age 60+ and 80+ constitute of different challenges and basic needs. A matrix should be created, where different needs, events and cases are mapped. It would include: age groups (60+, 70+, 80+ and 90+), the needs and necessary vital services of the elderly (health, social need/welfare, safety, labor market and financial livelihood) and the sources of problems, where help is needed.

4 Discussion and Recommendations

The silver generation includes people who spent their youth in an era where digital technology was at its inception stage. As stated in the literature, we now know that for the elderly to adopt new technologies, their perceptions about the ease of use and its overall usefulness need to be factored in. 57.9% of the respondents agreed that they do not have the means to access e-services. Therefore, a great contributor to their low technology readiness is the fact that they do not use digital devices very frequently. Since the elderly prefer to follow a set pattern of habits, they find it difficult to add the use of digital technology to their daily activities. Although the survey results confirmed that most of them have access to the internet, computers/laptops, and even smartphones (tablets and smartwatches being less popular), yet their use of those devices was very limited.

Limited technology readiness of the elderly is also a by-product of their suspicion and lack of trust towards ICT solutions. Most of them prefer a face to face mode of interaction as opposed to online communication. When asked about their inclination towards e-health services, the elderly participants of the workshop proclaimed that they preferred to visit their physician physically instead of opting for the more convenient e-health portals. This attitude depicted the underlying trust issues of the silver generation with digital services. Field experts in the workshops also confirmed that people belonging to the elderly segment find it difficult to depend upon e-services. Jensen & Mahan (2008) have also stated a lack of trust as a major obstacle towards ICT framework implementation [23]. A considerable percentage of the survey participants also showed concerns about their privacy while using websites and e-services. They felt more comfortable using traditional methods for measuring blood pressure and pulse and were reluctant to depend upon high-tech devices.

Another major obstacle that was identified as a result of this study, was the limited awareness of the elderly about digital services. Secondary research suggests that senior citizens are less likely to adopt technological innovations since they are not tailored according to their needs. Discussions during the workshops also highlighted that the elderly have limited information about the ICT services and this might affect their confidence to use these services accordingly. It was also found out through the workshops that very few had received any kind of training or guidance on using tech devices, either by their organizations or by peers or family. While literature suggests that about 40% of the working-age population has received tech-trainings [19], it is very clear that the silver generation has been neglected in this respect.

Secondary research has also highlighted the role of individual variables like compatibility, social influence, facilitating conditions, effort expectancy, and enjoyment to improve technology readiness in the elderly [22]. The survey results and the workshops also indicate a general unwillingness of the aged population to learn new IT skills. This is understandable because the human capacity to learn is expected to reduce with age.

This calls for the triple helix actors (the public sector, the private sector, and academia) to come up with community-based solutions to impart tech-based knowledge and skills to the elderly. Based on their mistrust of online transactions and websites, they need to be educated systemically about their cyber rights and cybersecurity practices. As suggested in the Cyber Security strategy 2019–2022, “a small and cohesive cybersecurity community and good interpersonal communication are prerequisites for responding effectively to salient problems.” [33] The approaches towards this training need to be user friendly and tailored according to the comprehension abilities of various age brackets amongst the silver generation. Websites for e-services must be designed with the ease of use and perceptions of senior citizens in mind. For examples, pre-filled forms for tax filing or e-health access will improve their reluctance to utilize these services online. Estonia needs to develop the digital competencies of its elderly population since the country has a strong digital infrastructure that can provide smart solutions to the problems faced by this segment. Once, the silver generation is engaged through digital technologies, there is a great scope for them to improve their quality of life.

5 Future Work

As mentioned earlier, this study is a part of a larger project and many fruitful outcomes are expected to be achieved in the future. The results from the study will serve as the basis for future endeavors of discovery, design and implementation process.

This in-depth analysis on the factors influencing the uptake of the technology can help in each of the stages of the project as shown in the Fig. 4.

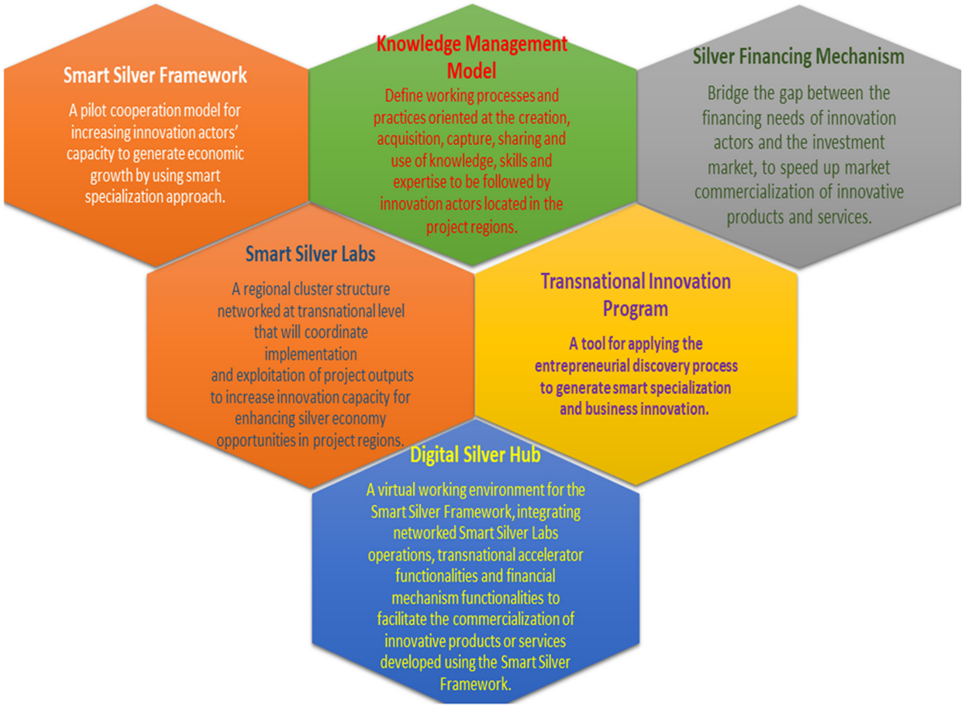

Fig. 4. Project Roadmap(https://www.osiris-smartsilvereconomy.eu/).

However, in terms of Tallinn University of Technology research area, main focus will be on Knowledge Management Model and Digital Silver Hub.

5.1 Knowledge Management Model

The in-depth analysis of the current trends amongst the elderly and issues that they face due to their inability to access to technologically advanced services in general and e-services, in particular, serves as the basis of the larger scope of a study. It is important to understand the current situation and facilities being utilized by the elderly or for the elderly to make sure that the future comes with advancements and ideas that provide support and assistance to them in their daily routines.

The findings from the current research will serve as a basis to develop the Knowledge Management Model for the silver generation of the country in times to come. A knowledge Management System can be defined as an IT system or infrastructure which is developed to improve the collaboration while locating knowledge sources and enhancing the process of Knowledge Management [28]. It helps in archiving, collaborating, and ensuring that all of the related processes are in alignment [27]. Knowledge Management Model will serve as the main instrument for handling the connection between smart specialization approach, industry and knowledge assets. The model will synthetize and integrate knowledge at the regional level for creating a common process for exploiting silver economy growth opportunities.

5.2 Digital Silver Hub

This study will set the cornerstone to realize the technical and operational analysis for developing a virtual collaborative platform known as the Digital Silver Hub that will serve as a virtual ecosystem where different stakeholders can collaborate in innovation processes using a methodology based on "knowledge exchange, co-creation/co-production techniques, and participatory methods" [29].

The aim is to create a conceptual and technical model that bridges companies and research organizations for generating new innovative solutions to tackle ageing challenges and to exploit silver economy opportunities. This study will help to build system specific requirements and design of the virtual collaborative platform to support learning process and knowledge diffusion between innovation actors and regions.

6 Conclusion

Silver economy is the third largest segment of the market where the major consumers belong to the elderly age group which suggests that they require and deserve more attention than it is being given at the moment. The results achieved so far help us to develop an understanding of the main factors that influence the ICT adaption in the elderly people which are lack of use of digital devices (internet, computers, smartphones etc.), lack of digital trust, lack of awareness regarding smart solutions and unwillingness to learn IT skills. The paper helps to build foundation to create a collaborative platform specifically for the elderly people. The collaborative platform will be aimed at innovative solutions to help elderly in their daily routine so they can perform activities independently. Therefore, the findings from this study will be helpful to build system requirements and design specifications of the platform.

It is important to note that this study suggests that the elderly are not very keen in taking up new technological trends and services; one of the reasons being the difficulty they encounter in operating advanced and sometimes even simple technology. This is because the elderly have not evolved with the latest trends and need support in developing an understanding. Hence, it is suggested to ensure that these services are easy-to-use and convenient. We should initiate a trend where elderly people start getting actively involved in IT solutions while learning new trends and skills.

Finally, the study urges the development of technological solutions that are in parallel with the requirements and demands of the silver generation ecosystem.

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References

1. Technopolis Group and Oxford Economics: The Silver Economy – Final report, Publications Office of the European Union, Luxemburg (2018)
2. Tambur, S.: Digital Economy Estonia: From IT Tiger to the World's Most Pre-Eminent E-State, New European Economy. https://neweuropeaneconomy.com/fdi/digital-economy-estonia/. Accessed 11 June 2020
3. Tepandi, J., et al.: The data quality framework for the Estonian public sector and its evaluation: establishing a systematic process-oriented viewpoint on cross-organizational data quality. In: Hameurlain, A., et al. (eds.) Transactions on Large-Scale Data- and Knowledge-Centered Systems XXXV. LNCS, vol. 10680, pp. 1–26. Springer, Heidelberg (2017). https://doi.org/10.1007/978-3-662-56121-8_1
4. Pappel, I., Pappel, I., Tepandi, J., Draheim, D.: Systematic digital signing in Estonian e-government processes. In: Hameurlain, A., Küng, J., Wagner, R., Dang, T.K., Thoai, N. (eds.) Transactions on Large-Scale Data- and Knowledge-Centered Systems XXXVI. LNCS, vol. 10720, pp. 31–51. Springer, Heidelberg (2017). https://doi.org/10.1007/978-3-662-56266-6_2
5. Drechsler, W., Madise, Ü.: Electronic voting in Estonia. In: Kersting, N., Baldersheim, H. (eds.) Electronic Voting and Democracy, pp. 97–108. Palgrave Macmillan, London (2004). https://doi.org/10.1057/9780230523531_6
6. Pappel, I., Pappel, I., Tampere, T., Draheim, D.: Implementation of e-invoicing principles in Estonian local governments. In: Borges, V.J., Rouco, J.C.D. (eds.) Proceedings of the 17th European Conference on Digital Government (ECDG): Military Academy, Lisbon, Portugal, pp. 127–136. Academic Conferences and Publishing International Limited (2017)
7. CEF Digital Connecting Europe: Estonian Digital Prescription. https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/2019/07/26/Estonian+Digital+Prescription. Accessed 11 June 2020
8. E-Estonia, e-tax: https://e-estonia.com/solutions/business-and-finance/e-tax/. Accessed 11 June 2020
9. E-Estonia, ekool and stuudium: https://e-estonia.com/solutions/education/e-school/. Accessed 11 June 2020
10. Särav, S., Kerikmäe, T.: E-Residency: a cyberdream embodied in a digital identity card? In: Kerikmäe, T., Rull, A. (eds.) The Future of Law and eTechnologies, pp. 57–79. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-26896-5_4
11. Czaja, S.J., Lee, C.C.: The impact of aging on access to technology. Univ. Access Inf. Soc. **5**, 341–349 (2007). https://doi.org/10.1007/s10209-006-0060-x
12. Gordon, C.: A silver economy: The value of living longer (2017)
13. Cornet, G.: Europe's 'Silver Economy': a potential source for economic growth? Gerontechnology **13**, 319–321 (2015)
14. Zsarnoczky, M.: Innovation challenges of the silver economy. Vadyba J. Manag. **28**, 105 (2016). 1648-7974
15. Kitsing, M.: Political Economy of Government Venture Capital in Estonia, pp. 115–124 (2017)
16. Kitsing, M.: Success without strategy: e-government development in Estonia. Policy Internet **3**, 1–21 (2011)
17. Arets, M.: How Estonia became the most digital country in the world. Smart City Hub (2017). http://smartcityhub.com/governance-economy/how-estonia-became-the-most-digital-country-in-the-world/. Accessed 11 June 2020

18. Laurits, M., Mägi, E.: E-skills in Europe: Estonia Country Report/ Empirica for European Commission. European Commission: PRAXIS Center for Policy Studies (2014)
19. Gichoya, D.: Factors affecting the successful implementation of ICT projects in government. Electron. J. E-Government **3**, 175–184 (2005)
20. Chatfield, K., Iatridis, K., Stahl, B.C., Paspallis, N.: Innovating responsibly in ICT for ageing: drivers, obstacles and implementation. Sustainability **9**, 971 (2017)
21. Buccoliero, L., Bellio, E., Ishmatova, D.: "Silver" technology acceptance model: a first research framework. In: Aging Society and ICT: Global Silver Innovation, vol. 5, p. 137 (2013)
22. Choudrie, J., Pheeraphuttharangkoon, S., Zamani, E., Giaglis, G.: Investigating the adoption and use of smartphones in the UK: a silver-surfers perspective. In: Proceedings of the 22nd European Conference on Information Systems, pp. 0–19 (2014)
23. Jensen, M., Mahan, A.: Towards better measures of global ICT adoption and use. In: Global Information Society Watch, p. 47 (2008)
24. Fors, M., Moreno, A.: The benefits and obstacles of implementing ICTs strategies for development from a bottom-up approach. Aslib Proc. **54**(3), 198–206 (2002)
25. Brannen, J.: Mixing methods: the entry of qualitative and quantitative approaches into the research process. Int. J. Soc. Res. Methodol. **8**, 173–184 (2005)
26. Vanderstoep, S.W., Johnson, D.D.: Research Methods for Everyday Life: Blending Qualitative and Quantitative Approaches, vol. 32. Wiley, Hoboken (2008)
27. Maier, R.: Knowledge Management Systems: Information and Communication Technologies for Knowledge Management. Springer, Heidelberg (2007). https://doi.org/10.1007/978-3-540-71408-8
28. Davenport, T., Prusak, L.: Working Knowledge: How Organizations Manage What they Know. Harvard Business School Press, Boston (1998)
29. Baccarne, B., Mechant, P., Schuurman, D.: Empowered cities? An analysis of the structure and generated value of the smart city ghent. In: Dameri, R.P., Rosenthal-Sabroux, C. (eds.) Smart City. PI, pp. 157–182. Springer, Cham (2014). https://doi.org/10.1007/978-3-319-06160-3_8
30. Zhou, J., Salvendy, G. (eds.): ITAP 2015. LNCS, vol. 9193. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-20892-3
31. European Commission: Ageing well in the Information Society: Action Plan on Information and Communication Technologies and Ageing. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Al24292. Accessed 12 June 2020
32. Republic of Estonia, Information System Authority: Cyber Security in Estonia 2020. https://www.ria.ee/sites/default/files/content-editors/RIA/cyber_security_in_estonia_2020_0.pdf. Accessed 12 June 2020
33. Republic of Estonia, Ministry of Economic Affairs and Communication: Cyber Security Strategy 2019–2022. https://www.mkm.ee/sites/default/files/kyberturvalisuse_strateegia_2022_eng.pdf. Accessed 12 June 2020
34. Pappel, I., Pappel, I.: Methodology for measuring the digital capability of local governments. In: Proceedings of 5th International Conference on Theory and Practice of Electronic Governance, Tallinn, Estonia, pp. 357–358. ACM (2011)
35. Pappel, I., Tsap, V., Draheim, D.: The e-LocGov model for introducing e-governance into local governments: an Estonian case study. IEEE Trans. Emerg. Top. Comput. (2020)
36. Anderson, M., Perrin, A.: Tech adoption climbs among older adults. Pew Research Center (2017). http://www.pewinternet.org/2017/05/17/tech-adoption-climbs-among-older-adults/. Accessed 07 Sept 2020

37. Kotka, T., Johnson, B., Cebul, T., Lovosevic, L., Liiv, I.: E-Government services migration to the public cloud: experiments and technical findings. In: Kő, A., Francesconi, E. (eds.) EGOVIS 2016. LNCS, vol. 9831, pp. 62–76. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-44159-7_5
38. Kotka, T., Kask, L., Raudsepp, K., Storch, T., Radloff, R., Liiv, I.: Policy and legal environment analysis for e-Government services migration to the public cloud. In: Proceedings of the 9th International Conference on Theory and Practice of Electronic Governance, pp. 103–108 (2016)

Appendix II

[II]
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A Knowledge Map for ICT Integration in the Silver Economy

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Abstract

In the European Union, the silver economy is focused on developing strategies to facilitate the elderly population, mainly in terms of creating services based on innovations and technology. The paper encompasses a detailed overview of the silver economy in Estonia and the introduction of ICT solutions for the elderly population through knowledge management techniques. A knowledge map has been created using the Ontology model in Protégé to demonstrate the key knowledge resources for ICT integration in the silver economy. The results and information displayed in the knowledge map have been gathered from two detailed workshops which were further validated through questionnaires and interviews from the professionals in the field. The purpose of this paper is to discuss the different knowledge resources and competencies relevant to the integration of ICT in the silver economy which will serve as a basis for the development of a knowledge management model in the future.

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Keywords: Smart Specialization Strategy; ICT; Silver Economy; Knowledge Map; Ontology; Digital Competency

1. Introduction

The aging population of the European countries is an emerging challenge in terms of its financial and communal repercussions but on the other hand, it is also a huge potential for market development. The Baltic Sea Region (BSR) countries are experiencing a change in demographic dynamics that will have a monumental impact on the economic

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and social fabric of these countries in the future [1]. According to an estimate by the European Commission, by 2060 one in three Europeans will be over 60 years of age, with the ratio of working to inactive citizens to 2 to 1 as compared to 4 to 1 today [2]. Some estimates suggest that by 2025, the percentage of citizens over 60 in the Baltic Sea countries will increase from 25% to 50% of the total population which implies a huge effect on the health and social care sectors as well as the overall productivity and job markets of the future [4]. With the rise in members of the population that will be more dependent on their families, the BSR will be faced with overwhelming challenges [7]. Therefore, this research focuses on creating an understanding of the existing knowledge resources with particular emphasis on investigating the potential of ICT solutions to facilitate the elderly population. It aims to highlight the competencies and cardinal resources for ICT usage amongst the elderly people. The findings are then visually represented on a knowledge map which will serve as a basis for the Knowledge Management Model in the future and also for building requirements for the Digital Silver Hub (see Sect. 6).

The European Commission has outlined research and innovation strategies for smart specialization at regional levels to spearhead progress in the future. According to the Commission: *"Smart specialisation is an innovative approach that aims to boost growth and jobs in Europe, by enabling each region to identify and develop its own competitive advantages. Through its partnership and bottom-up approach, smart specialisation brings together local authorities, academia, business spheres and the civil society, working for the implementation of long-term growth strategies supported by EU funds."*[5] This study is a part of a larger research initiative: OSIRIS - 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth'[*]. The project aims to create an innovation ecosystem where private sector, public sector, education sector and the end user can collaborate and co-create innovative solutions to help elderly people live a comfortable independent life.

The first phase of the research undertook to understand the demographic characteristics of those who benefit from digital services. Estonia has a dynamic and efficient digital infrastructure which means that its citizens enjoy a paper free and hassle-free system where they can file their taxes, register their businesses, sign documents, get prescriptions and even vote online [11]. It was found out that the elder generation was not very motivated to utilize digital services. 90% of people above the age of 85 years did not want to learn new IT skills whereas those in the 65-85 age group did want to adopt new technologies to some extent. Most of the elderly were satisfied with the medical services they received online but a clear hesitation to adapt to technological innovations was observed.

Estonia is an impactful and energetic member of the European Union (EU), with a thriving digital economy fuelled by its technologically advanced infrastructure [16]. Estonia has expended tremendous efforts to build an information system that allows data exchange between public and private entities in order to build synergies. With respect to this, X-Road is considered to be a backbone of Estonia's e-government in the organization of interoperability [14]. As a Smart Specialization priority (RIS3) of Estonia, ICT encompasses a wide array of realms including e-health, e-governance, data analytics, cybersecurity, and many more [5].

In order to identify the key knowledge resources for ICT integration in the silver economy, two extensive workshops have been conducted and the results have been represented as a knowledge map using the ontology model on Protégé. The knowledge map serves as the primary source of information which then has been further validated´ from questionnaires and expert interviews. You can view the ontology based knowledge map on WebProtégé [†].

In Sect. 2, we provide a brief theoretical background of the silver economy in Estonia and knowledge management. In Sect. 3, we propose a knowledge map for ICT integration using the ontology model in Protégé. In Sect.´ 4, the research methodology is described which is used to validate the knowledge map from Sect. 3. In Sect. 5, we provide the results. We proceed with a discussion of possible future directions in Sect. 6 and finish the paper with a conclusion in Sect. 7.

[*] https://www.osiris-smartsilvereconomy.eu/

[†] https://webprotege.stanford.edu/#projects/175753ab-fdcf-48f2-a28f-15f9053626d1/edit/Classes

2. Theoretical Background

2.1. Silver Economy in Estonia

The silver economy encompasses a broad term that pertains to the considerations of the elderly population. It deals with the economic activity related to the direct and indirect purchasing and spending patterns of people above 50 years of age. According to the European Commission: *"Silver economy encompasses a unique cross-section of economic activities related to production, consumption, and trade of goods and services relevant for older people, both public and private, and including direct and indirect effects."*[16] The term silver economy also represents the challenges and opportunities that catering to the aging population entails [17]. Despite being ranked third in the index of Economic Freedom in the EU and second in Internet Freedom, with internet access declared as a human right, highly developed telecommunications and fastest broadband networks all across the country and digital public services a part of everyday life, Estonia or "e-Estonia" as some call it, has a lot of challenges pertaining to its older population using the available ICT services. [15]

2.2. Knowledge Management and Transfer

Knowledge management and transfer, both refer to the interdisciplinary concept of achieving a predetermined set of objectives through the optimal use of knowledge in professional settings. It's a complex process because knowledge embedded in any organization's processes, members, resources and networks includes both its explicit and tacit forms that are sometimes hard to define [9]. It is especially relevant to the innovation process and its tactical and strategic manifestations to create value by utilizing the knowledge assets of any entity [12]. The Knowledge Management Model (KMM) provides a practical framework to:

- identify needs,
- recognize the knowledge resources,
- acquire, create or eliminate knowledge related tools, processes or scenarios,
- recover, apply and share knowledge,
- store knowledge [3]

For this study, to understand the process of knowledge management and transfer in the silver economy in Estonia, a knowledge map has been created which will be utilized to develop the Knowledge Management Model in the future. The goal is to apply the smart specialization strategies (RIS3) to the Baltic Sea Region countries through this model. In this case, the RIS3 includes the implementation of ICT resources and strategies to the silver economy in Estonia.

2.3. Knowledge Map

For knowledge management and transfer to be effective, knowledge maps serve as beneficial tools and methods that capitalize on the explicit and tacit knowledge resources for problem-solving through visual representation. They identify the knowledge sources, the actors involved in knowledge creation and dissemination, how knowledge flows through various networks and reaches the target audiences and the hindrances that may stifle the process [3]. Through knowledge maps, we can have a practical representation of how information travels through a system amidst the innovation actors and recognize the imminent threats and weaknesses within the process. Consequently, pockets of opportunity and improvement can be pinpointed and adjustments can be recommended to make sure that the relevant knowledge reaches the concerned people at the right time [13]. For the purpose of this study based on the silver economy, the knowledge map is a fundamental outcome to serve as a base for open dialogue and knowledge management model for long term purposes.

3. Proposed Knowledge Map for ICT Integration in the Silver Economy

The integration of ICT in the silver economy is particularly challenging, because the elderly citizens are usually the last one to accept and implement change [1]. However, they are most vulnerable to be dependent on others due to their restricted mobility, lack of digital competencies, social, emotional and financial needs [8]. Two workshops were conducted to comprehend the important issues involved in the implementation of smart environments for the elderly.

The needs of this segment of the population are distinctively different from those aged between 20-40 years in terms of acceptance of innovative technologies. The participants of workshops were mainly professionals from the fields of IT, science, business and government bringing together their extensive experience and knowledge to apply ICT in the silver economy of Estonia.

3.1. Workshop Results

The workshops sought to explore the following concerns regarding the digital environment for the silver generation which were based on strategy and direction from the EU strategy on the silver economy [6]:

- The need to reform the existing digital environment or "smart environment".
- Key components in the development of such environments.
- Ways to find information on various factors.
- Kinds of information required to create a smart environment.
- Challenges and constraints in finding information.

The focus areas of workshops included the following:

- Smart living: Smart living includes solutions that enable digital environments that require minimum effort from the users so that the elderly people do not have to learn complex procedures to accomplish simple tasks.
- Digital competencies for the elderly/digital e-government forms: There is a need for the silver generation to acquire basic digital competencies such as navigating the internet, as the digital environment is inevitable. The digital e-government forms, however, need to be simpler and more user friendly with one time data input and pop-up windows to be effectively maneuvered by the elderly. The issue of the lack of experts to train the elderly in digital skills is also pertinent and needs to be addressed.
- Medical help: One of the most important and frequent services that the elderly require is medical help. Although the need to see a medical expert in person cannot be eliminated yet the medical resources can be managed effectively by providing digital platforms that are user friendly.
- Information technology/Internet penetration: Although Estonia has extremely high internet penetration rates, there is still a likely chance that the silver generation may not have it at their premises. It's important that they have infrastructural means to access to the information technology such as electricity, internet connection etc.
- Active lifestyle and sociability: If a person has a healthy lifestyle and an active interest, with adequate social support he is more likely to adjust to changes. There is a need to develop unified information centers by the government so that if the elderly does not have any social support, they can still learn to navigate the digital environment and feel secure.
- One size doesn't fit all: It was suggested that customized smart solutions, according to relevant age brackets, should be developed. In order to create a need-based approach to information flows, a matrix should be created for different elderly age groups(60+, 70+, 80+, 90+), as each age bracket presents a different set of challenges and demands.

It's imperative to understand that the elderly population does not have the necessary IT skills that the younger digital generation enjoys. Moreover, a retired person today may possess a different set of skills than a pensioner twenty years later. So the ICT implementation would have to take into account all these factors to facilitate the silver generation. Estonia being a second home to the internet, a vast number of organizations here are already working for smart solutions, for instance, virtual assistants. In order to improve e-governance and social welfare services, proactive approaches need to be incorporated in the ICT system such as one-time data input that may be cross-referenced. The workshops, with participants from various expertise, contributed towards developing a holistic knowledge map that took into consideration the following aspects of ICT implementation:

- Legal
- Infrastructure
- Service Design
- Actors

- Promotion
- Knowledge Management

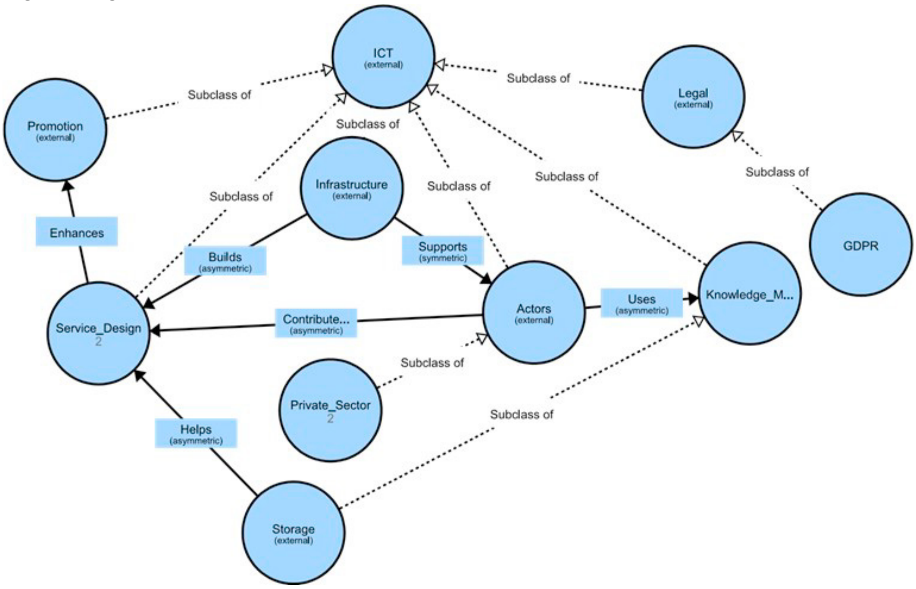

Fig. 1. Knowledge map (created from workshop results)

A comprehensive model of the necessary components of the knowledge map coupled with the capacity to navigate through different levels of abstraction across the related factors and actors was needed. For this reason, we constructed our ontology model defined in Figure 1. In the ontology, we defined a glossary of classes that serves as a central repository for the silver generation. More precisely, we defined a set of classes, sub-classes and instances for specifying the main concepts regarding the contextual characteristic of the ICT. In order to make more informed decisions, we represent the relationships between different classes. Relationships are represented by properties in OWL.

4. Methodology

For the purpose of developing a knowledge map, two dedicated workshops have been conducted, that ensured that the collected data was participant-centric. This allowed us to ground the data within the framework of the interregional Baltic Sea Program project ”OSIRIS” while making sure that the participants of both the workshops were assisted well to frame their experiences and opinions. One of the most important uses of the derived knowledge map is the visual representation of all the gathered knowledge and information. It is through knowledge maps, that the researchers can gain valuable insight into the topic under discussion through an easy to navigate visual knowledge map.

4.1. Expert Interviews and Questionnaires

The proposed knowledge map has been created through the information gathered from the participants of the two workshops which was dedicated to understanding the knowledge resources and competencies for ICT integration in the silver economy. However, it is essential to make sure that the map is validated and supported through other primary methods of data collection and research. For this purpose, the study aimed to conduct detailed interviews and questionnaire surveys to gather information that further related and supported the results of the knowledge map. Questionnaires were sent out to numerous influential professionals from different fields of IT, social sciences and healthcare and we received a total of 19 responses. In addition to this, six structured expert interviews were also

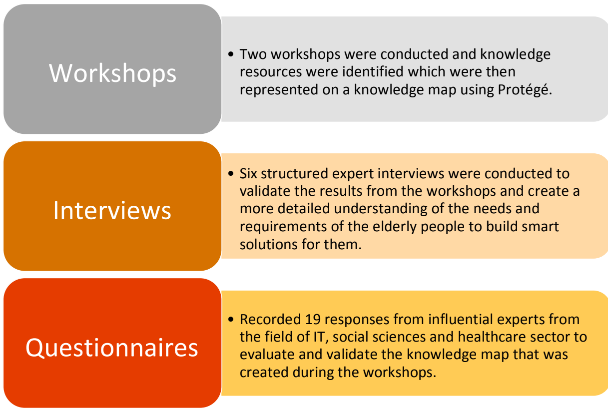

Fig. 2. Methodology Summary

conducted. The purpose of these interviews was to develop a better understanding of the needs and requirements of the silver economy while exploring the options that can assist in formulating detailed ICT solutions. Moreover, the objective behind the interviews was to ensure that the knowledge gathered through the workshops and the knowledge map was further validated and supported by expert opinions. The experts were chosen carefully while the questions were well-articulated and interviews were 30 min long on average which provided the research with a deeper insight to the topic at hand. Experts were from the following organizations:

- Tallinn University of Technology
- Tallinn University
- Ministry of Social Affairs (Sotsiaalministeerium)
- Estonian Association of Pensioners' Societies (Eesti Pensionaride Uhenduste Liit)
- NGO Estonian Village Movement Kodukant

Hence, the methodology applied for this research is mainly qualitative where the primary source of data collection includes workshops as well as expert interviews and questionnaires (see Fig 2). Here the purpose of the interviews and questionnaires is to support and further validate the knowledge map drawn in conclusion of workshops carried out to identify the key knowledge resources for ICT integration in the silver economy.

5. **Results and Discussion**

5.1. Results from Questionnaires:

All of the respondents agreed that there was no redundant information displayed in the knowledge map. All of the information was unique and essential for the study. 63.2% of the respondents agreed that the knowledge presented in the map covered all of the details related to ICT. Whereas 36.8% felt that there was some information left out. They believed that concepts such as interoperability and integration should also be discussed. One of the most essential factors that were discussed throughout the research is the readability of the elderly to adapt to new and dynamic technological changes. It has been analyzed that learning new skills and coping with new mechanisms at an elderly age may not be ideal and often requires extensive assistance and guidance.

When asked the most effective way of training the elderly, 73.7% of the respondents opted for "Training workshops". These workshops can allow them to come together with their age fellows and start learning at the basic level.

It is also important to create awareness amongst the elderly population about the benefits of integrating ICT solutions in their daily routines. Communication mediums easily accessible to them should be used for this purpose such as TV advertising, print advertising, radio advertising, informative sessions, activity clubs, enforced online services, and word of mouth. Out of which the most effective ones are print (63.2%), TV (52.6%), and radio (52.6%) advertising.

Smart living is a concept that we often see extensively advertised. However, the target audience that is still not very much catered to the concept is the elderly population which can, in fact, reap maximum benefits out of the new ideology. As per the respondents, one of the most common advantages for Smart living for the elderly will be the monitoring of health and medication reminders. 94.7% respondents believe that the elderly will get timely medication reminders, whereas 89.5% think that the caretaker of an elderly individual can be notified on time in case of any sort of emergency. However, the major obstacle that may arise while introducing smart living concept is the unwillingness of the elderly population to adapt to new changes (68.4%). Moreover, there is a likely chance that elderly population may not be able to keep the cyber hygiene and may fall for a scam (see Fig 3). The majority of the elderly population as per the results of the questionnaires are connected to technology through smartphones (94.7%). This factor needs to be kept into careful consideration while developing technology and related applications targeted for the smart living concept amongst the elderly population.

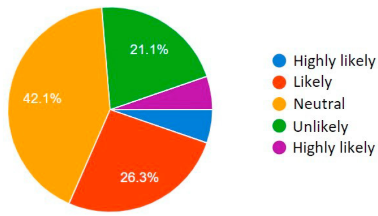

Fig. 3. Likeliness of elderly population to keep cyber hygiene.

Concluding the results from the questionnaires, it can be said that the results gathered from the survey concede with the ideas and information, as represented in the knowledge map.

5.2. Results from Interviews:

Interviews were conducted to explore expert insight on the issues pertaining to the integration of ICT solutions for the elderly population. One of the integral ideas discussed is the need to create a consolidated platform or a portal that can host an information bank for the elderly. The portal can serve as a means of creating a reliable environment for providing varying services and information to the elderly population. The platform can be further customized to provide user support which is age-appropriate and personalized. *"Information should be available in one place that is familiar and already in use"*. The information bank can include all the related medical history of a user, including the communication with the family doctor, the previous health conditions, and so forth. In order to ensure that the elderly population becomes acquainted with the e-environments, it is imperative to provide them with *"accessibility to services as a pre-requisite to motivate them to use, personal support, and automation of forms and/or critical reviews that may otherwise overwhelm them"*. However, the challenge remains to ensure that all of the information on the consolidated platform is reliable and authentic.

One of the most significant issues while creating ICT solutions for the elderly is their ability to use them appropriately and with ease. As discussed earlier, the elderly population is most of the time unaware as to how to utilize e-services such as e-Health. It is, therefore, essential to make sure services are easily accessible and personal support is available. For example, often a plethora of different online forms can be overwhelming, one solution can be to create forms that are not redundant and are easier to fill out. It is also essential to introduce training programs for the elderly population. The training should especially include information related to cyber hygiene to protect the elderly from falling at the hands of fraudulent activity. It was further advised that their systems should have warning messages displayed consistently to remind them and make them acknowledge the importance of cybersecurity. Moreover, different promotional campaigns should be organized to create ICT awareness amongst the elderly. These should include dedicated videos, TV programs, and face-to-face training by the professionals.

It is agreed upon, without any doubt, that IT solutions support a healthy lifestyle. It enables the elderly to ensure that their daily routines and health is carefully monitored while maintaining an independent lifestyle. However, all of this depends significantly upon the type of applications being developed, the ease of use, and the training programs. The collection of personal data through a unified portal will also allow IT professionals to develop pre-filled forms for the elderly. Governments and even private companies go to great lengths to support the younger population in the society

[10]. It is high time we also understand the importance of the role of the elderly population and provide support to help them lead a more independent life. This can be achieved by creating more proactive services for them. As one of the interviewees suggested: *"Event-based approach (e.g retirement course), public services should all be pre-filled, support-system for the healthy and active years supported by the state through local government, preparing people with the right information at an early stage, and the introduction of many more ideas that may support the elderly population maintain a healthy lifestyle"*.
Hence, it can be concluded that the interviewees mainly conceded with the competencies and knowledge resources gathered through the workshops and subsequently validating the knowledge map. The need here, now, is to define and create a consolidated approach that will help better integrate ICT solutions in the lives of the elderly population.

6. **Future Work**

As mentioned earlier, this research is part of a project called OSIRIS which is focused on the development of the silver economy through innovative solutions and ICT services that can help them live a comfortable independent life. The results from the current as well as future research will be compared to the findings from the other countries in the BSR so that outcomes can be discussed and generalizations can be made in order to build requirements to create an innovation ecosystem model in the future.

6.1. Knowledge Management Model

The purpose of creating detailed knowledge map by conducting dedicated workshops is to set the foundation of a Knowledge Management Model. The primary outcome of the complete process is the "Knowledge Management Model"; where it helps in defining processes that are best customized in accordance to the unique requirements of the project at hand. Furthermore, it also helps in retrieving and displaying relevant information in the most valuable and presentable form. Therefore, it can be said that the formulation of a Knowledge Management Model on the basis of the created knowledge map helps achieve the long-term goals and targets of the research. This model not only allows researchers to develop a better understanding of the needs and solutions for the silver economy but also helps the local authorities and policy makers find a deeper insight [13]. The knowledge management model which will be created on the basis of the knowledge map does not only take into account factors that are dependent but works on a system where all of the listed factors are interdependent. This means that the model is applicable at a wider scale and caters to different regions and is not limited to Estonia; providing relevant insight for both regional and inter-regional research purposes.

6.2. Digital Silver Hub

The research will set the cornerstone for future study and development of the digital silver hub in the BSR. The idea is to introduce a virtual collaborative platform referred to as 'Digital Silver Hub' which will connect *"researchers, product developers, financers and user organizations into a network and enable all innovation actors to screen and accelerate the uptake of innovative products and services enabling older adults to continue living a comfortable, independent and active life"*.[1] The introduction of technology specifically designed to help the elderly population will help in their care-taking and wellbeing.

7. **Conclusion**

The expected demographic change highlights the importance of the silver generation and their role in the economy. With the increase in the elderly population, it seems to be a high time to turn population aging into entrepreneurial opportunities. Integrating ICT solutions to aid the elderly population to live a healthy lifestyle can be challenging due to their resistance to change and digital incompetency. However, if proper training and guidance programs are in place and e-services are designed with convenient user-interface, there is a likely chance that the elderly population would be keen to adapt. Private, public, and academic sectors need to build synergies to develop ICT solutions for the silver economy. Expertise and knowledge from the different actors can result in innovations that are designed to help the elderly population to maintain their cyber hygiene while availing e-services independently from the comforts of their homes. The need here is to amalgamate the requirements of the elderly and develop ICT solutions. The best way to promote these services is by introducing them to their activity clubs or using TV and radio commercials. When the silver generation is aware that their data is protected under GDPR and the service is easy-to-use and readily accessible, they might be more convinced to become technologically equipped.

References

[1] Ahtonen, A., 2012. Healthy and active ageing: turning the 'silver' economy into gold. EPC Policy Brief .

[2] Balland, P.A., Boschma, R., Crespo, J., Rigby, D.L., 2019. Smart specialization policy in the European Union: relatedness, knowledge complexity and regional diversification. Regional Studies 53, 1252–1268. doi:10.1080/00343404.2018.1437900.

[3] Davenport, T., Prusak, L., 1998. Working Knowledge: How Organizations Manage What they Know. Harvard Business School Press, Boston, MA.

[4] Erceg, A., Barkovic Bojanic, I., 2017. Silver economy: Demographic change and economic opportunity, in: INTERDISCIPLINARY MANAGEMENT RESEARCH CONFERENCE XIII.

[5] European Commission, 2018. National/Regional Innovation Strategies for Smart Specialisation (RIS3). European Commission .

[6] European Commission, 2019. THE SILVER ECONOMY: An Overview of the European Commission's Activities. The First-Ever Global Silver Economy Forum Finland .

[7] Holgersson, J., Soderstr¨ om, E., Rose, J., 2019. Digital Inclusion of Elderly Citizens for a Sustainable Society, in: Proceedings of the 27th¨ European Conference on Information Systems (ECIS).

[8] Kitsing, M., 2011. Success without Strategy: E-Government Development in Estonia. Policy & Internet 3, 1–21. doi:10.2202/1944-2866. 1095.

[9] Kitsing, M., 2017. Political Economy of Government Venture Capital in Estonia, in: Proceedings of IE'2017: the 7th Annual International Conference on Innovation and Entrepreneurship, pp. 115–124. doi:10.5176/2251-2039_IE17.34.

[10] Lohmus, K., Nyman-Metcalf, K., K.Ahmed, R., Pappel, I., Draheim, D., 2019. The Private Sector's Role in e-Government from a Legal˜ Perspective.

[11] Lips, S., Aas, K., Pappel, I., Draheim, D., 2019. Designing an Effective Long-Term Identity Management Strategy for a Mature e-State. pp. 221–234. doi:10.1007/978-3-030-27523-5_16.

[12] Loogma, K., Kruusvall, J., Umarik, M., 2012. E-learning as innovation: Exploring innovativeness of the VET teachers' community in Estonia.¨

Computers & Education 58, 808–817. doi:10.1016/j.compedu.2011.10.005.

[13] McAdam, R., McCreedy, S., 1999. A critical review of knowledge management models. The Learning Organization 6, 91–101.

[14] Paide, K., Pappel, I., Vainsalu, H., Draheim, D., 2018. On the Systematic Exploitation of the Estonian Data Exchange Layer X-Road for Strengthening Public-Private Partnerships, pp. 34–41. doi:10.1145/3209415.3209441.

[15] Quadrello, T., Hurme, H., Menzinger, J., Smith, P., Veisson, M., Vidal, S., Westerback, S., 2005. Grandparents use of new communication technologies in a European perspective. European journal of ageing 2, 200—207. URL: https://europepmc.org/articles/PMC5546345, doi:10.1007/s10433-005-0004-y.

[16] Tambur, S., 2016. Digital Economy Estonia: From IT Tiger to the World's Most Pre-Eminent E-State. New European Economy . [17] Zsarnoczky, M., 2016. Innovation Challenges of the Silver Economy. VADYBA Journal of Management 1648-7974 28, 105.

Appendix III

[III]
Sidra A. Butt and Dirk Draheim. Ethical challenges of ICT for the silver economy. In *Proceeding of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 152–155. IEEE, 2021

Ethical Challenges of ICT for the Silver Economy

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***Abstract*—The silver economy has been identified as a potential domain for business growth and opportunity all around the globe especially in the developed world like the European Union (EU) countries and the Baltic Sea Region (BSR) that are characterized by a significant demographic change. While ICT offers a wide array of solutions for meeting the needs of the silver generation, such as healthcare, independent living, accommodation, e-governance, assistive technologies etc., many other factors also come into play following the practical manifestations of technological development. After introducing the concept of demographic change and silver economy, this paper explores the effects of ICT solutions on the silver generation in terms of their ethical and moral ramifications. These pertain to concepts like informed consent, over-reliance on technology, social isolation and loneliness, lack of real human interaction, a decline in the quality of cross-generational communication, privacy, cybersecurity and affordability of ICT innovations. The discussion conducted in the paper emerged in the OSIRIS project – an initiative to respond to the challenges of the growing ageing populations through smart specialization approaches and technological innovation in the Baltic states.**

***Index Terms*—Silver Economy, Ethics, ICT, Innovation**

I. Introduction

The exponential development in the echelons of science and technology are manifested in the way we conduct our everyday lives; businesses, communications, education systems, governance and even our social lives. As the ratio of older citizens increases in the relatively economically prosperous nations, we are looking towards technology to provide us with solutions to manage this ageing population. Organizations and individuals, in both the public and private sectors of the BSR and the EU are systematically working towards creating smart specialization approaches to address the needs of their ageing populations. This has prompted the emergence of large scale initiatives that aim to provide age-friendly housing, transportation, entertainment, healthcare and social welfare services. While a lot of research is directed towards creating technological innovations for the silver economy, there is minimal focus on how these solutions impact their private life. This paper will seek to explore the underlying ethical considerations for technology solutions for the elderly generated through these public and private sector driven projects. These include matters related to inter-generational support, inclusion, excessive dependability on technology, empowerment, informed consent, integrity, privacy and social participation of the silver generation.

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The developed world has been lately introduced to the concept of demographic change that refers to the age structure of the population being modified by the changes in their living conditions [1]. To understand the enormity of the demographic change, the global population of the elderly aged 60 or above can be evaluated. According to a United Nations Report in 2019, the number of elderly people in the population is expected to double by 2050 as compared to 2017. The population of people aged 65 and above is growing the fastest amongst all age groups [2]. This phenomenon of population ageing is more pronounced in Europe and North America. By the year 2050, the elderly are expected to constitute 35 percent of the population in Europe, 28 percent in North America and 25 percent in Latin America [1].This outstanding ratio of the elderly amongst the population entails myriads of legal, economic, political, social and technological consequences that may have their associated ethical ramifications.

The ICT solutions related to the silver economy are focused on improving the quality of life of the ageing sector. In attempts to offer independent and comfortable living, they ignore some basic ethical concerns. An important question to ask here is whether these efforts are actually making the elderly more "independent" or creating other dilemmas and concerns for them.

Most of the ICT innovations are aimed at addressing the issue of dependency of the elderly. For example e-health services, e-transport, electronic ID cards, smart homes, virtual assistants and household robots and many more. According to some estimates, by 2060 one out of three Europeans will be over the age of 65 [2]. This means that about one thirds of the population may need services and products to exercise independence through ICT solutions. The idea of a silver economy addresses the potential challenges of demographic change within the global population, by providing goods and services that respond to the needs of the ageing population through gerontechnology and ICT. According to Krzyminiewska (2020):

> *"Silver economy is an economic system oriented on adjusting the spheres of production and distribution of goods and services to the needs of older people and younger generations that are entering the ageing process."* [3]

The evolution of technology especially in the world of digital communication and artificial intelligence offers a wide array of innovations in terms of healthcare, home accommodation, transports, e-health systems, e-governance, e-commerce, robotic assistance and much more. According to the European Commission, the ICT sector can adequately address the dependency needs of the ageing population [1]. But what such large bodies of policy makers have left unattended are the moral and ethical aspects of such innovations. For example, there is also a lot of talk about the changing "burden ratio" that signifies the ratio of working age to retirement age in the developed world [4].The term "burden ratio" itself stigmatizes the phenomenon of ageing, creating a sense of marginalization and exclusion for those who fall in the category of senior citizens.

This study will attempt to understand the ethical impacts of these technological solutions for the silver generation. This paper has sought to analyze the problem and its solutions by reviewing the relevant literature and has come up with a set of findings and discussion based on a critical evaluation of the available literature resources. The search was based on keywords: elderly people, innovation, ICT, ethics, privacy. Available literature have been thoroughly perused to formulate a stance based on ethical grounds related to the ICT innovations in the silver economy.

In Sect. 2, we provide the findings and discussion obtained from the literature analysis. In Sect. 3, outlook is provided that draws attention towards limitations of the study while Sect. 4 incorporates the scope of future research and we finish the paper with a conclusion in Sect. 5.

II. Findings and Discussion

The changes in the dynamics of worldwide demographic realities have served as a stimulus for technology related solutions to manage the effects of the change. However, technology only or in this case, ICT may not be the answer to all the problems faced by the human race. Bertrand Russell communicates a similar concern when he states, *"Science, by itself, cannot supply us with an ethic. It can show us how to achieve a given end, and it may show us that some ends cannot be achieved. But among ends that can be achieved our choice must be decided by other than purely scientific observations"* [5]. While we see an emergence of ICT related programs to improve the living standards of the much vulnerable ageing population, there is much to consider in terms of the ethical repercussions of such initiatives.

While ICT solutions for the ageing population have been continuously considered for the improvement in their standard of living, research exploring the attitude of the elderly towards technology suggests that the elderly do not believe that using technological innovation can positively improve their quality of life [3]. Although Gerontechnology attempt to improve the quality of living of the silver generation through technological innovations in their daily lives such as remote work solutions, alarms, assistive devices for hearing and vision, bathroom systems, smart homes, sensors and alarms, it has many ethical and social repercussions to consider as well [4].

On one hand ICT addresses the needs of the ageing population through innovation, but on the other hand it creates new dilemmas to consider. There is no doubt about the utility of technology for the silver generation, for example, there are significant developments creating special products and interactive devices that allow real time monitoring through GPS systems, so that the elder population, especially people with medical problems like the early stages of dementia can be kept under observation [6]. ICT solutions such as these strive to support independent living for the elderly yet they also contribute to the feelings of social isolation and technology dependence. Their urge to not depend on other humans may lead them to become over reliant on technology. Despite breakthroughs in artificial intelligence, it cannot replace the value of real face to face human interaction. This over-dependence on communication and digital technologies has a potential to produce an unbridgeable gap between subsequent generations while disregarding the human need to connect with others like them [7]. This can also have a denigrating effect on familial ties and interpersonal relationships across generations. Subsequently, we can expect a rise in the feelings of isolation and loneliness that can develop as a result of this over-dependence on technology [3].

The concept of remote supervision also creates apprehensions centered around a compromise on the integrity and privacy of the vulnerable elderly. The benefits of remote supervision cannot be negated especially for the vulnerable elderly who want to live independently and may have memory related illnesses or other medical problems [8]. However, under constant supervision with cameras, there are fears of losing their integrity and confidentiality, while for example changing clothes, visits to the bathroom or during other personal activities [9].

Artificial intelligence and robotic assistants like Siri and Alexa, may provide value to the elderly by simplifying the use of technology for them, however, this gives rise to "dehumanization" of interaction, where instead of contacting a real human, the elderly get to interact with a personalized robot [10]. This limits the chances of real human interaction and potentially creates social isolation and loneliness. Researchers have been referring to this takeover of artificial intelligence as a "civilization prostheses" that is expected to aggravate the case for social isolation and exclusion from inter-generational interaction [3].

Cyber bullying and security pose another ethical challenge for the elderly. While opting for ICT solutions, the silver generations face a serious security threat from miscreants or forces that can misuse data from these services for their own interests. The benefits of ICT services for the elderly are somewhat overshadowed if the users are at a risk of their data security and cyber safety [8].

As with all technology, the question of affordability and accessibility is another issue to be considered with ICT for the silver economy. Some researchers are also concerned about the "robotics divide" that is emerging as a result of limited availability of automation and robotics to specific countries,

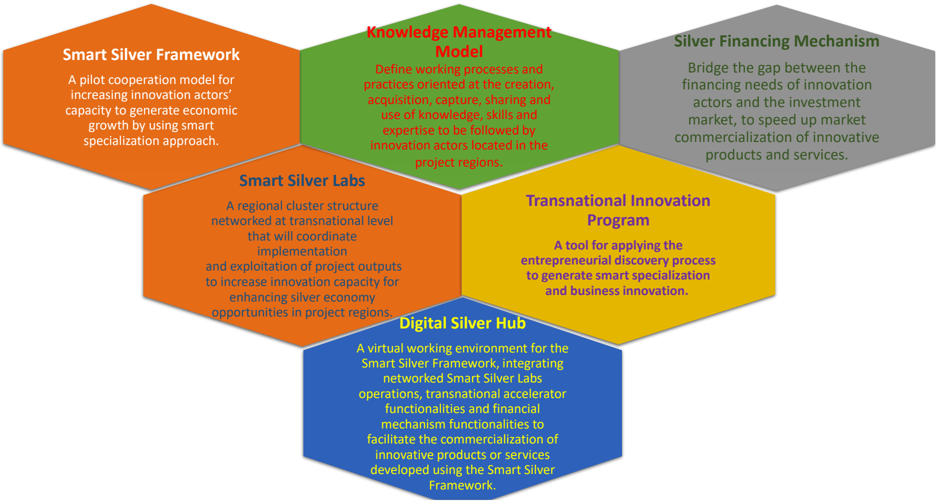

Fig. 1. Project OSIRIS Roadmap

regions, individuals and communities [6]. On a perfunctory level, ICT promises solutions for all members of the silver generation, yet they can be more suitably understood as selective solutions for the wealthy elderly. These technology solutions are not inclusive of all cultures, ethnicities and economic backgrounds which could have varying levels of understanding of autonomy and obtrusiveness. Hence, there is a strong need to understand the internal diversity of the silver generation, which may have different needs based on their social and economic status, educational and work backgrounds, the state of their physical and mental health, their personal preferences for social interaction, their degree of dependence on their families and their levels of tech-savviness [4].

III. Limitations

Technology without ethics leaves us with incomplete solutions to the challenges faced by the elderly population. ICT solutions aim at improving their quality of life while focusing on their autonomy and independence. Instead of focusing on their independence, solutions should be aimed at empowering the silver generation to make choices about the level of dependency on technology and promote inter-generation communication. There is a clear gap regarding research on the ethical issues surrounding technology-driven initiatives for the silver economy. Further research is also required on the internal dynamics and diversity of the silver generation like their financial position, economic and ethnic background, their health profiles, their understanding of the concepts of autonomy and empowerment.

The paradox of technology solutions to the problems related to our daily lives is that once applied, they create perplexities of their own. The very assumption that the quality of life of the ageing citizens is determined by their ability to conduct their daily lives independently is a premise that needs to be further explored. By involving the concerned silver generation in the planning process of the ICT solutions, a better understanding of their perspective and struggles can be developed.

IV. Future Work

This research is part of a bigger project called OSIRIS - Supporting the Smart Specialization Approach in the Silver Economy to increase Regional Innovation Capacity and Sustainable Growth. The aim of the project is "to respond to the challenges of meeting the needs of aging populations that the governments of the Baltic Sea countries are currently facing, particularly in the provision of age-friendly housing, transportation, leisure, healthcare and social welfare services. In addition, increased life expectancy deepens concerns about the adequate supply of essential services."[1]

It is important to include the end-user which in this case are the elderly people when developing innovative technologies that could help them live a more comfortable and independent life. OSIRIS is one such initiative that ensures that the end-user is involved actively and work with other actors to develop a collaborative digital platform. We call this platform as the Digital Silver Hub (DSH) which will serve as an environment where all the stakeholders will co-create and share knowledge to accelerate the uptake of the innovative solutions in order to tackle challenges relating to aging population of the BSR. In short, senior citizens are involved in developing the DSH and once it is up and running, they will again collaborate with other stakeholders to develop innovative technological solutions

[1] https://www.osiris-smartsilvereconomy.eu/

[11]. There will be different outcomes of the project as shown in the Fig 1, however, Tallinn University of Technology will be responsible for Knowledge Management Model and Digital Silver Hub.

V. Conclusion

In conclusion, the major ethical challenges posed by the use of ICT for the silver generation can be categorized as follows:

- Feelings of social isolation and loneliness amongst the elderly population due to lack of face to face human interaction
- Disintegration of familial ties and inter-generational communication
- "Dehumanization" of social interaction by AI and robotic assistance
- Threats of cyber bullying and security issues for the elderly
- Unhealthy over-dependence on technology for the elderly population
- Accessibility and affordability of the ICT solutions
- Emergence of the "robotics divide" across generations and social strata
- Threat to the integrity and privacy of the vulnerable elderly and the need for informed consent.

ICT has the potential to facilitate all strata of the society, especially the elderly who deserve a dignified life and respect. It is transforming the very social fabric of human existence across cultures and geographical boundaries. It has created ways to eliminate distances and especially facilitated those who have mobility challenges due to their age or health status. However, in order to create comprehensive and effective technology solutions we need to address the ethical challenges associated with them. For improved living and enhanced quality of life for the silver generation, the social and ethical aspects of technological innovations and their impact on the inter-generational solidarity, social cohesion, social divide and the communal fabric of societies must be taken into consideration. Lastly, it is highly imperative to include them in the planning process of the ICT solutions in order to understand their perspective and gain insight from their experiences. It can be a first step towards comprehending their notions of autonomy, empowerment and quality of life.

References

[1] K. Linz and S. Stula, "Demographic change in Europe - An Overview," Institute for Social Work and Social Education (ISS), 2010.

[2] United Nations: Department of Economic and Social Affairs - Population Division, "World population ageing 2019," *The United Nations*, 2019.

[3] G. Krzyminiewska, "Ethical dilemmas of the silver economy," *Ekonomia i Prawo*, vol. 19, 04 2020.

[4] R. Mostaghel, "Innovation and technology for the elderly: Systematic literature review," *Journal of Business Research*, vol. 69, no. 11, pp. 4896–4900, 2016.

[5] B. Russell and M. Ruse, *Religion and Science*, ser. ISSR library. Oxford University Press, 1997.

[6] A. Klimczuk, "Supporting the development of gerontechnology as part of silver economy building," *Ad Alta: Journal of Interdisciplinary Research*, vol. 2, no. 2, pp. 52–56, 2012.

[7] J. Leikas, A. Sigfrids, J. Stenvall, and M. Nieminen, "Good Life Ecosystems – Ethics and Responsibility in the Silver Market," in *Culture and Computing - 8th International Conference, C and C 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Proceedings*, ser. Lecture Notes in Computer Science, M. Rauterberg, Ed. Germany: Springer, 2020, pp. 105–122.

[8] P. Juusu and S. Sävenstedt, "Ethical issues in the use of ICT as support for vulnerable older people to live longer in their homes – a review of literature," Summary report, September 2017.

[9] K. Caine, A. Fisk, and W. Rogers, "Benefits and Privacy Concerns of a Home Equipped with a Visual Sensing System: A Perspective from Older Adults," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 50, 10 2006.

[10] S. Zwijsen, A. Niemeijer, and C. Hertogh, "Ethics of using assistive technology in the care for community-dwelling elderly people: An overview of the literature," *Aging and Mental Health*, vol. 15, no. 4, pp. 419–427, 2011.

[11] S. A. Butt, I. Pappel, and E. Õunapuu, "Potential for Increasing the ICT Adaption and Identifying Technology Readiness in the Silver Economy: Case of Estonia," pp. 139–155, 2020.

Appendix IV

[IV]
Sidra A. Butt, Karin Rava, Taivo Kangilaski, Ingrid Pappel, and Dirk Draheim. Designing a digital collaborative platform for the silver economy: Inception and conceptualization. In *Proceedings of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 47–54. IEEE, 2021

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Designing A Digital Collaborative Platform for the Silver Economy: Inception and Conceptualization

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***Abstract*—The silver economy presents a vast realm of potential that has emerged as a consequence of pronounced demographic change specifically in the developed countries. There has been immense research and deliberation especially by the European Union (EU) and the Baltic Sea Region (BSR), to meet the challenges posed by the ageing population. The OSIRIS project is one such initiative to develop a collaborative digital platform which we call as the Digital Silver Hub (DSH) that aims to incorporate the quadruple helix actors (public sector, private sector, academic sector and the end-user) to facilitate the development of technological solutions for the silver economy. In this paper, an initial set of requirements is identified and, based on that, a consolidated concept of the platform is elaborated. In service of this, a total of 22 interviews have been conducted and analyzed using tool-based thematic analysis. Interviews were taken from the quadruple helix actors already involved in the project to help set a general scope and direction of the platform. Based on the results, the initial functionalities were identified which were then validated with the project partners and, therefore, led to groundwork to generate a plausible vision and mission statement for the platform.**

***Index Terms*—Silver Economy, Quadruple Helix Actors, Collaborative Digital Platform, Innovation, Agile Methodology, Inception, Smart Solutions**

I. Introduction

According to the United Nations (2019), the world is in the midst of a longevity revolution where the chance of surviving to age 65 has increased from less than 50 percent (as was the case in Sweden in the 1890s), to more than 90 percent at present in countries with the highest life expectancy [1]. This means that the global population is going through a noticeable demographic transition in terms of their age structures. This change is more pronounced in developed areas like Europe and North America [2]. Moreover, the proportion of adult life spent beyond age 65 as compared to total life span has risen from less than one-fifth in the 1960s to a quarter or more in most developed countries today. Consequently, by 2050 the ratio of people over the age of 65 will increase to 1 in 6 people as compared to 1 in 11 in 2019 [3]. This notion of a seismic demographic change has resulted in the emergence of the concept of the "silver economy" as an area of interest for the development of technological innovations and economic prospects.

As the world population ages, their needs also change accordingly. This projects a significant demand for related products and services in the future. This has grabbed the attention of various segments of the society such as policymakers, economic operators, researchers, technology actors, and the private business sector. The advancement in the areas of digital communication, artificial intelligence and smart technology presents an opportunity for the development of a plethora of innovative products and services pertaining to assistive technologies, e-health systems, e-governance [4], e-commerce, transport, accommodation and everyday living to cater to these needs.

According to a research by the European Commission, the development of ICT solutions for the silver economy warrants a coordinated policy response, where various innovation actors interact effectively to create comprehensive, scalable, and enduring solutions for the changing needs of the society[1]. 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth' – OSIRIS project is one such initiative taken up by the governments of the BSR countries to respond to the changing needs of the ageing population in these areas[2]. This project addresses the concerns about the increased life expectancy of the BSR populations and the provision of appropriate technological innovative products and services for the ageing society.

[1] https://ec.europa.eu/digital-single-market/en/news/silver-economy-study-how-stimulate-economy-hundreds-millions-euros-year

[2] https://www.osiris-smartsilvereconomy.eu/about-project/

The development of the silver economy needs input from all sectors of the society which have been identified in the quadruple helix actor model (See Fig 1). This model focuses on the end-user perspective for implementing innovative change. As compared to the Triple Helix model, it includes the involvement of the consumers/recipients of the product or services along with the other three innovation actors. This model identifies the four innovation actors as the academic sector (researchers), the private sector (businesses and companies creating the products and services), the public sector (government and policy makers) and end-users (in this case, senior citizens)[3]. In order to foster smart innovations for the ageing populations, an integrated response from all these actors is imperative.

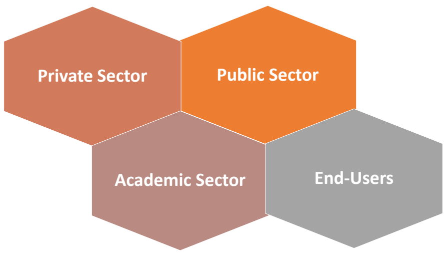

Fig. 1. Quadruple Helix Model

This research will explore the **foundations of the development of a digital collaborative platform** which we call as the Digital Silver Hub (DSH) which would serve as an environment to create innovative solutions to tackle the challenges of the aging population. The development of the DSH would facilitate virtual collaborative efforts across diverse actors to create a smoothly integrated strong network for enhancing inter-regional cooperation in the OSIRIS project regions [5]. The project consortium consists of Estonia, Finland, Latvia, Lithuania, Denmark and Russia. The platform will seek to bridge the gaps between the innovation actors to enhance the market growth opportunities for the silver economy [6]. This paper seeks to identify the very initial understanding of the DSH and its contribution towards the growth of the silver market.

To foster collaboration and knowledge exchange, an agile methodology will be adopted to build the platform. This means that the DSH will be built through a flexible model, where a web developer can work on small bits of the projects, whose multiple iterations can be available at the same time. The platform is still in its inception phase of agile development and by the end of this research, a clear mission and vision of the platform will have taken shape and a thorough understanding of the preliminary requirements of this digital collaborative platform will be determined.

[3]https://northsearegion.eu/media/11651/a-quadruple-helix-guide-for-innovations.pdf

It is significant to assess the role of all the stakeholders involved in the process of commercializing smart solutions for the silver economy. The study will investigate the possibility of a digital space for fostering innovation capacities that address the role of all the stakeholders involved in the achievement of smart specialization goals in the silver economy including the academia, the business organizations, the policymakers and the older citizens. Since the platform is at its early stages of inception, the input from all the innovation actors will be utilized to shed light on the capacities it will support. The objective of this research is to evaluate how the digital collaborative platform will benefit the aging population in maintaining the quality of their lifestyle and enhance independence and empowerment. It will also construct a basis for further research on the role of the quadruple helix actors in knowledge creation for the silver economy.

In Sect. 2, we provide a brief literature overview of the silver economy, digital collaborative platforms to help silver economy and various methodologies to build such a platform. In Sect. 3, we describe the research methodology used for the paper. In Sect. 4, we provide the results followed by the discussion in Sect. 5. We proceed with possible future direction in Sect. 6 and we finish the paper with a conclusion in Sect. 7.

II. Literature Review

A. *Silver Economy*

Studies addressing 'silver economy' rely mostly on two sources: insights from the Organisation for Economic Co-operation and Development (OECD) and Global Coalition on Aging (GCOA) Expert Consultation[4] and European Commission (EC) background paper[5]. From OECD - GCOA point of view, silver economy is oriented to population over 60 who consume products and services enhancing their healthy and active life and also participating in active work-life as workers, entrepreneurs or consultants. European Commission sees silver economy more generally, as opportunities to serve needs of the population over 50. From an overview of the EC activities concerning silver economy can be concluded that the mission of the silver economy forum is to promote ageing population participation in economic life being active and healthy[6].

One solution for satisfying needs of senior citizens is viewed in information and communication technology (ICT) and corresponding (innovative) solutions. ICT provides opportunities to stakeholders in the silver economy to give their portion in that environment. Zsarnoczky (2016) considers: *"The sector of AHA (active and healthy ageing), wellbeing, eHealth, senior tourism, age-friendly housing, health and social care and their ICT-related subsectors are facing huge development processes in the near future"* [7].

[4]https://www.oecd.org/sti/the-silver-economy-as-a-pathway-to-growth.pdf.
[5]http://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/silvereco.pdf
[6]https://silvereconomyforum.eu/wp-content/uploads/2019/07/Silver-Economy-Brochure.pdf

ICT also brings opportunities for older people to be engaged in new initiatives. In a silver economy study conducted by Technopolis Group and Oxford Economics (2018) among other ideas concerning of potential solutions for older people was pointed out: *”development of an interactive platform connecting people that are working on developing new solutions with older people that want to support and/or invest in business development and share experience with the younger generation or be involved in test-bed activity“*[7].

While ICT brings new products and services consumed by older people and new ways of working and living, there are obstacles as clarified by Butt et al (2021) [6]. Raising the level of digital literacy among older people is a way to deal with these[6].

B. Digital Collaborative Platforms to help the Silver Economy

By outlining the concept of the “digital collaborative platform”, it is important to first clarify the concept of the “digital platform” (DP). Staub et al (2021) define DP as *”software-based system that: a) consist of a modular technological architecture, b) coordinate external actors that innovate and/or compete and c) can function as a central hub of an ecosystem, in which peripheral firms or individuals facilitate complements and are connected via boundary resources“* [8]. By that definition, a digital collaborative platform and digital platform are the same. Authors derive four DP archetypes: business innovation platforms, consumer innovation platforms, business exchange platforms and consumer exchange platform. In exchange platforms, different parties exchange goods and platforms act as marketplaces, while in innovation platforms, partner management is the main activity. That enables collaboration between different parties. The main difference between business and consumer innovation platform lies in the participation of consumers in innovation initiatives as end-users of platforms. Thereby based on taxonomy proposed by Staub et al (2021), it can be concluded that business and consumer innovation platforms are both digital collaborative platforms [8]. Several European research initiatives have attempted to explore the ageing market. Camarinha-Matos et al. (2013) created a roadmap for active ageing that incorporated ICT. They presented a framework that accommodated relevant stakeholders to define a vision to take the society to a desirable level of active ageing [9]. In a Policy brief by the European Policy Centre, Ahtonen (2019) suggested the involvement of the ageing citizens and a collaborative approach by the policy makers for effective solutions[8]. One example is AGE Platform Europe[9] which is the European network of non-profit organisations and for people older than 50 to tackle issues concerning them. Another example is HoCare2.0 network[10]. It connects co-creation labs and their mission is to provide customer-centred home care by co-creation. They engage the members of the quadruple helix - SMEs, public institutions, research institutions and citizens in the development of new innovative health and social services or products. One platform, not yet operating, will be SilverStar Platform, a Transnational Open Innovation Platform for Smart Elderly Care[11]. Platform users will be creating a virtual community for co-creation of innovative solutions to take of the elderly people. Another platform, under development, is the DSH. According to project activities description, the purpose of the DSH will be to support making innovative products and services available to market[2]. By using features offered by DSH these products and services will be developed in collaboration of R&D organizations, companies, local and national authorities, and senior citizens known as the quadruple helix using open innovation tools and knowledge management models. However, the DSH is the only platform that targets all the stakeholders in the BSR region. Its unique feature is the smart specialization approach to address the silver generation challenges. It is a collective intelligence platform that prioritizes inputs from the older citizens/end-users through their first hand experiences to create technology based solutions to their everyday lives. Outside the European Union, one example is The Aging2.0 Collective[12]. This platform connects innovators with providers looking for solutions for the silver generation. The platform will act as issues and solutions knowledge system.

C. Software Life Cycle and Corresponding Models

From the definition of the digital platform, it became evident that the platform is considered as a software system, therefore it must be implemented using some software system life cycle model. International standard ISO/IEC/IEEE 12207 regarding software life cycle processes defines software system as a system for which software is of primary importance to the stakeholders [10] and considers it as human-made, created and utilized to provide products or services in defined environments for the benefit of users and other stakeholders [10]. In the same standard life cycle is defined as the evolution of a system, product, service, project or other human-made entity from conception through retirement and accordingly life cycle model as a framework of processes and activities concerned with the life cycle that may be organized into stages, which also acts as a common reference for communication and understanding [10]. ISO/IEC/IEEE 24748-1 (Guidelines for life cycle management) suggest for software life cycle following stages: concept, development, operation & maintenance and retirement [11]. In simplified terms, software development can be seen as implementing requirements that have been stated towards software usage in the conceptualization stage.

Guidelines for the application of ISO/IEC 12207 (ISO/IEC/IEEE 24748-3) propose that life cycle stages may be interdependent and overlapping, of differing duration, and iterate or be applied recursively [12]. These combinations

[7]https://www.mayoractual.com/media/mayoractuals/files/2018/09/11/Silver-Economy.pdf

[8]https://ec.europa.eu/eip/ageing/library/healthy-and-active-ageing-turning-silver-economy-gold_en.html

[9]https://www.age-platform.eu/

[10]https://www.interreg-central.eu/Content.Node/HoCare2.0.html

[11]https://www.interreg-central.eu/Content.Node/I-CARE-SMART.html

[12]https://www.aging2.com/thecollective/

of stages form sequential, incremental, or evolutionary life cycle models [12].

In the sequential approach, decision gates are defined to help the management of software (system) progression [12]. The software passes all its life cycle stages in sequence, that means that the quality of the following stage outcome depends on the quality of the previous stage(s) outcome(s') quality. In other mentioned life cycle models, software stage and process repetition occur, mainly to deal with uncertain, vague and ever-changing requirements [10].

In incremental approach development of new versions of a product at frequent planned intervals or iterations takes place [12]. The first iteration is often dedicated to establishing development environment and collecting and prioritizing features to be developed. With each new version, more features are added until the last release consists of all features which were determined.

In the evolutionary model, an incremental approach is also taken, but full functionality of future versions of the systems are unknown at the beginning of the development [12]. System requirements are firstly defined in part and from the early version, user feedback and new features for successive version are defined.

D. Agile Methodology

Software development and business literature affirm that businesses are dependent on software usage and their ways of doing business are continuously changing, demanding rapid reactions from the software side to support these changes. Therefore, the agile approach is needed, where they get suitable software more quickly. In software development, the literature concepts such as "approach", "methodology", and "method" are used interchangeably [13]; [14]; [15]. Merriam Webster Dictionary defines "methodology" as 1) a body of methods, rules, and postulates employed by a discipline; 2) a particular procedure or set of procedures; 3) the analysis of the principles or procedures of inquiry in a particular field[13]. The method is defined as a procedure or process for attaining an object[14]. In the same dictionary synonym to the method is an approach.

Alistair Cockburn in his book, Agile Software Development proposed following methodology elements: roles, skills, teams, techniques, activities, process, work products, milestones, standards, quality, team values [16]. An agile methodology can be understood as a body of agile methods or all these elements as agile elements proposed by Cockburn. Noura Abbas et. al proposes a software development method to be agile satisfying following conditions: it is adaptive, iterative and incremental, and people-oriented [15]. The same idea conveys also ISO/IEC 12207 stating that in agile software endeavours highly incremental and evolutionary (adaptive) life cycle models are used [10]. A comprehensive overview of agile methodology elements is given in an article by Zahidul Islam and Alex Ferworn [14].

[13]https://www.merriam-webster.com/dictionary/methodology
[14]https://www.merriam-webster.com/dictionary/method

Agile methods and therefore agile methodologies with all its elements are consistent with statements written in 2001 by 17 software practitioners called agile manifesto putting priority or value to team communication, working software, customer collaboration and embracing change [17]. Most known agile methods beside Scrum and XP are for example Crystal, Adaptive Software Development, Test Driven Development, Feature Driven Development.

In developing the DSH, an evolutionary life cycle is being used (see Fig 2), not any particular agile method. Initiating the DSH development, organization to whom it is targeted does not exist yet, but is taking shape during the project. That means, project participants among others will be becoming members of this organization (innovator actors community) and therefore they are defining organization's work processes and functionality simultaneously with requirements for building the DSH supporting these processes and functionality. In order to not wait until the organization stabilizes with its processes and functionality and then start with requirements gathering, we instead adopted an agile approach which means that initial requirements are being gathered and an initial working platform is being developed. As agile approach is flexible, we are not collecting all the requirements at once and instead we gather the requirements as we get outcomes from other project participants.

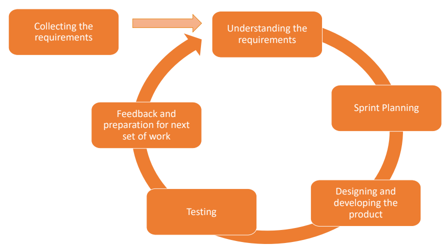

Fig. 2. Life cycle of Agile Methodology

III. Methodology

The research methodology needs to be adequately designed to meet the objectives of the research. This study aims to explore the DSH as a virtual platform to facilitate the growth of the silver market by providing innovative solutions to help the older population live a more independent life. Since the platform is at its inception stage of development, the initial requirements and scope of the platform need to be explored in detail.

In order to understand the initial requirements of the collaborative platform, the study will employ the qualitative research methodology. Qualitative research uses non-numerical data to explore viewpoints, opinions and attitudes. This research method seeks to achieve an understanding of underlying motives, thoughts, and inspirations and allows the researcher to probe deeper into the problem at hand [18]. The structure of the data collection methods for qualitative research range from unstructured to semi-structured. The data may be obtained from direct fieldwork, observations, open-ended interviews, focus group discussions and written documents [19].

The data for the research was collected through conducting direct interviews with 22 participants belonging to the quadruple helix sectors (academia, private sector, public sector and senior citizens) involved in the OSIRIS project. However, due to the precautionary requirements during the Covid-19 pandemic, direct face-to-face interviews with the study participants were not feasible. Hence, the participants were asked to provide written answers to the questions related to the initial stages of the platform.

The qualitative data obtained through these interviews were subjected to a tool-based thematic analysis to yield patterns and themes related to the research. According to Clarke et al. (2015), thematic analysis (TA) can be used to *"identify patterns within and across data in relation to participants' live experience, views and perspectives, and behaviour and practices"*. It is a useful method for identifying, analyzing, and interpreting patterns of meaning ('themes') within qualitative data as part of 'experiential' research which seeks to understand what participants' think, feel, and do. [20]

Braun and Clarke (2013) posit that TA not only allows theoretical flexibility, but also versatility in terms of the research question, sample size and constitution, data collection method, and approaches to meaning generation [21]. Hence, this method is most appropriate for creating an initial understanding of the DSH based on the qualitative responses from the stakeholders involved in the platform. The interviews will be analysed through an open-source qualitative data analysis software, RQDA for thematic analysis. According to Chandra and Liang (2016), RQDA is a relatively easy to use open-source tool compatible with most operating systems that helps in analyzing large amounts of qualitative data to extract meaning out of it for research purposes [22]. Through tool based thematic analysis, a better understanding of the interview questions and their responses can be developed.

According to Maguire and Delahunt (2017), TA involves the following process to analyze data :

- familiarization with the interview data by reading and assessing it repetitively,
- assigning initial codes to the data that describe what is being said in a way that is meaningful and relevant to the study,
- generating broader themes through the analysis of the codes,
- reviewing the themes to ensure their connection with the study purpose,
- defining the themes and sub-themes,
- reporting the themes and sub-themes in a structured and systematic manner. [23]

This approach allows for an in-depth rich analysis of an otherwise hard to analyze qualitative data, into actionable results relevant to the research objectives.

IV. Results

In this section, results from the thematic analysis of the qualitative data will be presented. The data has been collected through the written interviews of the participants belonging to the quadruple helix sectors already engaged in the OSIRIS project. Through the thematic analysis using RQDA, several codes were generated within the qualitative data. The codes were then used to identify the four themes shown in Table I. The themes generated through the codes help us to identify patterns and help derive meaningful and actionable results from otherwise non-quantifiable data (See thematic map in Fig 3).

TABLE I
THEMES

Concept of the DSH
Actors and their roles in the DSH
Focus areas of the DSH
Barriers to the successful implementation of the DSH

The DSH is currently in its initiation phase, hence exploring the concept behind it through empirical research, can be very valuable to its development. By involving participants from the quadruple helix model namely the academia, public sector, private sector and the aging end-users, who are already involved in the OSIRIS project, the study seeks to explore the preliminary requirements and understanding of the digital platform. For the initiation phase, the concept of the hub must be investigated by considering input from all the innovation actors. The first theme generated from the interviews is identified as the **"concept of the DSH"**. When asked about the general idea of the DSH, a majority of participants suggested that it should be a combination of a virtual marketplace as well as a social media platform. They also proposed that the DSH should also incorporate a crowdsourcing platform. According to one of the participants, *"it should be both a marketplace and social media platform. It should also include possibilities of crowdsourcing not only content but also sharing business, hobbies, art, sports, travel as well as recreational, holistic lifestyle, charitable, spiritual, educational and scientific research activities etc. of seniors communities So the DSH should be a platform of new opportunities of an active and long life full of purpose for the elders."*. Another participant suggested that it should have the combined features of a *"silver economy business incubator as well as a marketplace and social digital platform"*. While explaining its role as a social media platform, it was identified that innovation actors could create their personal or business presence on the platform to facilitate communication between them where they could share and publicize their interests and could create a unique community for honest peer to peer conversations and crowdsourcing. Another interesting concept related to the platform was the idea of a knowledge hub, that allowed organic interaction and information sharing regarding the lives of the elderly. Some participants identified it as a knowledge base to provide systematic information in areas relevant to the silver economy, like employment and education opportunities, healthcare, accommodation etc. A few also brought forward the notion of a utility platform related to the DSH.

The second theme generated through the analysis of the codes identified from the interviews was **"actors and their roles in DSH"**. The silver economy pertains to the elderly population as the end-consumer and the DSH is an effort to address their needs. However, there are many other stakeholders involved in the process of creating such a platform. The actors/stakeholders significant to the platform are the innovators, older population, academic institutions, public sector, private sector and the voluntary sector. These include the researchers, product developers, entrepreneurs, policymakers, government actors, business entities and the end-users. All of them have their roles and contribute towards the creation of the platform. This was also confirmed through the data collected for the study. Responses from the interviewees identify that the innovators initiate research and development (R& D) to bring about innovations. The aging population is the market for innovations, which help address their needs. They can utilize the platform to improve their lifestyles, capitalize on inter-generational communication opportunities and mentor others through sharing their life experiences. The role of the private sector in the platform will be related to developing its market share and to use the platform to generate investments. The public sector can employ DSH for the effective use of public funds for social care. The academia can employ the hub for scientific research related to the silver economy, as a source of possible research funding and creating educational opportunities for emerging professions related to silver services. The voluntary sector can play a role in developing growth opportunities for social services. A few participants identified the role of the actors to *"find collaboration partners and relevant information"* through the platform.

The third theme refers to the **"focus areas of DSH"**. According to a majority of participants, the DSH focus areas pertain to building collaborative communities, fostering social connectivity and economic change in the silver economy. All of them agreed to the need for a "unified repository" of knowledge exchange to submit a project proposal and subsequently to initiate funding. An important focus area mentioned by one interviewee was to increase the capacity of innovation actors and enhance silver economy opportunities in all project regions. The platform was termed as a co-creation project with different stakeholders, where the idea is to *"enable future business opportunities, especially in the field of smart living (e.g. project possibilities, information concerning different devices etc)"*. A few participants suggested that the most significant function of the platform was information sharing amongst the quadruple helix actors and trying to get more funding to the future development of the DSH. According to one respondent, *"the DSH should provide digital connectivity, support the development of digital skills and encourage the use of emergent innovative technologies"*. A very important feature of the hub which was pinpointed was to make it a place to look up for collaborations or investment at any stage of the innovation development process including gathering and evaluating ideas, prototype, testing/piloting phase, product launch, full-scale production. In addition to this, most of the respondents also agreed that there was a need to create a forum where each region can submit initial ideas and the stakeholders can vote for initial innovations to be included in the hub. They also stressed on the need to find and bridge the gap between the different users, thereby creating an ecosystem where senior citizens and other innovation actors would engage.

The fourth theme generated through the thematic analysis of the collected qualitative data was **"the barriers to the successful implementation of the DSH"**. The successful implementation of any project depends upon the efficacy of its finances and funding requirements. It was suggested by one of the participants that *"long term viability of the DSH could enhance the chances of obtaining private funding. The potential engagement and reach of the platform, further enhanced by backing from NGOs, state actors could be a good selling point"*. If the governments of the BSR countries didn't work on the project on a priority basis to stimulate tax rebates, subsidies, donations and attract grants, the DSH could face severe bottlenecks. Another problematic aspect for the implementation of the project was highlighted as the involvement of a highly independent EU Project Developer Organization, that can take the project from its initial phases to completion phase while disregarding the need to collaborate across various innovation actors and the needs of the end-user. The long-term sustainability of the project is also a cause of concern since there is a need to constantly update it and align it with future needs, as mentioned by a few interview respondents. Other factors that may affect the success of the platform were identified as poor communication and visibility of DSH, not enough users, low activity, lack of good content, inadequate support from innovation actors, vaguely defined objectives and the inability to continuously improve and update the platform.

V. DISCUSSION

This study has been conducted to launch the preliminary phase of a digital collaborative platform for implementing ICT solutions for the silver economy. The results from the thematic analysis of the study have confirmed that a collaborative digital platform is a viable option to spearhead silver economy growth, especially in the BSR. The literature also supports the need for such a platform that enables interaction between various stakeholders to generate effective solutions for the silver economy[2]. While some innovative solutions for the older population have already been introduced in the European markets especially those in the BSR countries, their progress is stunted due to the absence of collaborative synergies amongst diverse segments of the society that are directly or indirectly linked with the development of the silver economy [2].

The development of a virtual platform offers a wide array of benefits for innovation actors and the older population. It ensures participation from the quadruple helix actors so that well-rounded and comprehensive solutions are created.

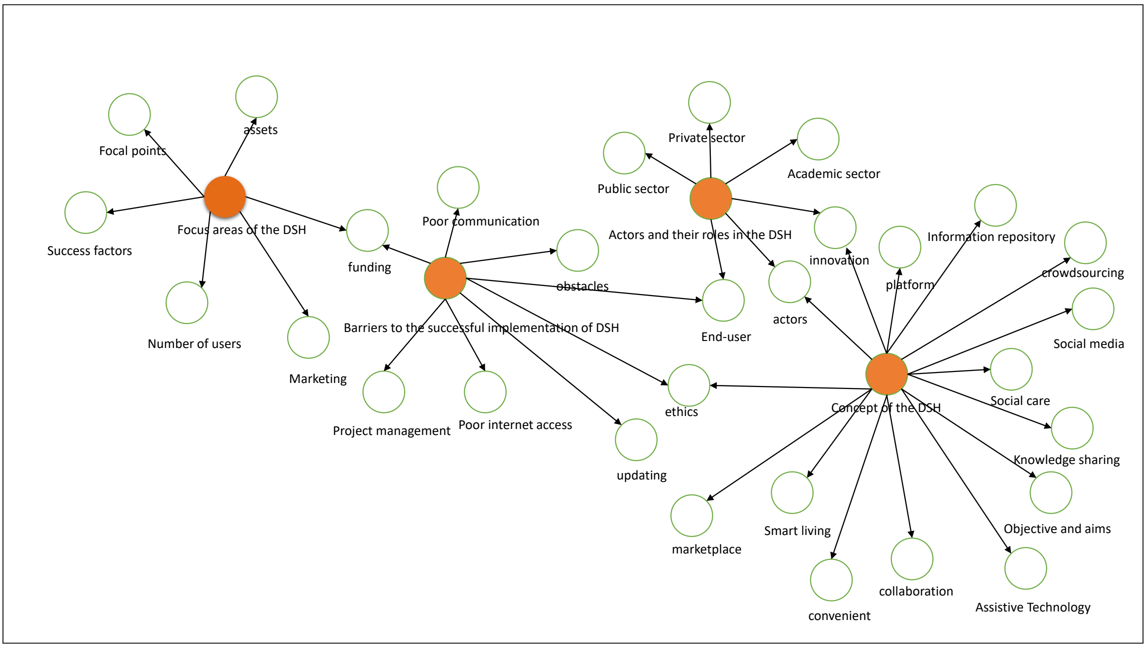

Fig. 3. Thematic Map

Following the qualitative research to determine the functionalities of the platform, several insights have surfaced that have contributed to understanding the platform functionalities. The results from the study as well as relevant literature further emphasize the importance of digital technologies for the silver economy. Both primary research and secondary sources suggest that the absence of clear objectives can pose barriers to the successful implementation of the platform. To maximize the effectiveness of the DSH and embark on its successful initiation phase, interview participants from the quadruple helix already working on the OSIRIS project have provided valuable inputs to the study. This has helped understand the various implications relevant to the development of the silver economy platform. The study findings suggest that in order to address the emerging needs of the silver economy, a multi-faceted smart specialization approach involving various innovation actors across transnational geographies needs to be adopted. A review of similar digital platforms like the AGE Platform Europe, HoCare2.0 network and the Ageing 2.0 Collective has provided a broader understanding of the workings of digital platforms for the silver generation. Oghojafor (2011) emphasize the significance of a carefully articulated vision and mission statement to enhance the performance of any organization or project [24]. The following mission and vision statements have been developed by combining the study results and findings from relevant literature to appropriately address the functionalities of the DSH.

Vision Statement: To support the life cycle of innovative solutions to tackle ageing challenges and to enhance silver economy growth opportunities in the Baltic Sea Region.

Mission Statement: To have a collaborative virtual hub which supports creation, deployment and publishing of innovative solutions to generate economic growth by using a smart specialization approach.

VI. Future Work

As mentioned earlier, the current research focuses on the inception phase of the DSH and preliminary requirements and features are being introduced. Further meetings were conducted with the OSIRIS project partners to validate the outcomes and subsequently, these requirements were challenged to ensure that work group and the stakeholders have shared understanding of what needs to be built and what is the minimum viable product (MVP) for the stakeholders.

Based on identified preliminary features, the initial requirement backlog must be developed. Then, based on requirements the initial solution architecture vision must be developed. Having an architecture vision is crucial to guide the sprints and keep DSH scalable and sustainable. The key elements of the architecture vision are the DSH mission, vision, strategy, goals and initial architecture principles. As OSIRIS project has its strategy and life cycle, the architecture vision must be aligned. After the architecture vision is developed and approved by the project team, then the construction iteration will be planned to deliver a working MVP. After every iteration, there will be release which will be tested and deployed into the production.

The initial focus will be to create the DSH platform backend functionality, which allows publishing content for all the actors in the quadruple helix model. As there are several countries engaged, the multilingual approach must be supported.

The stakeholders in different countries have a very different level of IT background. Thus, according to our experience, it is mandatory to prepare a set of actual data which must be uploaded into the DSH before introducing the functionalities to the stakeholders. Using just test data will be not enough for the stakeholders to understand the created functionality. Thus, collecting the data to be presented for the actors must be handled parallel to agile software development and this need must be introduced to the project steering to be planned.

When from the stakeholders' point of view the MVP is created, the DSH platform marketing must be planned and performed, to introduce its features to the society over the countries participating in the OSIRIS project. An analysis of the potential competitive advantage of the proposed product must also be conducted as it would be helpful in evaluating its potential sustainability.

VII. Conclusion

The silver economy presents a vast number of opportunities for innovative products and services, economic growth and societal well-being. A digital platform for supporting silver economy growth is a valuable addition to facilitate the implementation of ICT solutions for the silver generation. However, the results from the study confirm that such a platform cannot function effectively in isolation. To create long-term solutions, participation from all stakeholders is imperative. The DSH should be based on the concept of knowledge exchange and co-creation techniques to foster collaboration across various transnational innovation actors. The idea is to facilitate regional cooperation and maximize the effectiveness of the platform for the ageing population. A plausible and inspirational vision and mission of the DSH has been determined through this study to spearhead the effective development of the collaborative hub. It has laid the foundations of developing the digital platform and has shed light on the concept, the actors involved, the focus areas and the barriers to the successful implementation of the DSH.

In conclusion, a collaborative virtual hub is a good start towards meeting the challenges of the ageing populations in the BSR countries. It encourages participation from all the relevant actors including governments, entrepreneurs, researchers, product developers, SMEs, the corporate world and senior citizens across the project regions. The digital platform holds great potential to facilitate economic growth in the silver economy and supports the concept of knowledge sharing and co-creation.

References

[1] United Nations: Department of Economic and Social Affairs - Population Division, "World population ageing 2019," *The United Nations*, 2019.

[2] N. Georgantzi, *The European Union's Approach towards Ageism*. Springer, 2018, pp. 341–368.

[3] K. Linz and S. Stula, "Demographic change in Europe - An Overview," Institute for Social Work and Social Education (ISS), August 2010.

[4] I. Pappel, V. Tsap, and D. Draheim, "The e-locgov model for introducing e-governance into local governments: an estonian case study," pp. 1–1, 01 2020.

[5] I. Pappel, V. Tsap, I. Pappel, and D. Draheim, "Exploring e-services development in local government authorities by means of electronic document management systems: 5th international conference, egose 2018, st. petersburg, russia, november 14-16, 2018, revised selected papers," pp. 223–234, 01 2019.

[6] S. A. Butt, I. Pappel, and E. Õunapuu, "Potential for Increasing the ICT Adaption and Identifying Technology Readiness in the Silver Economy: Case of Estonia," pp. 139–155, 2020.

[7] M. Zsarnoczky, "Innovation challenges of the silver economy," *Vadyba Journal of Management*, vol. 28, no. 1, pp. 105–109, 2016.

[8] N. Staub, K. Haki, S. Aier, and R. Winter, "Taxonomy of digital platforms: A business model perspective," in *Proc. 54th Hawaii International Conference on System Sciences (HICSS 54)*, 2021.

[9] L. Camarinha-Matos, H. Afsarmanesh, F. Ferrada, A. Oliveira, and J. Rosas, "A Comprehensive Research Roadmap for ICT and Ageing," *Studies in Informatics and Control*, vol. 22, pp. 233–254, 09 2013.

[10] International Organization for Standardization, "ISO/IEC/IEEE 12207:2017(E), International Standard – Systems and software engineering – Software life cycle processes," 2017.

[11] ——, "ISO/IEC/IEEE 24748-1:2018(E), International Standard – Systems and software engineering – Life cycle management – Part 1: Guidelines for life cycle management," 2018.

[12] ——, "ISO/IEC/IEEE 24748-3:2020(E), International Standard – Systems and software engineering – Life cycle management – Part 3: Guidelines for the application of ISO/IEC/IEEE 12207 (software life cycle processes)," 2020.

[13] S. Cronholm and P. J. Ågerfalk, "On the concept of method in information systems development," 1999.

[14] A. K. M. Z. Islam and A. Ferworn, "A Comparison between Agile and Traditional Software Development Methodologies," *Global Journal of Computer Science and Technology*, 2020.

[15] N. Abbas, A. M. Gravell, and G. B. Wills, "Historical roots of agile methods: Where did "agile thinking" come from?" in *Agile Processes in Software Engineering and Extreme Programming*, P. Abrahamsson, R. Baskerville, K. Conboy, B. Fitzgerald, L. Morgan, and X. Wang, Eds. Springer, 2008, pp. 94–103.

[16] A. Cockburn, *Agile Software Development: The Cooperative Game*, ser. Agile Software Development Series. Pearson Education, 2006.

[17] P. Hohl, J. Klünder, A. Bennekum, R. Lockard, J. Gifford, J. Münch, M. Stupperich, and K. Schneider, "Back to the future: origins and directions of the "agile manifesto" – views of the originators," *Journal of Software Engineering Research and Development*, vol. 6, 12 2018.

[18] U. Sekaran and R. Bougie, *Research methods for business: A skill-building approach*. New York: Chichester : John Wiley & Sons, 2016.

[19] M. Q. Patton, *Qualitative Research*. American Cancer Society, 2005.

[20] V. Clarke, V. Braun, and N. Hayfield, *Thematic analysis*, ser. J. Smith (Ed.), Qualitative psychology: A practical guide to research methods. Sage, 2015.

[21] V. Clarke and V. Braun, *Successful Qualitative Research: A Practical Guide for Beginners*. Sage, 2013.

[22] Y. Chandra and E. Liang, *Qualitative Data Analysis with RQDA*. Springer Singapore, Dec 2016.

[23] M. Maguire and B. Delahunt, "Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars." in *All Ireland Journal of Higher Education*, 2017.

[24] B. E. A. Oghojafor, O. O. Olayemi, P. S. Okonji, and J. U. Okolie, "Enhancing Organization's Performance through Effective Vision and Mission," *Chinese Business Review*, vol. 10, no. 11, pp. 1071–1075, November 2011.

Appendix V

[V]
Sidra A. Butt, Ingrid Pappel, and Dirk Draheim. Digital Silver Hub: User dialogue model technical document. *IEEE TechRxiv. Preprint*, pages 1–49, 2022

Digital Silver Hub: Technical Document

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Preface

Europe is on the brink of a significant demographic shift that will increase the silver population and a decline in the working age group. This change highlights the importance of addressing the evolving needs of individuals, especially older adults. With this in mind, the European Union and the Baltic Sea Region are leading the way in groundbreaking research in aging and technology-driven services aimed at empowering older adults to live fulfilling lives.

The OSIRIS project, funded by the European Union, is a vital initiative in this regard. Its primary focus is on creating a 'Digital Silver Hub' that provides solutions specifically designed to tackle the challenges faced by the silver population. The Digital Silver Hub is an ecosystem that fosters collaboration between various stakeholders, including private companies, public institutions, academic organizations, and, most importantly, older adults themselves.

This document provides an in-depth exploration of the user dialogue model and system architecture of the Digital Silver Hub, which are the intertwined components driving its functioning. We use the Unified Modeling Language (UML) to represent the parts of the platform and show how it brings together collective intelligence to support the silver economy.

This research is a testament to the dedication, innovation, and forward-thinking of those committed to improving the quality of life for the silver population. It shows that technology and collaboration can combine to meet the preferences and needs of older adults, ensuring they can live independently with dignity and a strong sense of community.

As demographics continue to shift, this research is a step towards a future where aging is not seen as a burden but as an opportunity to celebrate experience, wisdom, and ongoing participation in society.

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Chapter 1

Introduction

The silver economy, as defined by the European Commission, represents all economic activity related to the needs of people aged 50 and over [26]. With the demographic makeup of the EU shifting towards an aging population, targeted strategic approaches are required to cater to active aging and mitigate the negative effects of aged dependency [21]. The European Union (EU) and the Baltic Sea Region (BSR) are actively engaged in research on active aging and technology-driven services to enable the silver population to live an independent life.[1] The OSIRIS project - 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth'[2], funded by the EU, is one such initiative that aims to develop a digital collaborative platform called the Digital Silver Hub (DSH) to accelerate the uptake of innovative solutions to the challenges faced by the silver population in the BSR. The DSH involves the quadruple helix actors [14], which include the private sector, public sector, academic institutions, and older adults, as shown in Figure. 1.1.

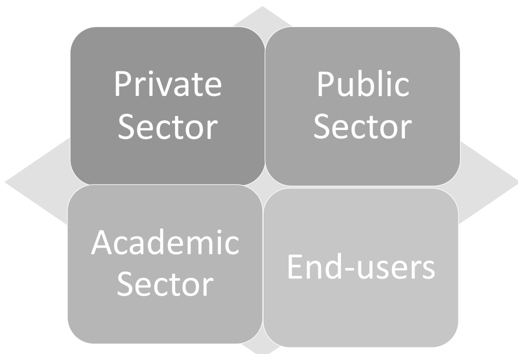

Figure 1.1: Quadruple Helix Actors

This research adopts principles and practices of both design science [24, 29] and, in particular, action design research (ADR) [32] to ensure that the designed and developed artifact contributes to the silver economy and develops innovative solutions that cater to the challenges faced by the silver generation. Therefore, research involves conducting several workshops, questionnaires, interviews, focus group discussions, and information sessions to develop the functionalities of the DSH. Knowledge resources [7], ethical considerations of using Information and Communication Technology (ICT) in the silver economy [6], ways to improve technology readiness of older adults [10], challenges and barriers to ICT adoption [8], and initial conceptualization and inception of the platform have been identified [11]. Moreover, required functionalities by stakeholders of the DSH, which include the OSIRIS project heads and quadruple helix actors from all the regions involved in the project, were identified and developed

[1] https://ec.europa.eu/eurostat/documents/3217494/5740649/KS-EP-11-001-EN.PDF/1f0b25f8-3c86-4f40-9376-c737b54c5fcf

[2] https://osiris-smartsilvereconomy.eu/about-project/

[12] based on the generic CI model by Suran et al. [34]. These functionalities were further subjected to a comprehensive analysis to refine and expand upon [9] and evaluated using the dimensions of the Technology Acceptance Model (TAM2) [16, 35]; *Perceived Usefulness*, *Perceived Ease of Use*, and *Attitude Towards Using the technology*, along with dimensions of generic CI framework [34]; staffing, processes, goals, and motivation.

This document uses outcomes and evidence from the previous work, and the inputs and outputs of the user interaction process have been defined. The user dialogue model is used to map the user interaction with the system. Different functionalities of the DSH are outlined. We proceed with the paper as follows. In chapter 2, we describe the research methodology of the study. In chapter 3, platform development methodology is defined. In chapter 4, platform architecture is explained. In chapter 5, we provide a description of the Digital Silver Hub system. In chapter 6, we report the user dialogue models. In chapter 7, we conduct a discussion on platform evaluation and future work. We finish the document with a conclusion in chapter 8.

Chapter 2

Research Methodology

To create the user dialogue models for the DSH, three group discussions with six experts were organized. These experts were selected for their knowledge in software development in front-end development, back-end development, and user experience (UX) design. The goal was to work to design the user dialogue models of the DSH, ensuring a seamless and user-friendly interaction between the users and the system.

2.1 Participant Selection

The success of the focus group discussions heavily relied on expert selection. The experts were carefully chosen who had experience in developing digital platforms. The panel consisted of experts in front-end development, responsible for creating the user interface (UI); back-end development, focusing on server-side logic, databases, and application functionality; and UX design, concentrating on improving user satisfaction and usability. By bringing professionals from these fields together, the aim was to incorporate a wide range of perspectives and expertise into the development process.

2.2 Focus Group Discussions

The approach involved conducting three group discussions with each session targeting different aspects of the user dialogue model. These discussions were structured to encourage conversation, promote the exchange of ideas and ensure participation from all experts involved. Throughout the sessions, the dialogue model were continuously refined. The key topics addressed during these focus group discussions included;

1. User interaction flow; We explored how users would navigate through sections of the platform, access functionalities and receive feedback from the system.

2. Visual and functional elements; The experts examined the components of the platform such as color schemes, font styles and layout designs. At the time they also scrutinized elements to determine which features would be most beneficial and intuitive for different users.

3. Error handling and user guidance; We discussed strategies, for handling user errors while providing instructions and support to older adults in case of misunderstandings or mistakes.

2.3 User Dialogue Models

The user dialogue model is a crucial component of the DSH, and it is designed using the Dialog Model, as explained by Dirk Draheim and Gerald Weber in their book Form Oriented Analysis [17]. The model defines the interaction process between the user and the system as a sequence of interchanging client and server states. The client state presents information to the user and offers several options for entering and submitting data. Upon submitting the data, the dialogue transitions to the server state, where the data is processed, and a new client page is triggered. [17]

The ISO 9241-110[1] defines dialogue principles as the interaction between a user and an interactive system as a sequence of user actions and system responses to achieve a goal. The principles include suitability for the task, self-descriptiveness, controllability, conformity with user expectations, error tolerance, suitability for individualization, and suitability for learning.

Unified Modeling Language (UML) Activity Diagrams are used to generate the Dialogue Models as they enable different levels of abstraction and can easily adapt to different contexts of use. The diagrams have a rich graphical notation [4] and modeling capabilities that allow the capture and visualization of the system structure.[2]

[1] https://www.iso.org/obp/ui/#iso:std:iso:9241:-110:ed-2:v1:enISO 9241-110:2020(en)
[2] https://www.ibm.com/docs/en/rational-soft-arch/9.7.0?topic=diagrams-uml-models

Chapter 3

Platform Development

To develop the DSH, the agile methodology was adopted, as shown in Figure 3.1. This approach is ideal as it allows web developers to work on small parts of the project simultaneously, which is useful when multiple iterations are created and reviewed [2]. It facilitates the implementation of changes and constant feedback, which results in the continuous delivery of semantically structured outcomes [2].

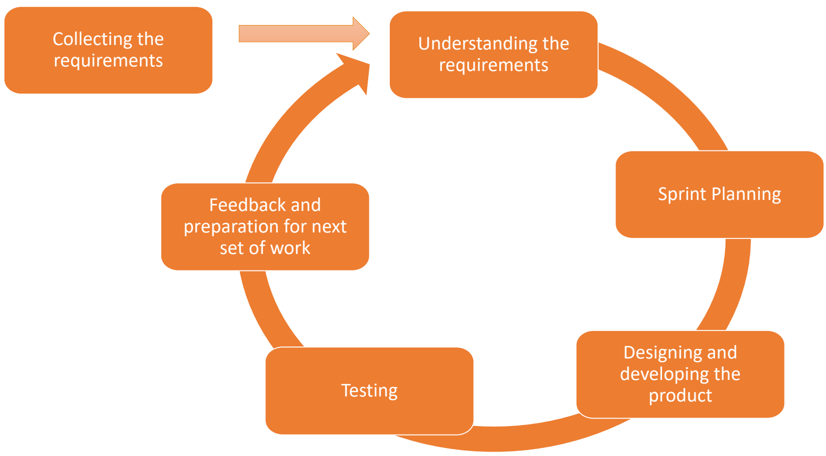

Figure 3.1: Agile Life Cycle

The first step of the agile lifecycle is to collect information about the project by gathering required functionalities from project partners and quadruple helix actors [3, 33, 27, 18]. The next step is to understand these requirements, prioritize them, and allocate necessary resources.[1] To create a backlog, we need data for the system that software developers can use. Once the data (requirements) is collected, it is analyzed and provided to the developer to add to the DSH. We meet with the developer twice a week and provide the requirements to be developed, and the sprint duration is one week. Our partners are expected to provide us with new data (backlog) as they get it, which can then be incorporated into the DSH.

Then, website designing and development are done, which includes incorporating the given requirements into the platform. This way, a part of the DSH is ready for visualization, providing a clearer picture of the outcome. In case of any bugs or errors, the immediate fix can be done, and testing is performed to ensure quality. The developer performs a small set of tasks on the website, feedback is

[1] https://www.techstep.io/articles/requirements-analysis-in-an-agile-world

given, and changes can be made constantly. Once a reasonable amount of functionalities were collected and incorporated into the DSH, project partners were invited to test the hub and give feedback. Once the feedback has been received, development processes are discussed further, and arrangements are made for the next set of work. [3, 33, 27, 18].

Agile methodology is less time-consuming due to constant feedback, meaning errors and bugs are instantly discovered and fixed, reducing the risks of complete project failure. Moreover, each sprint of work is demonstrated, resulting in a visual representation of the progress and higher satisfaction. It is an adaptive approach providing flexibility to make dynamic changes according to changing circumstances, and because of the direct communication with the developer, a high level of transparency is maintained. [3, 33, 27, 18].

Chapter 4

Platform Architecture

Selecting an appropriate software architecture to support complex and powerful operations performed by modern software applications is paramount [5]. In simpler terms, software architecture refers to the basic structure of a software system and all the functions required to enable the system to behave as desired [20]. There are several software architectures available today, such as client-server, data-centric, microservices, reactive, and rule-based architectures. However, for the DSH, we use the 3-tier architecture to achieve flexibility, easy scalability, enhanced security, and robustness [1].

N-tier architecture has recently gained immense popularity due to its adoption of a client-server model [25]. It is a multi-layered architecture divided into logically and physically separate tiers of presentation, processing, and data functions [30]. It is a request-response service provided over the internet, where the client executes a set of actions over the network, and the server sends the result sets to the client system. There are different types of N-tier architectures, such as 1-tier, 2-tier, and 3-tier architecture, and each one has its own use cases, benefits, and drawbacks. However, for the DSH, we only concentrate on the 3-tier architecture, which has three distinct hierarchies of independent tiers: presentation, application logic, and data tier, and each tier performs a separate job.

Each tier is independent and has its own technology, logic, language, and platform. This means that its operation, maintenance, and troubleshooting are also independent. Despite this, the tiers need to continuously interact with each other and are backward and forward-compatible with other components in the system for the software application to work seamlessly.[1]

The presentation tier is the user-interface tier of the software application that manages the input/output data and presents information in an understandable format to the user [1].[2] The application tier is the middle tier that manages the processing of functions, including command executions, handling of errors, calculations, and any logical decisions [1]. It is the hidden connection between the user interface and the principal database. Lastly, the data tier is the database tier that manages the data store and optimizes the data access. The application logic tier retrieves data from the database stored in the data tier and processes it, and the results produced are stored back in the database [1]. For the DSH, each tier has its technology and language, which is elaborated on in the subsequent sections.

The 3-tier architecture is used for the DSH because it has three separate components, making it convenient to maintain each component of the architecture without affecting others, thus increasing flexibility. Because of this factor, it is also easy to upgrade one component without affecting other components' performance, significantly improving scalability. Each tier can have its security privileges, enhancing the security of the DSH by assuring that each component is protected according to its criticality level. Moreover, recovery times are shortened in case of a partial service disruption, as the 3-tier architecture allows restoration of an individual component with other tiers unaffected.[3]

[1] https://www.techopedia.com/2/32100/software/a-detailed-look-at-3-tier-software-architecture
[2] https://www.ibm.com/topics/three-tier-architecture
[3] https://www.geeksforgeeks.org/advantages-and-disadvantages-of-three-tier-architecture-in-dbms/

4.1 Data Tier

The data tier is the back end of the DSH, where user information is stored and managed. The DSH uses a NoSQL database as it offers more flexibility and rapid scalability to manage extensive data sets [28]. Moreover, as NoSQL is also a distributed database, information is stored on various remote or local servers, ensuring robust availability and data reliability [28]. This means that if some of the DSH data goes offline, the remaining database will still be functional. NoSQL provides the speed and ability to manage vast amounts of data generated from the DSH by scaling horizontally. The NoSQL database will be managed using object storage as the data model. Structured data, such as user profile information like name, date of birth, etc., will be stored in a regular NoSQL database. However, images, audio and videos, and other binary data will be stored with object storage. According to the focus group discussions, it was identified that the data generated from the DSH cannot be structured in rigid tables and hierarchies, and therefore, a more flexible database has to be chosen, which leads to our choice of object storage. Object storage offers ease of use and improves scalability [19], which means that when more and more users join the DSH and data grows, object storage also grows without limits. Moreover, due to the limited budget, an infrastructure team cannot be hired full-time, which means if any changes are made to the platform by the developer, it can be easily done with agility.

The expert focus group discussions identified that the DSH may produce isolated pools of data, resulting in a fragmented storage portfolio that adds to the complexity and, consequently, slows down innovation. The DSH needs a database solution that is durable but also secure, and compliant, leading to our choice of Amazon Web Services (AWS) cloud solutions. Amazon Simple Storage Service (Amazon S3) and Amazon Glacier deliver the advantage of managing the DSH data storage in one place at an optimal cost. AWS cloud services are estimated to provide 99.99% durability and are the only cloud service providing three different forms of encryption. “Amazon S3 & Glacier support more security standards and compliance certifications than any other offering, including PCI-DSS, HIPAA/HITECH, FedRAMP, SEC Rule 17-a-4, EU Data Protection Directive, FISMA and many more, helping satisfy compliance requirements for virtually every regulatory agency around the globe”.[4]

4.2 Application Logic Tier

The application logic tier interacts with the presentation tier, handles all processing functions defines solutions to complex problems, and communicates with the underlying database to, for example, retrieve or store data. NodeJs will be used to write the application logic tier. It is an open-source server-side JavaScript runtime environment. Based on a JavaScript engine called the V8, NodeJs supports many web browsers like Google Chrome and includes many V8 optimizations that help in running server-side applications. It is input/output (I/O) intensive, which makes it efficient for real-time applications running on distributed devices and, consequently, leads to improved scalability. NodeJs supports a single-threaded architecture “using non-blocking I/O calls, allowing it to support tens of thousands of concurrent connections held in the event loop.”[5]

The DSH provides a platform where quadruple helix actors can collaborate using the real-time collaboration tool that offers project management, file uploading, scheduling, video and audio conferencing, and much more. Keeping this in mind, NodeJs offers an asynchronous and event-based architecture with events and I/O requests occurring concurrently. As the users grow in number, the load on the server will also increase; however, Node’s WebSockets and Event API ensure that heavy I/O operations do not hang the server. NodeJs is event-driven and a non-blocking architecture that instantly propagates updates and makes it highly suitable for collaboration environments.[6]

4.3 Presentation Tier

The presentation tier defines the user interface of the DSH by managing the I/O data and how it is displayed. The users can access the DSH by using any existing web browser like Google Chrome, Safari, Internet Explorer etc. According to the expert focus group discussions, user interface requirements were identified which are as follows:

[4] https://aws.amazon.com/what-is-cloud-object-storage/
[5] https://www.toptal.com/nodejs/why-the-hell-would-i-use-node-js
[6] https://www.netguru.com/blog/node-js-apps

- The user interface should be easy to use and convenient;
- The user interface should be well-designed and of high quality to attract users to its main functionalities;
- Webpages should load quickly and render quickly;
- If functionality is added to one component of the DSH, it should not cause a ripping change throughout the codebase;
- The data flow and structure should provide code stability with seamless performance;
- There should be a possibility of upgrading the DSH from web development to a mobile app;
- The changes made to the platform should be trackable;
- Triggered outputs, functions, events and any other technical aspects should be testable.

Keeping in mind these requirements, React.js was chosen as the major web-scripting language exploited in designing the presentation tier of the DSH. React.js is a JavaScript library widely used for creating user interfaces for websites.[7] Top companies like Airbnb, Tesla, Walmart, Paypal, and many more are using React due to its numerous functionalities and features. React works with many components, making it easy to iterate with the system and allowing a larger user interface to be built. It uses virtual DOM (Document Object Model) that allows faster loading of web pages and helps in Google Search engine optimization, resulting in greater visibility online and further opportunities.

[7] https://uu.diva-portal.org/smash/get/diva2:971240/FULLTEXT01.pdf

Chapter 5

System Description

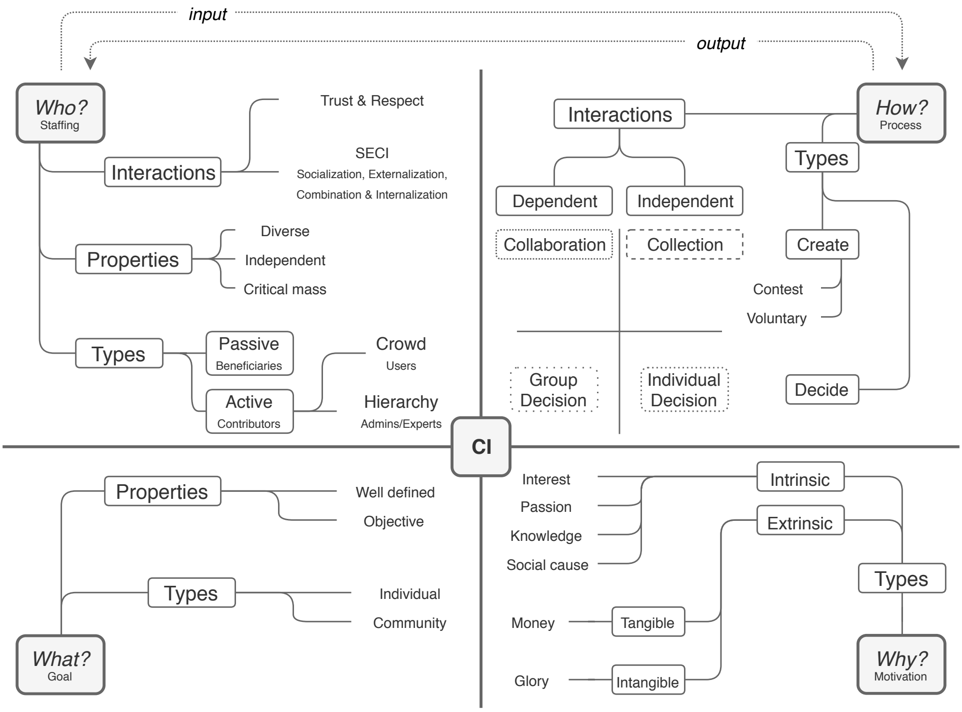

Figure 5.1: The Generic CI Model [34]

The DSH's functionalities are based on a generic CI model [34], which encompasses key components such as staffing, processes, goals, and motivation as shown in Figure. 5.1. It serves as a collaborative space for a diverse group of stakeholders and innovation actors, such as private sector representatives, academicians, policymakers, and older adults. The success of the platform hinges on the effective utilization of these quadruple helix actors, with policymakers being instrumental in delivering public value, engaging older adults, and identifying market gaps. The participation of older adults is also crucial, as they serve as consultants on senior needs, and their contributions towards developing innovative solutions on the platform are highly valued. Stakeholders can join in by sharing innovative ideas, discussing the feasibility of these ideas, organizing training programs, and providing networks for collaboration. [12]

To ensure platform success, loyal users, up-to-date content, and successful collaborations are essential. Integrated systems like Zoom/Skype/Teams facilitate smooth collaboration between innovation actors. LinkedIn and Facebook can be utilized to channel networking and build public relations. Chatting is preferred over calls to maintain privacy. The DSH platform is an open innovation ecosystem that enables the development, testing, and collaboration of innovative solutions. Incorporating patenting and copyrights is crucial to protect stakeholders. Decision-making is democratic, with no hierarchies. Contests can also be held to attract and encourage users to generate innovative ideas, with cash prizes or gift cards as rewards.

External incentives are crucial in motivating stakeholders and innovators to participate in the platform. Senior members of the community can benefit from feeling valued and involved in the creation of goods and services, as well as combating social isolation and loneliness. The platform should be engaging, user-friendly, and easy to access to ensure that users remain active. It would be beneficial if the government, incubation centers, and private sector to provide funding for the platform to support innovation development and address social challenges. The components of the DSH according to the generic CI model are shown in Figure. 5.2.

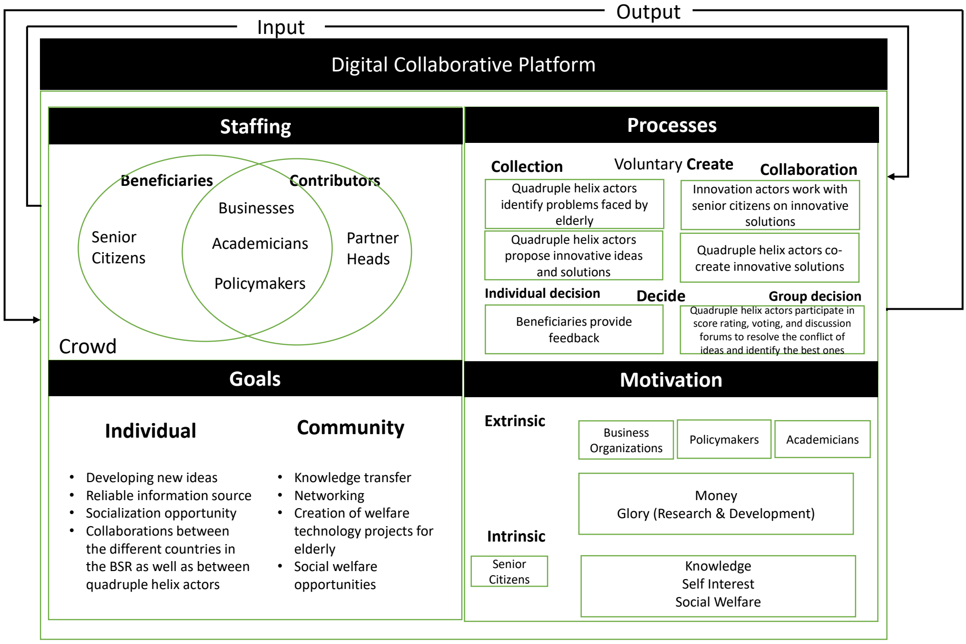

Figure 5.2: Components of the Digital Silver Hub [12] according to the Generic CI Model [34].

A smart specialization approach was employed to develop the DSH supporting the silver economy. Considering this, a Smart Silver Framework was developed, representing a pilot cooperation model enabling collaboration between stakeholders and increasing their capacity to generate economic growth through innovation. The Smart Silver Framework comprises three layers, with the first focusing on the quadruple helix actors. The second layer includes infrastructure focus areas for each helix actor, and the third layer includes classification and references. The Smart Silver Framework has been evaluated and validated by each region and found to be flexible, scalable, and transferable [9]. A comprehensive report on the Smart Silver Framework can be accessed publicly.[1]

The Smart Silver Lab is a multi-level governance structure that employs the Smart Silver Framework and serves as an open innovation ecosystem.[2] The Lab focuses on innovation actors and enables them to connect, coordinate, and build collaboration to develop innovative products and services for the

[1] https://osiris-smartsilvereconomy.eu/smart-silver-framework/
[2] https://osiris-smartsilvereconomy.eu/smart-silver-lab/

silver economy in the BSR. The Lab's first layer of governance consists of quadruple helix actors who communicate and establish collaborations using the DSH. The Smart Silver Lab also includes the Idea Lab, a repository for all innovative ideas that have been shared, given feedback on, concluded, or are still in development.

To support innovation management, various innovation-supporting tools are put to use, such as the Open Innovation Development Toolkit[3] for developing innovations, prototyping, accelerating market uptake, and enhancing partnerships. The Silver Financing Mechanism[4] for connecting innovation actors with various funding instruments, while the Knowledge Diffusion Toolkit[5] for enhancing the utilization, transfer, and reuse of knowledge amongst innovation actors. [9] The toolkit is structured in accordance with the innovation development phases shown in Figure. 5.3.

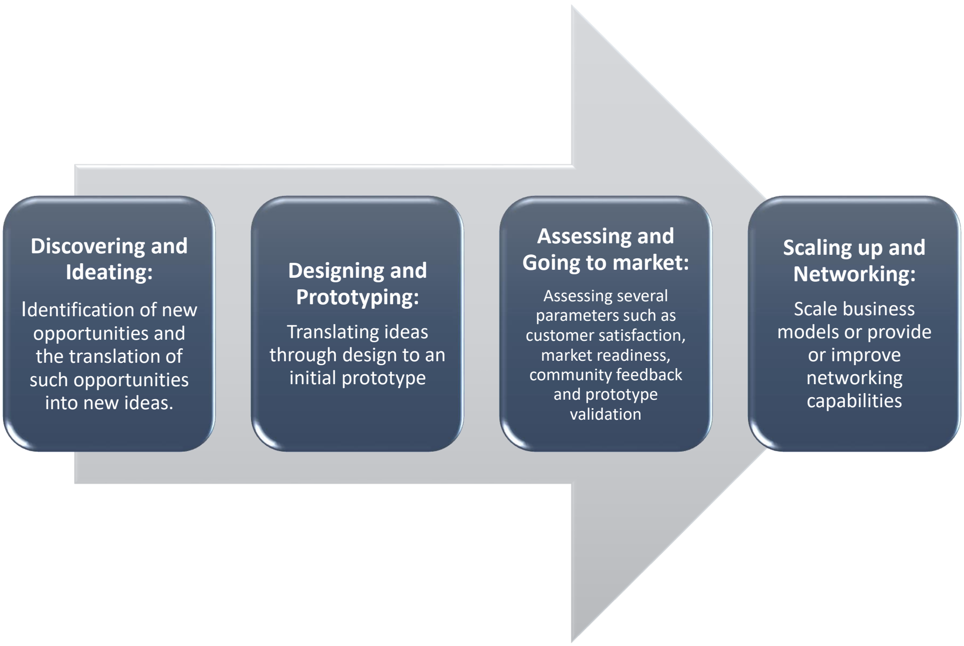

Figure 5.3: Innovation Development Phases

The mission of the DSH is to facilitate collaboration among quadruple helix actors by emphasizing networking. The platform provides a space for innovation actors to interact and exchange ideas, with the potential to form partnerships on future projects. It features discussion forums that serve as a social hub for innovation actors to chat and share ideas and a dedicated partner search function. The DSH acts as an information hub for events and publications related to the silver economy, with a library of silver market characteristics that can be updated and modified by users. The collaboration tools are the most important feature of the DSH, as they allow project owners and managers to invite new partners, assign tasks, create agendas and workflows, schedule deadlines, and hold Zoom meetings. Users can also make notes, upload files, and archive no longer active projects, enabling innovation actors to work together efficiently and effectively.

To access certain functionalities on the DSH platform, users must sign up and log in with the correct email and password format. Users will be redirected to an error message and asked to re-enter their credentials if entered incorrectly. After logging in, users can manage their accounts, edit their data, and change their passwords.

[3] https://silverhub.eu/ww/c/10054/p/1
[4] https://silverhub.eu/et/c/10064/p/1
[5] https://silverhub.eu/et/c/10284/p/1

Market research can be conducted on the DSH platform through one-on-one discussions with different actors, creating and sharing surveys, or organizing focus group discussions. Competitions can be held on various themes related to the silver market, offering rewards such as gift cards, prize money, or collaboration opportunities to grow the DSH user base and encourage innovative ideas.

Chapter 6

User Dialogue Models

6.1 Smart Silver Framework

The project partners highlighted that the project employs the smart specialization approach and develops a virtual system supporting the silver economy. A smart specialization is an approach that enables regions to focus on their strengths and comparative advantages and invest in carefully chosen priorities to boost regional enterprise innovation to ensure the greatest impact[1]. The DSH enables the six regions of the BSR, Finland, Estonia, Denmark, Latvia, Lithuania, and Russia (St. Petersburg), to come together and collaborate to develop innovative solutions for the growing aging population in the BSR.

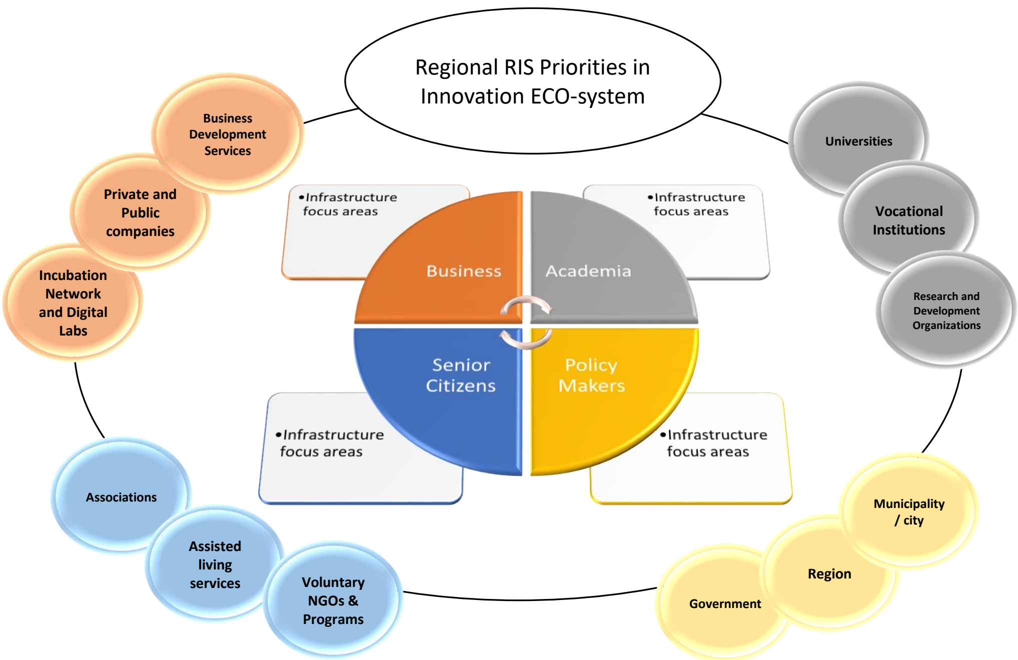

Figure 6.1: Smart Silver Framework

Considering this, a Smart Silver Framework was developed, representing a pilot cooperation model

[1] https://s3platform.jrc.ec.europa.eu/what-we-do

that uses a smart specialization approach to enable collaboration between stakeholders and increase their capacity to generate economic growth through innovation. The Smart Silver Framework consists of three layers (See Fig 6.1), and the first layer consists of the quadruple helix actors. The development of the silver economy cannot be done in isolation and therefore requires input from all the major sectors of the economy that are identified in the quadruple helix model of innovation.[2] This model identifies the four innovation actors the academic sector (researchers and institutions), the private sector (businesses and companies), the public sector (government and policymakers), and end-users (in this case, older adults). An integrated response from all the helixes can reap greater benefits, efficient utilization of resources, and consequently, foster smart innovations for the silver economy. The second layer of the Smart Silver Framework consists of the infrastructure focus areas for each helix actor. These focus areas can vary and depend on the actors' priorities, which can be determined by analyzing their region's silver market characteristics. The third layer, which is also the outer layer of the Smart Silver Framework, consists of classification and references, which are as follows:

- Senior Citizens: Associations/NGOs; Assisted living services; voluntary program
- Business: Business development services; Companies; Incubator Network and Digital Lab
- Academia: Universities; Vocational institutes; Research and development organisations
- Policymakers: Municipalities/Cities; Region; Government

The Smart Silver Framework was further evaluated and validated by each region, and it was concluded that the framework is flexible, scalable, and transferable. A detailed report on the Smart Silver Framework is publicly available.[3] The framework aimed to develop a structure to implement the DSH and incorporate Smart Silver Labs.

6.2 Landing Page

When the user opens the URL, there will be a landing page with the main title, 'Digital Silver Hub' and introductory statements to familiarize the user with the main concept of the hub. The taskbar shows the sections: 'About', 'How it works?' and 'Login/Signup'. The landing page will also have the option to choose from different languages as the platform targets the BSR region, so the DSH will have the option to choose from the languages in Table. 6.1.

Table 6.1: Languages

Languages
English
Estonian
Finnish
Russian
Danish
Latvian
Lithuanian

The landing page will also consist of the 'Help' icon to assist the users to navigate through the system and asking the chatbot for instant queries (as shown in the user dialogue model in Figure. 6.2. The FAQ will also be developed to help users identify solutions if they get wedged at some point on the hub. The landing page will show the signup option not only on the Taskbar but also as the main text below the introduction of the DSH to familiarize the users that it is a platform, and the precondition to use it is to signup and log in to the system.

[2] https://northsearegion.eu/media/11651/a-quadruple-helix-guide-for-innovations.pdf
[3] https://osiris-smartsilvereconomy.eu/smart-silver-framework/

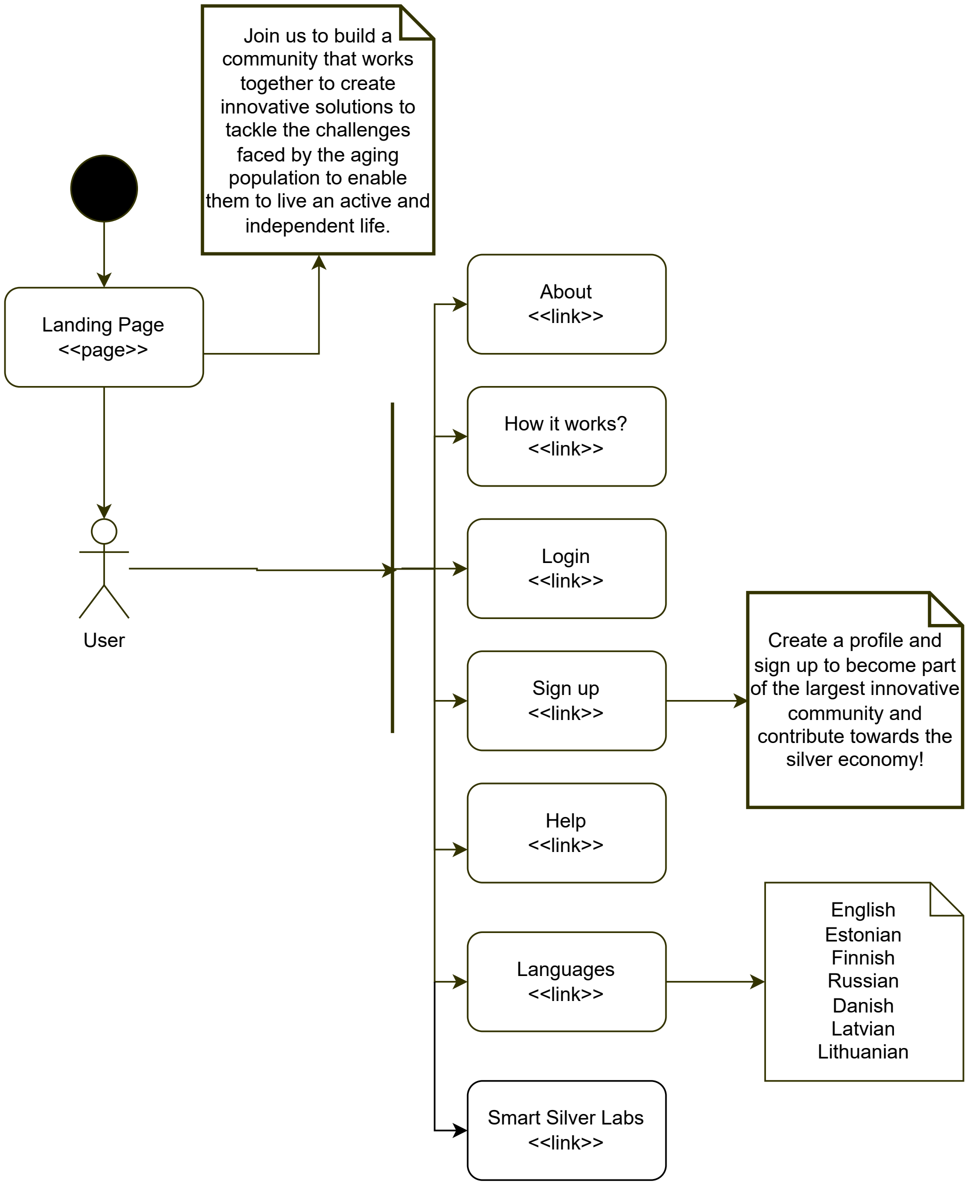

Figure 6.2: Landing Page of the Digital Silver Hub

6.3 Signup and Login

The precondition to use the platform is that the user has to signup, build a profile, and login and then be able to access all (or most of) the functionalities. The signup form will be different for each of the roles at the DSH. Each entry on the form will become a row in the database, and every piece of information they provide should be verifiable. The verification process will be outsourced to the verification company (e.g., Veriff) which will provide all the information that is required from each participant to ensure security and credibility on the DSH. When a user clicks on Signup, a form will appear to allow them to choose one of the roles as shown in Figure. 6.3.

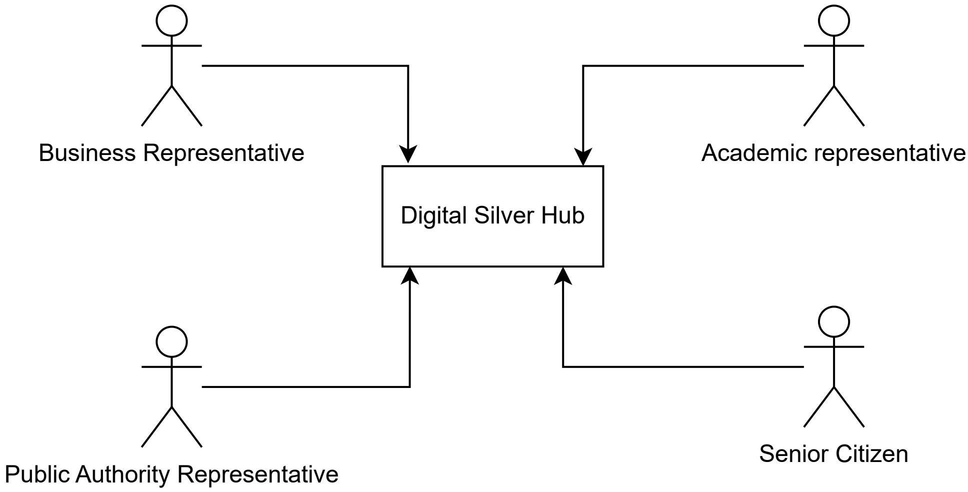

Figure 6.3: Choose a Role

The basic information required from each participant will be the same, and the form is shown in Figure. 6.4.

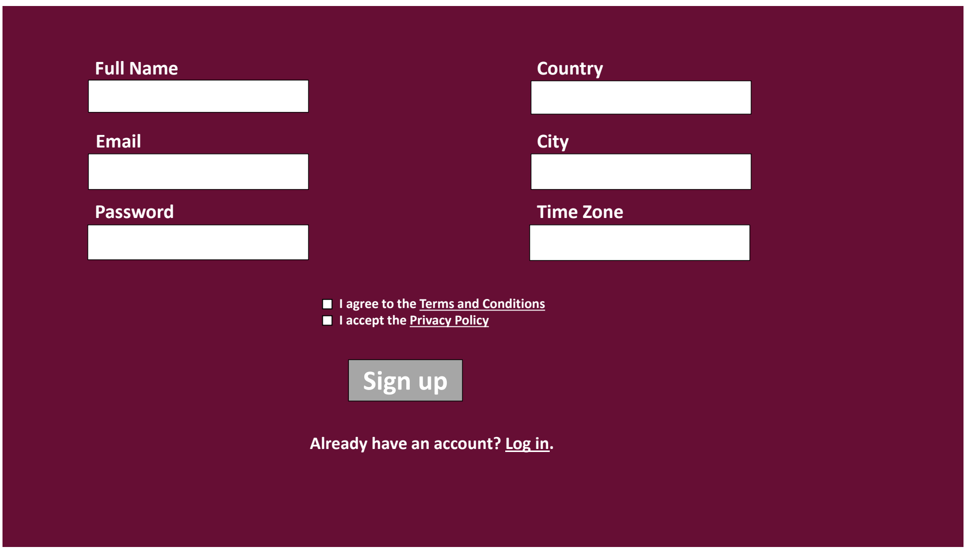

Figure 6.4: Signup Form

Country and city will give information about the region of the participant, and the time zone will help them when communicating with actors from a different region. For specific roles, the form will include the tabs shown in Table. 6.2.

The precondition to using the different functionalities of the DSH is to sign up and log in. Once the user logs in, entering their username and password, they enter the homepage of the DSH that shows different functions. When a user signs up, the correct email and password format have to be used. If

Table 6.2: Tabs on Signup Form

Senior Citizen	Business Rep	Academic Rep	Public Authority Rep
Age	Company name	University name	Organization name
Gender	Position	Position	Position
Working status	Business Registration/VAT No	Research topic	Sector

entered incorrectly, the user will be redirected to an error message and to re-enter their credentials. When entered correctly, the system will check if data already exists in the system, and if it does not, a verification email will be sent with a link that redirects to the login page where, after putting in the correct credentials, the user should be able to log in and view the home page as shown in Figure. 6.5.

The home page consists of different links that lead to different platform features and functionalities, as shown in Figure. 6.6.

6.4 Smart Silver Labs

The landing page gives information about the Smart Silver Labs (SSL), and the user can choose a region to view the Lab. The Smart Silver Lab is a multi-level governance structure that employs the Smart Silver Framework and serves as an open innovation ecosystem. The Lab focuses on innovation actors and enables them to connect, coordinate, and build collaboration to develop innovative products and services for the silver economy in the BSR. The Smart Silver Lab uses the DSH to communicate and establish collaborations amongst its first layer of governance, which is the quadruple helix actors, to identify new "*trajectories, which each region may need to acquire to access new forms of knowledge, create new recombinations of their resources, and move from path extension to new path-creation.*" The second layer of governance is the Transnational Cluster, which is composed of each regional Smart Silver Lab (Figure. 6.7) and supports innovation actors to "*joint actions to acquire knowledge, to diffuse knowledge, to access global value chains, to improve policy instruments and programs, to exchange best practices, to replicate successful measures, and to combine assets, capabilities, and competences for generating innovative products or services*".[4] Each Lab will have a Lab member and its own Managing Committee responsible for processing applications, accepting new Lab members from their regions, and proposing them to become part of the Managing Committee. The Lab members and managing committee of the six regions employ the DSH to interact with each other and conduct meetings and open-access events to connect the ecosystem members and the relevant silver economy actors.

6.4.1 Idea Lab

There will also be an Idea Lab (Figure. 6.8), which will serve as the repository for all the ideas that have been shared, provided feedback on, and concluded, as well as the new and upcoming ideas. Ideas will be presented in a list that will be sorted by the following attributes; publication date, top reactions, or relevance. There will also be a search bar to look for a particular idea using the keywords. The *active idea* is the one that has been recently shared and is open for feedback from the participants, and an *idea contributor* is the participant who shares the idea. An idea will stay active for at least three months, but the idea contributor can decide the time from a couple of weeks up to 6 months. Any participant can look through the list of ideas and give their feedback; however, the idea contributor would be able to see the participant's profile giving feedback and analyze if their expertise matches the concept of the idea shared. The Moderator of the platform is the administration staff for the DSH and can remove/delete any comment that is against the terms of use or may be offensive without any justification.

Now when an actor shares an idea, participants can vote for it in two ways; they can either up-vote it, which will be depicted as a thumb-up signaling that they like the idea, or they can down-vote it, which will be depicted as the thumb down signaling dislike towards the idea. The number of votes (up and/or down) defines the top reaction and the most voted idea. Along with voting, participants can comment on the idea in the comment box to reason their vote and give suggestions. Participants can sort the ideas from the list by relevance, which will be determined by the ideas on which they

[4] https://osiris-smartsilvereconomy.eu/smart-silver-lab/

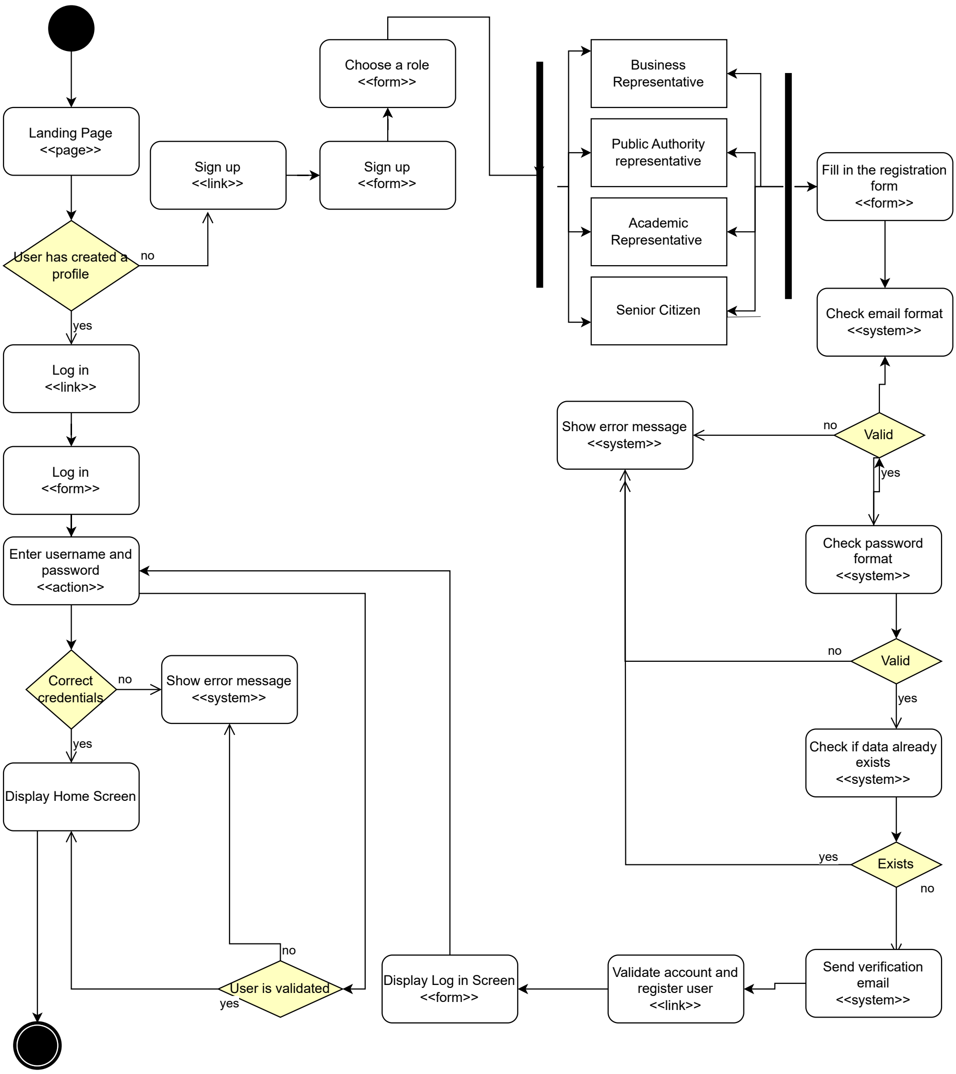

Figure 6.5: Signup and Login

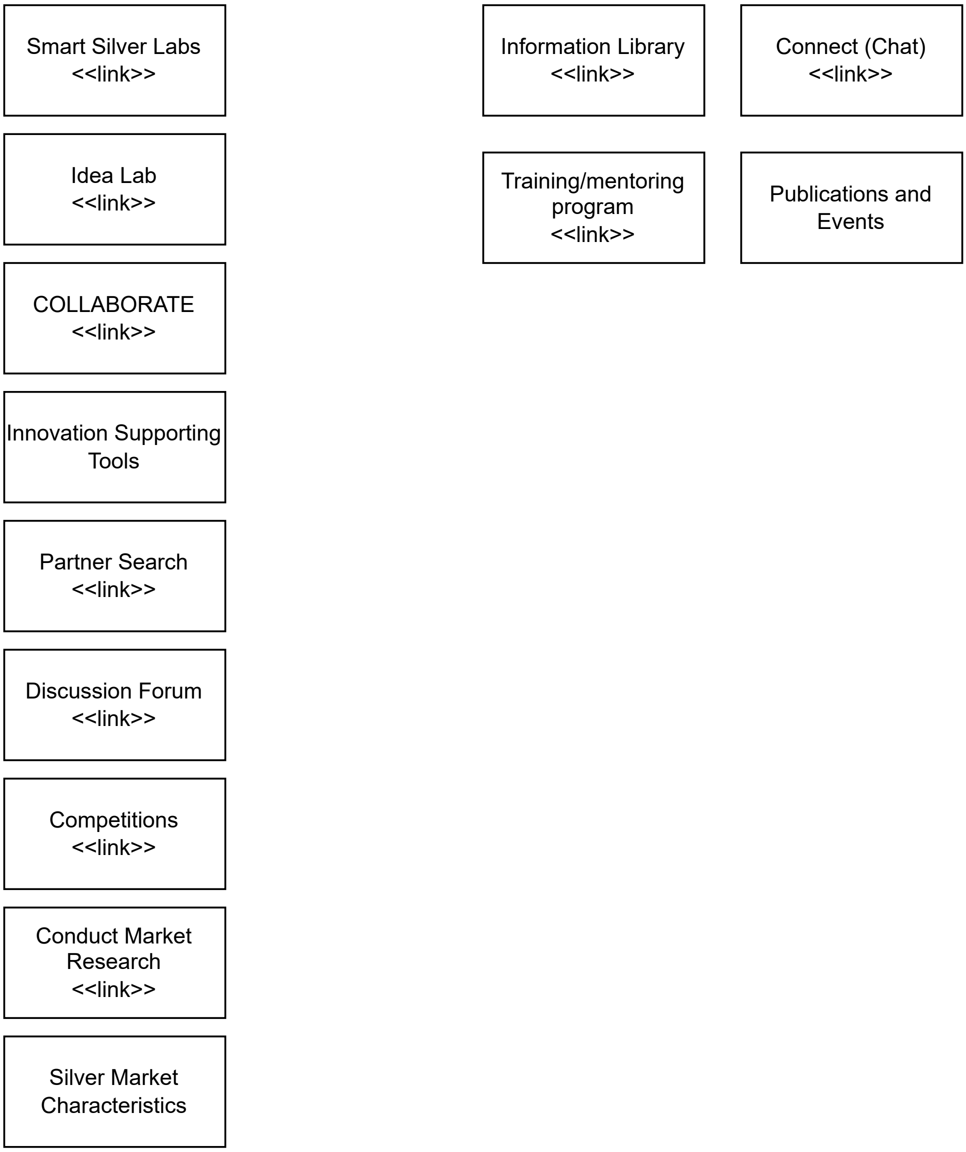

Figure 6.6: Home Page of the DSH

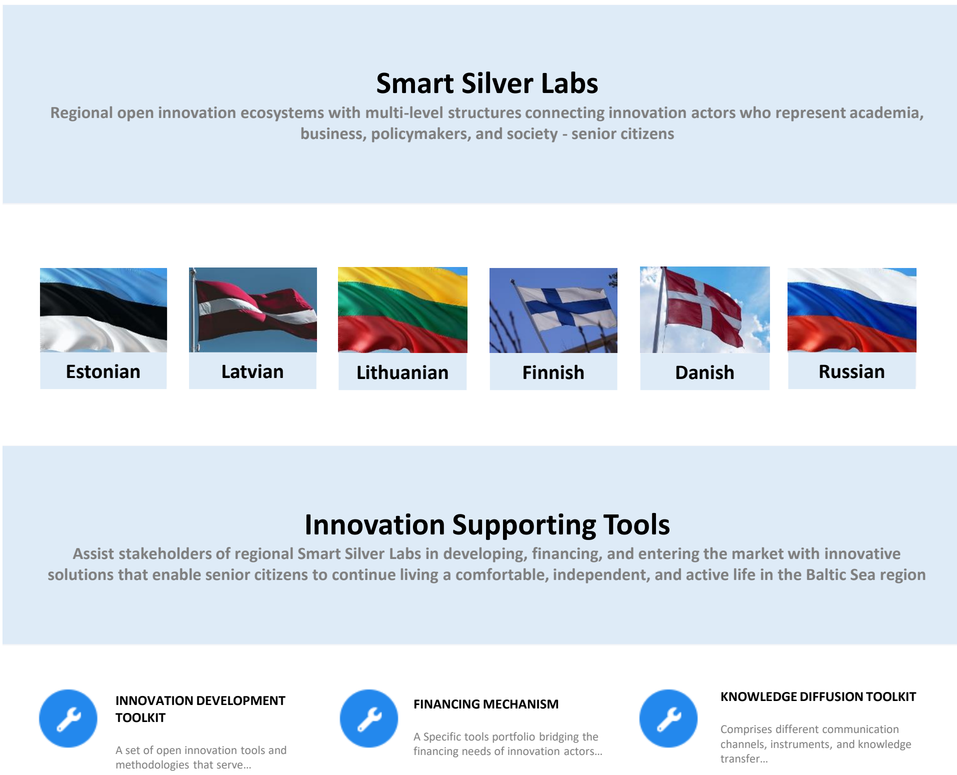

Figure 6.7: Regions and Smart Silver Labs

would have commented. If ideas have to be thoroughly discussed, these ideas can be taken to the discussion forums where all participants can argue, give their critique and/or praise, and offer to build a partnership.

The idea contributor can work further to build on the idea by finding a partner from the comment section, discussion forum, or the partner pool. The partner pool will be organized according to the quadruple helix model. There will be four categories: business representatives, public sector authority representatives, academic institution representatives, and older adults. Within each category, representatives will be listed with a brief introduction of their institution name and position for triple helix and age, gender, and working status for the older adults. Their profiles should be visible when clicked on them individually. Search functionality can be used to identify relevant actors by putting in their names or other keywords. Once a relevant partner has been identified, the idea contributor can connect with them on chat, voice call, or video call using the Zoom integrated communication app.

Moreover, an idea contributor can also check the practicality of their idea and test it with different stakeholders by either organizing a focus group from the DSH or running a survey. If a prototype is in question, it can be tested with the target group, and feedback can be gained. In addition to this, market research can be conducted to identify the likeliness of the idea being successful, if older adults find the product/service idea to be useful to them, or if businesses consider that the idea is feasible and willing to fund it. Once the idea has received feedback, partners have been identified, and it's time to work further to develop it, the idea contributor can use the collaboration tool and ensure that they have everything in one place. Different tasks can be assigned to different partners, and a team can be formed with a decided agenda using the calendar. Deadlines and work steps can be organized, and schedules can be maintained.

6.4.2 Feedback on Idea

If a user comes on the DSH and logs in to submit a new idea, the following steps will be followed (see Figure 8):

1. The user goes to the landing page, and if the user already has an account, logs in to see the home page.

2. On the home page, the user clicks on the Idea Lab, chooses to share an idea, and will be redirected toward an idea proposal form, which allows the user to add a detailed description and attach photos or any other supplementary documents. The idea proposal form would include all fields as mandatory, meaning that the user has to add descriptions or attach files (lower than 3MB) and include keywords and an interesting title to help gain the attention of other participants, as shown in Figure. 6.9. If any one of the fields is left empty, the system will not allow submitting with the help of the logically restricted *Submit* button. Once all fields are filled out, the 'Submit' button will become green, which means the idea is ready for submission.

3. Once the idea has been formulated and submitted, it will be available in the idea lab on the top, as the sorting by default will be set by the publication date. Now, different users will read the title and keywords and, if interested, will open the idea proposal and give their feedback. Feedback will be provided in two ways: votes and comments. Positive votes in favor of the idea will be up-voted by clicking the thumbs-up button, or in case of disliking an idea, a down-vote can be given as a thumbs-down. Moreover, comments can be added to justify their vote choice and general feedback on the idea.

4. If an idea needs to be further discussed, it can be taken to the discussion forum, where different actors can simultaneously comment on the idea and build on it.

5. If an idea receives a majority of downvotes and is rejected by other actors for any further development, the idea will be archived, and the idea contributor should be able to resubmit the idea with improvements from step 1.

6. If an idea has been given upvotes with positive comments, it's considered a good idea, and the idea contributor can either leave it as it is or work further to build on it. The contributor can test their idea, conduct market research, find a partner, and start collaboration.

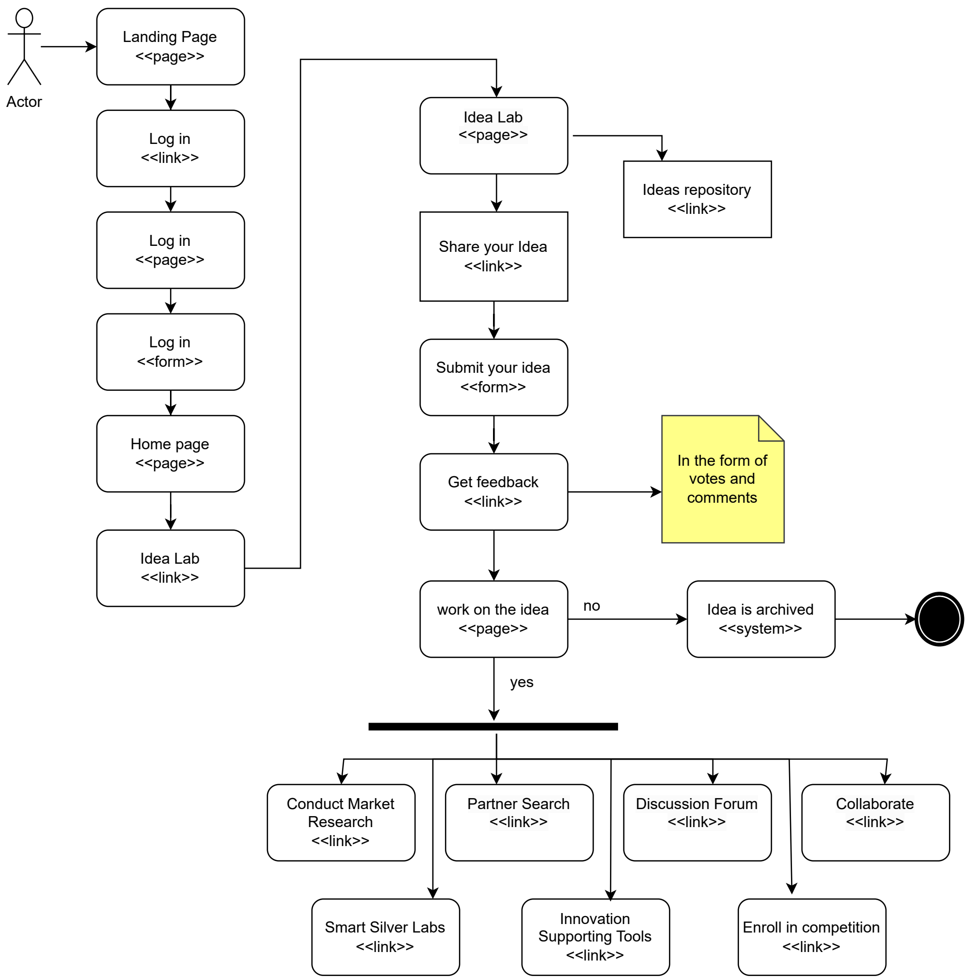

Figure 6.8: Idea Lab

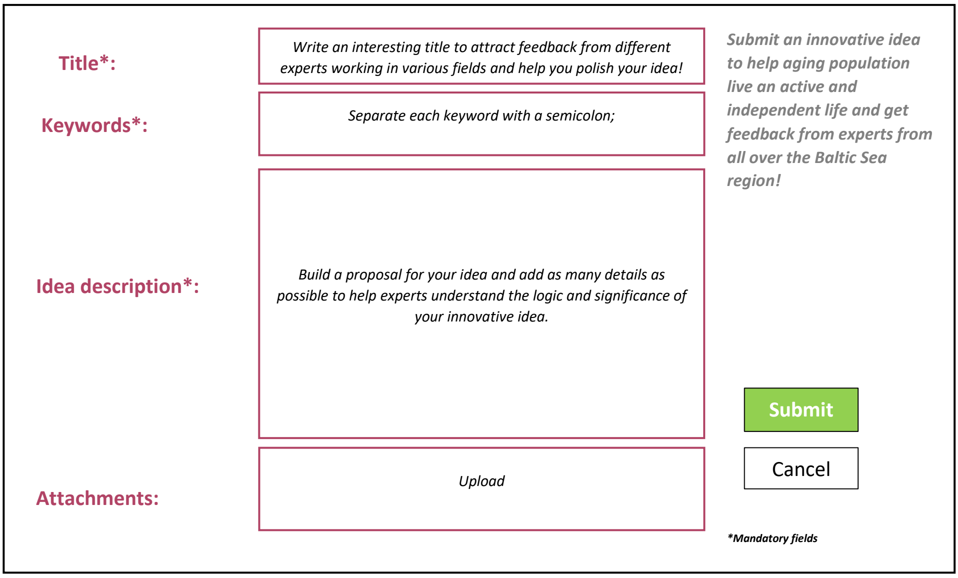

Figure 6.9: Idea Proposal Form

6.5 Discussion Forum

The discussion forum serves as a bulletin board for the DSH where different users can initiate topics and discuss and help each other out. It can be used to further build on the idea, discuss an infant idea, appreciate it, or criticize one. The discussion forum will appear as a list of topics with titles, and sorting can be done by publication date, most comments, or relevance. There are two ways in which a user can use the discussion forum functionality. One is mentioned above, through the idea lab, when an idea has to be further discussed and taken to the discussion forum. The user who starts a discussion topic is referred to as the 'discussion starter.' The other way is when a user logs in and straight enters the discussion forum, the following steps (See Figure. 6.10) are taken:

1. The user goes to the landing page, and if the user already has an account, then logs in to see the home page.

2. On the home page, the user clicks on the 'Discussion Forum', sees a list of existing discussion topics, and chooses one to contribute their opinion or create a new topic for discussion.

3. A brief description of the discussion topic must be added with a catchy title to attract other users to participate. Once the discussion topic has been initiated, other users will be able to see it when they go on the discussion forum, add comments, and discuss back and forth in detail about the given topic.

4. If any comment is against the 'terms and conditions and rendered offensive, other users and the discussion starter can report it, and an admin will be notified who has the right to remove/delete the comment.

5. If the comment is not offensive, the constructive discussion will continue until the discussion starter feels that the topic has been sufficiently discussed and requires no further input. In this case, the discussion starter has the right to switch off comments on the discussion, which means the discussion has been concluded. The discussion will remain in the discussion forum list for others to read; however, with new topics coming in, it will be dragged down in the list and can be fetched using the keywords or by sorting the list accordingly.

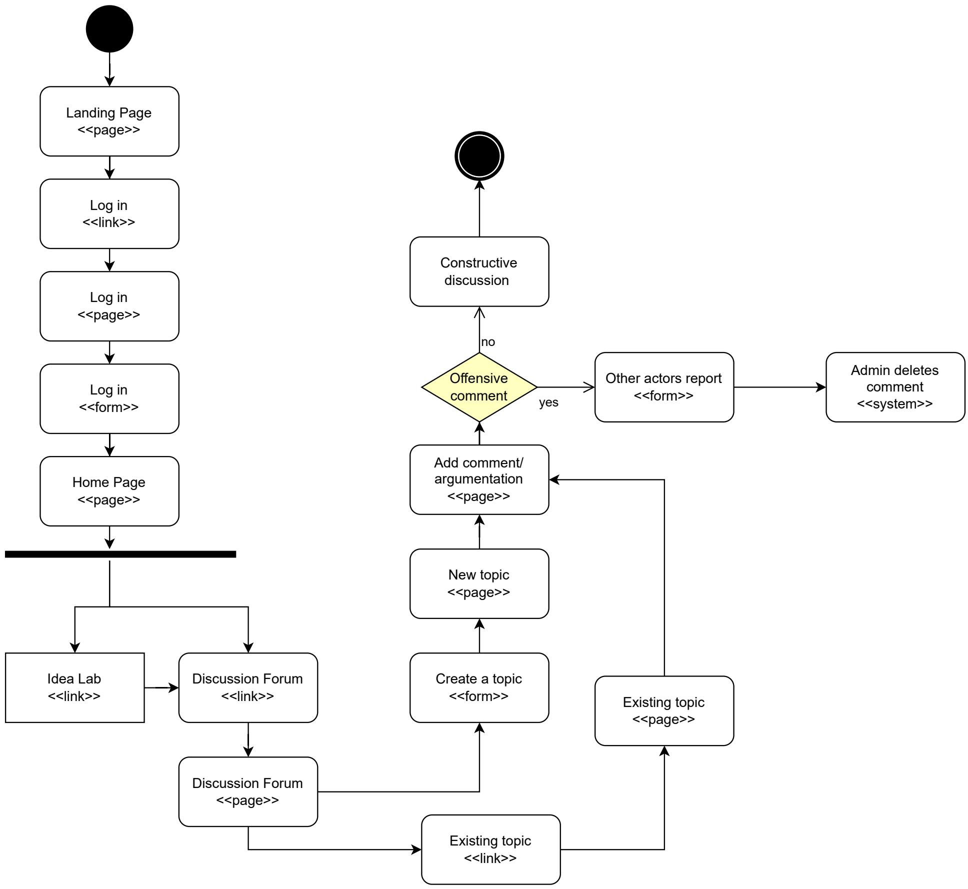

Figure 6.10: Discussion Forum

6.6 Partner Search

The DSH is a collaborative platform that aims to build a network of innovation actors from the quadruple helix model, which means that there will be participants from the private sector, public sector, academic sector, and older adults to come together and work on innovative ideas that are aimed to help the silver population in the BSR to live a healthy and independent life. When the users come on the DSH, they must sign up and build their profiles to be visible to other actors. When an idea contributor posts a new idea and looks for partners to collaborate with, they can search from the partner pool and choose actors from different quadruple helixes using the keywords. Another option is to find a partner and share ideas privately with them either on Zoom or the discussion forum and then collaborate.

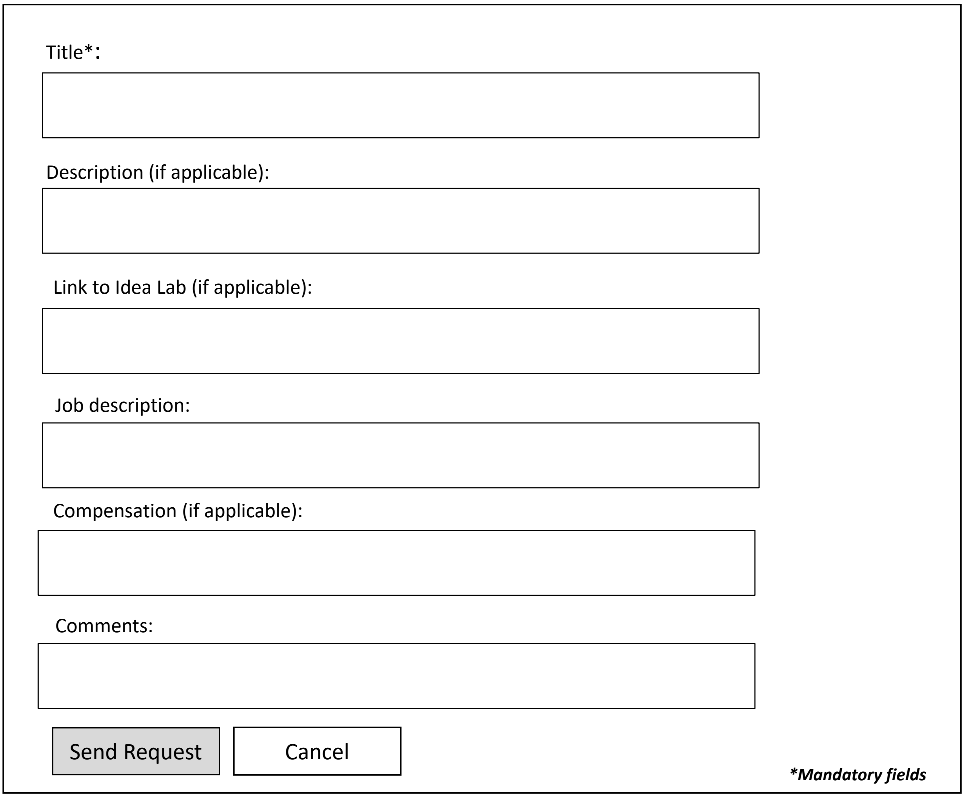

Figure 6.11: Partner Contact Form

When a user goes on the landing page, logs in, and chooses ‘Partner Search’ from the homepage, the following steps are to be followed (See Figure. 6.12):

1. Choose the helix that the user would like to partner with. Once the helix has been chosen, e.g., the user selects ‘Business Representative,’ different profiles of various business reps will be listed with their names, positions, and organization names. Users can search for a specific partner by searching for their name or using a keyword in the search bar.

2. Once the relevant partner/s have been identified, they can be contacted using the ‘Partner Contact Form’ that includes all the details of the idea in question as shown in Figure. 6.11. The mandatory field has to be filled out, and if it is left empty, the system will not allow sending the request with the help of the logically restricted ‘Send Request’ button. Once all fields are filled out, the ‘Submit’ button will be highlighted, which means the request is ready to be sent.

3. If the partner agrees, the user can connect with them on Zoom and collaborate with them over the DSH. If the partner is uninterested, the user must find a different partner. If multiple partners from different helixes are to be chosen, then the user must contact partners from each helix individually.

6.7 Collaboration Tools

This is the most crucial functionality of the DSH, as it is the core aim of the platform to help the innovation actors collaborate on ideas and work together as one team as shown in Figure. 6.15. The

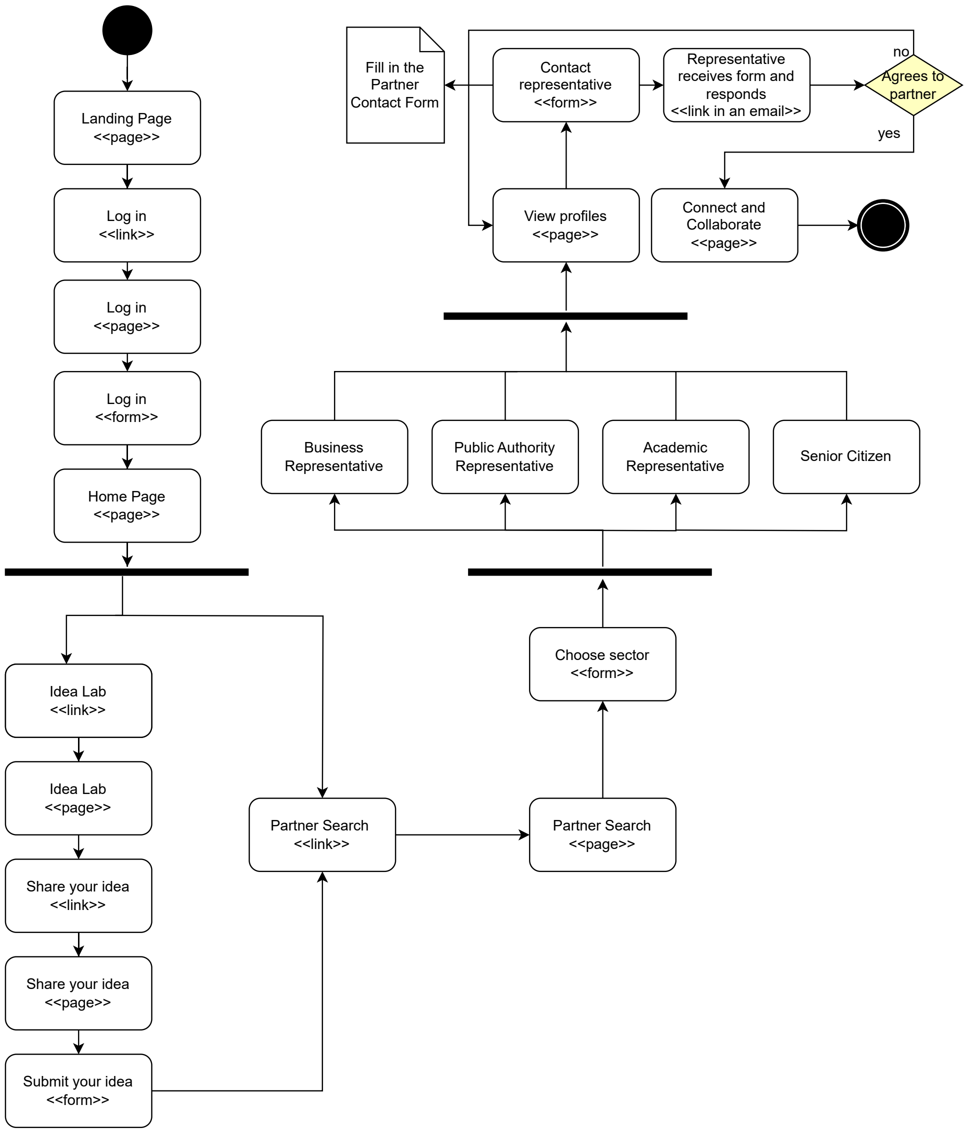

Figure 6.12: Partner Search

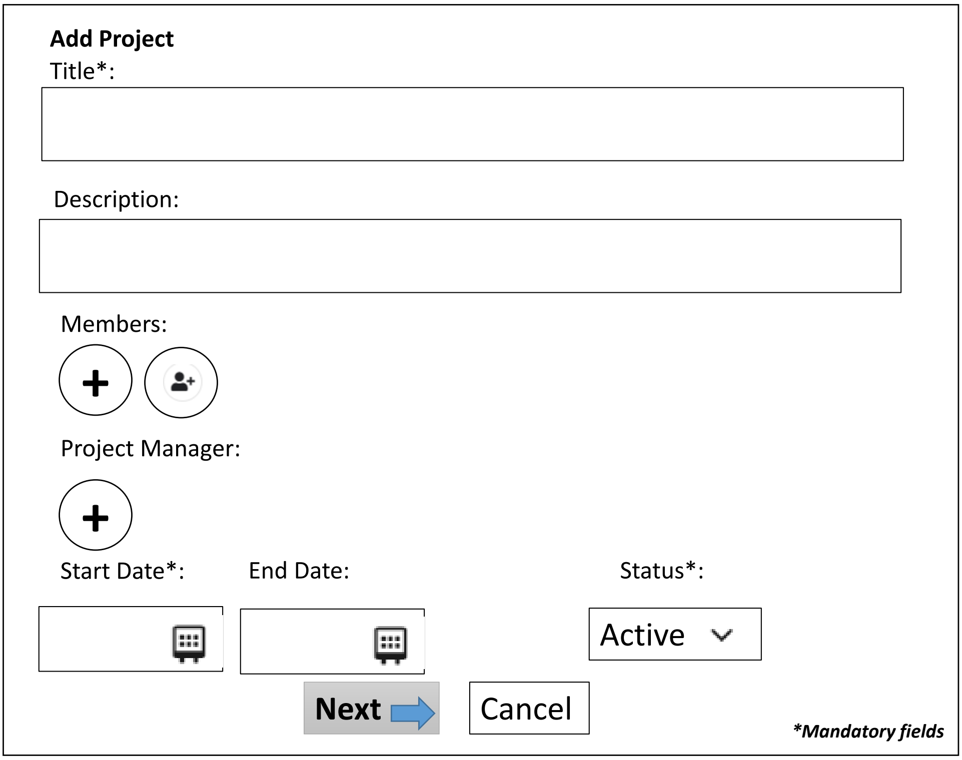

Figure 6.13: Add Project Form

user who adds a new project is the *Project Owner*, and the partners collaborating on the project are *Project Members*. The team can also assign a Project Manager who would be responsible for ensuring that deadlines are met, and necessary resources are available to work on the idea. There are two ways to get to the Collaborate page; one is through the Idea Lab when the user receives positive feedback from innovation actors and has also searched for a partner for themselves, and they should be able to go to the Collaborate page and work to build further on the idea. The second way is to go straight to the Collaborate page from the homepage after logging in. Once a user has logged in and clicked on Collaborate on the homepage, the following steps are followed:

1. Users can either choose the existing project from their dashboard or add a new project. Adding a new project requires the user to fill out an *Add project form* (Figure. 6.13) and choose which tabs they'd like on their project interface (Figure. 6.14). Adding title, start date, and status are mandatory fields and, if left unfilled, would show an error message. Project members can be either added using this form or can be added later in the project from the dashboard.

2. Once the form has been filled out and project tabs have been enabled, the project will be added and visible on the main dashboard of the project owner and other assignees.

3. Now, according to the enabled project tabs in step I, enabled tabs will show on the taskbar when the project is clicked. Given that the user allows for all the tabs on the new or existing project, the user should be able to:

    - *Invite/add new partners:* As the users discover new partners to collaborate with, they can add them to their projects as new members.

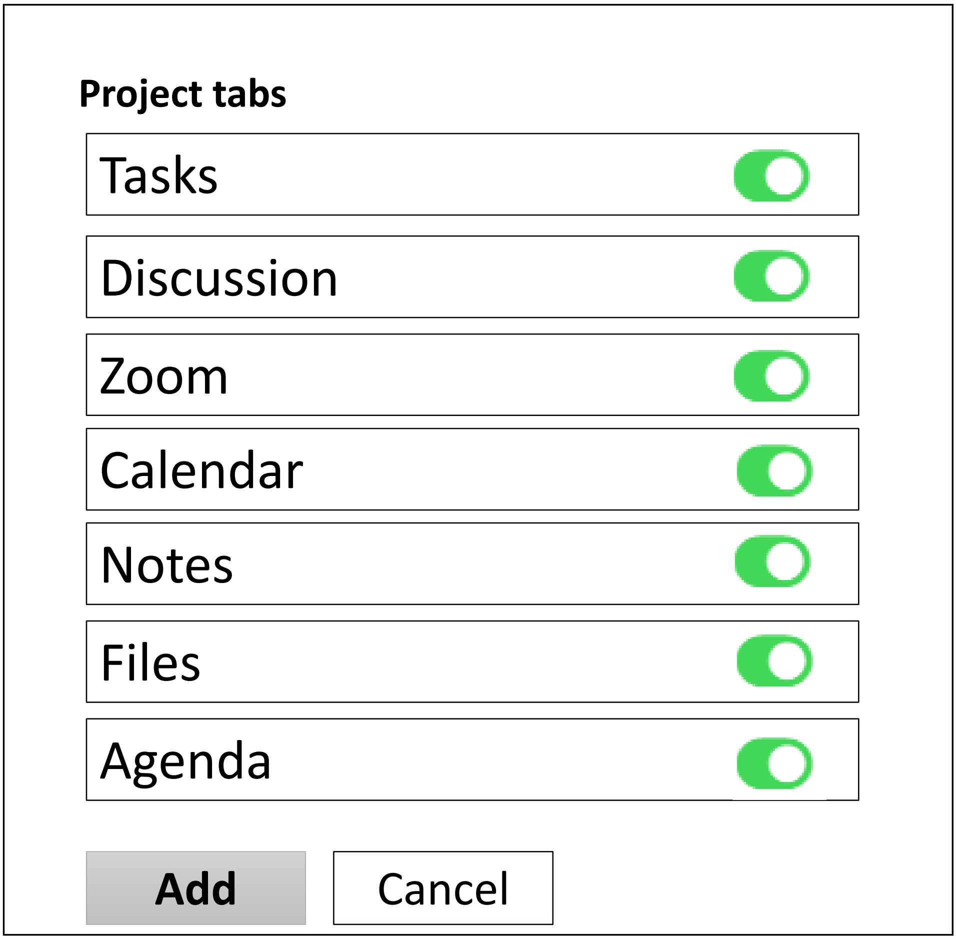

Figure 6.14: Enable/Disable Project Tabs

- *Assign tasks:* Different tasks can be added by the project owner or manager and assigned to the project partners. Each task can be associated with a workflow and has its own agenda. Deadlines can be set, and groups can be organized according to the tasks.
- *Make agenda:* Project managers can create an agenda for the whole project and different tasks within the project. Deadlines, calendars, and workflows can be associated with each agenda. This helps develop a direction for the project and assists members in understanding their tasks and timelines.
- *Build workflows:* The user should be able to create and manage activities at different stages of the workflow and keep track of all the tasks within a project. Users can either use an inbuilt default workflow with three stages: Backlog, Ongoing, and Done, or create customized workflows.
- *Discussion:* This is connected to the Discussion Forum, where the users can initiate their own topics and choose to either make them private for their own team only or public to gather opinions from other actors on the DSH.
- *Zoom meetings:* This is a more personalized communication medium and lets project members communicate in real-time. Members can individually interact with one another or form groups. Zoom allows chats, voice calls as well as video calls.
- *Schedule on the calendar:* For the teams and individual members to organize their tasks and events like meetings and deadlines, the calendar helps them have them in one place.
- *Time Deadlines:* The project manager should be able to add deadlines to each task and monitor the estimated and logged time. Timesheets can be created to record logged time, and project progress can be analyzed.
- *Make notes:* Project members can choose to leave notes either for private use or to share with the whole team or selected team members. Notes can be made under each project or task and are easily accessible.
- *Upload important files:* The DSH makes it very convenient for its users to save and share their files linked to the project or even smaller tasks. Files can be attached either directly from the user's computer or other applications like Google Drive, Dropbox, etc. The files attached to the project or team will be visible to all the members within that certain group. To privately share the files with an individual over the DSH, zoom chat should be used.
- *Archive project:* Projects that have concluded or no longer require any collaboration over the DSH can be easily archived and removed from the dashboard.

6.8 Other Functionalities

6.8.1 Conduct Market Research

If a user believes that it has a very good innovative idea but wants to test it before considering investing in a minimum viable product (MVP) or a tangible product, the DSH provides a perfect environment to do so. The user who performs the test will be referred to as the tester, and the audience with whom the idea is being shared will be referred to as the 'testing sample'.

The prerequisites to be able to test the idea are:

- The tester should have a mockup or even a simple sketch to provide a visual representation of the idea to build a connection.
- The tester should be able to describe the idea effectively and explain different use cases to enable the testing sample to understand what problems it will solve in simple language.
- The tester should be able to detach themselves from the idea to allow objective feedback by presenting the idea in a neutral manner to avoid the tester's bias.

The goal of testing an idea is to get an understanding of the customer needs, viability, and practicality of the idea and eventually to improve the idea. Testing can either be conducted with the consumers (older adults) or with other business representatives to understand the market. There are three ways in which the idea can be tested on the DSH:

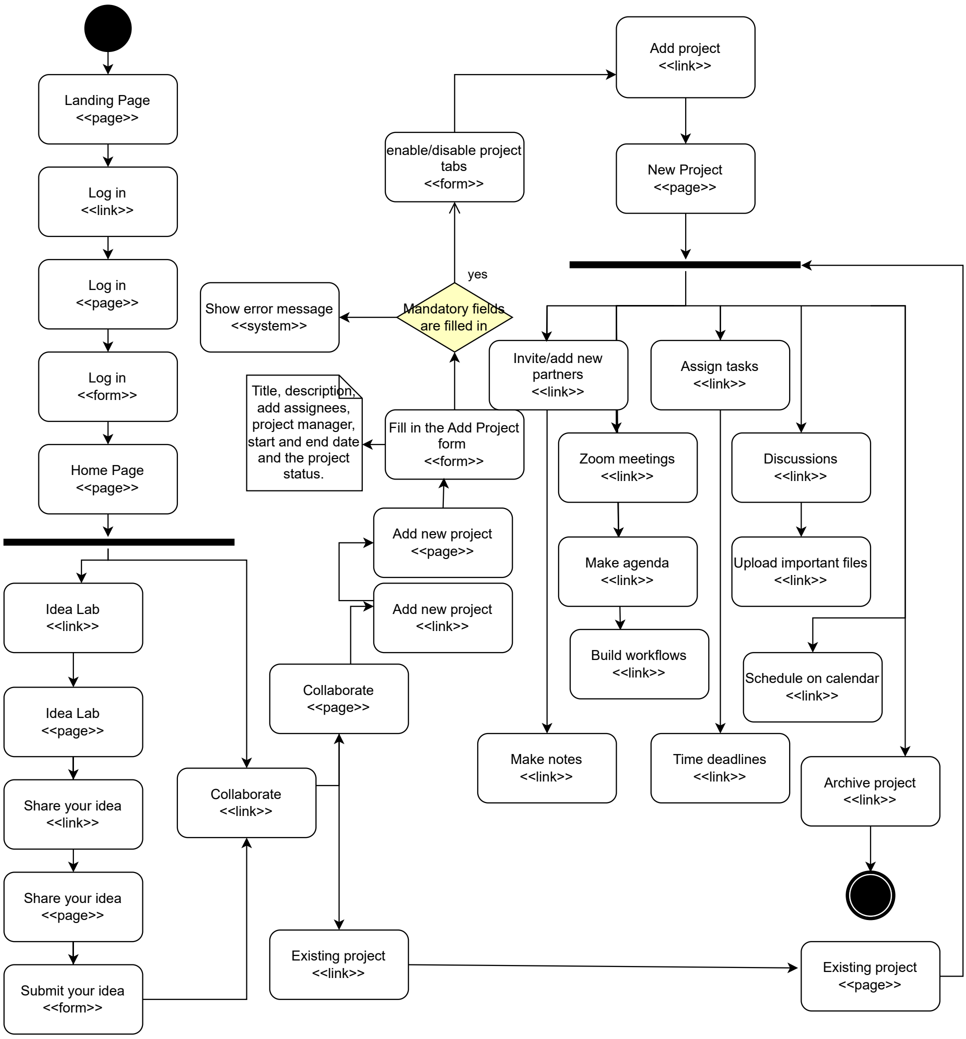

Figure 6.15: Collaboration Tools

1. *One-one discussions:* If the tester only wants to get an initial idea about how someone would respond to the idea, different actors can be contacted, and short interviews can be conducted. This leads to a more personalized and individual reaction to the idea and enlightens the tester about different preferences.

2. *Surveys:* The tester can approach different users, build a testing sample, and share the idea in the form of a survey. Survey questions can be open or close-ended depending on the requirement of the idea in question. Questions about whether they like the idea, if they'd use such a product/service, or what kind of features they'd like to add to the service can be very critical and useful for any idea to materialize. On the DSH, the tester can build their own surveys or use other services like Survey Monkey or Google Forms to build and distribute a survey.

3. *Focus Group Discussions:* A group of about 7-10 people from similar demographic profiles, experiences, and backgrounds can be gathered to discuss the idea. This is ideal if the tester wants to identify the group's behavior towards the idea, their perceptions and the overall viability of the idea. On the DSH, the tester can find appropriate participants and analyze group responses for actionable insight.

Similar testing methods can be used if the tester already has an MVP or a tangible service and evaluates it by testing it either individually or in a group and get their reactions in the form of open discussions or using surveys to collect their responses.

Moreover, if an innovation actor (e.g., academician) only wants to conduct market research about a certain idea, problem, solution, or any other topic, should be able to use the three testing methods to conduct their research. To encourage participation in the testing, it is also possible to offer gift cards or any other interesting rewards to participants. This usually helps increase motivation, leads to increased participation, and may also stimulate careful responses.

6.8.2 Competitions

Competitions are a great way to increase the user base and grow a community of like-minded people. Moreover, it can also motivate the participants to come up with interesting ideas and contribute to the cause of the DSH. Competitions can be held on various themes related to the silver market: healthcare, leisure, social life, living environment, safety, etc. According to the theme, a problem will be highlighted that participants can decipher through innovative ideas for solutions. Competitions will be posted on the DSH, and actors already on the DSH or new members can join to participate in the contest. New competitions and details will be presented on the main landing page.

The prerequisite to entering the competition would be to sign up and log in, after which the user can click on competitions, read the details, and participate. Participation would require the user to build a proposal and a sketch of their innovative idea to solve a certain problem. E.g., if the theme of the competition is safety and the problem is that older adults find it difficult to climb up the stairs or ramp, either on foot or wheelchair, how can this be resolved? Now, participants can either come up with solutions on how staircases can be designed or how wheelchairs can be designed, etc. Competitions allow creative juices to flow, and rewards like gift cards, prize money or the opportunity to collaborate with a private firm to fund the idea can be highly motivating.

6.8.3 Information Library

Just like any yellow pages, the DSH will serve as a directory for all the services and products related to/aimed at older adults. To access the library, the user doesn't have to sign up and should be able to access it from the landing page. Every region will have its own list. This helps the elderly to find all related items in one place and choose the most appropriate one. For example, in Estonia, if a senior citizen is looking for a taxi service then using the DSH, just typing taxi would show options (or more) as shown in Table. 6.3.

Brief descriptions for each service will be provided, and the name will be a hyperlink that will redirect to the main service provider from where the user can avail of the service outside of the DSH. Information library is a service of the DSH to make it convenient for the elderly to find all the services in one place without the hassle of looking all over the internet.

Table 6.3: Taxi Services in Estonia

Amigo Taxi	Taxi Per Te Tallinn
Tulika Takso AS	Sõbra Takso OÜ
Yandex	Vaba Takso OÜ
Bolt	Taxigo
Bongo Taxi	Pärnu Taxi
Tallink Takso	TARTU TAXIS
Reval Taxi Ltd.	Yes Transport OÜ
Q Takso OÜ	SETI TAKSO OÜ

6.8.4 Silver Market Characteristics

The DSH serves as a directory for all the services and products related to or aimed at older adults. It consists of all the characteristics of a regional business or market environment, including all the factors, forces, and institutions that directly or indirectly influence the interactions between various innovation actors in the silver economy. Users can also comment, give feedback, and suggest updates to the list. The user doesn't have to sign up to access the library and should be able to access it from the regional Smart Silver Lab. Every region will have its list, and users can get an overview of regional silver markets, their characteristics, and descriptions, and also propose new regional silver market characteristics' descriptions or modifications of existing ones. The silver market characteristics consist of the following categories:

- Actors and Organizations
- Common practice
- Development of new technologies
- Ethics
- Family and extended family
- Funding mechanisms
- Growth drivers
- Legislation and laws
- Market analysis
- Motivation
- Professionals
- Users and Citizens

6.8.5 Training and Mentoring

Different training and mentoring programs will be held at the DSH to help older adults learn different technical skills. Certified trainers from each quadruple helix can offer personal training and attract an audience from the DSH. Other trainings being held in the user's region will also be announced in this section. Users should be able to access this webpage without signing up or logging in.

6.8.6 Publication and Events

The DSH also provides information regarding different events in the six regions. These events may include hackathons, conferences, workshops, and other innovation/technology-themed meetups. Moreover, different competitions will be held on the DSH with various themes related to innovative solutions for the challenges faced by the silver population. News regarding other innovations for the silver economy will be displayed in the newsletter along with upcoming events, seminars, webinars, etc., organized by the Baltic Sea Region Cluster, where not only the triple helix but also older adults can participate and contribute. Different actors can also use this platform to publish their upcoming innovative solutions and events they are organizing to attract their audience. Actors can also explore publications related to the senior economy of the BSR and give their feedback using the comment functionality.

Chapter 7

Discussion

7.1 Platform Evaluation

The DSH was evaluated in two information sessions; the first one was conducted online due to the pandemic, and the second one was conducted in person. The first information session was conducted to present the DSH webpage to the project partners. Silverhub.eu is still a work in progress however, it was imperative to take input and feedback from the partners. This is the advantage of using an agile approach for hub development, as small iterations can be displayed and tested, and feedback can be instantly incorporated. Help manuals were explained whereby the basic structure of the hub and agile methodology were briefed. Step-by-step instructions were provided to help partners navigate through the hub. Portal management was also elaborated on but very briefly, as this will be explained in more detail in further sessions to come. Once the hub is stable and has enough functionalities, each region will have a representative who will be trained to use and manage the platform on their own. This aims to ensure that country-specific and local language content can be uploaded and kept up-to-date even after the OSIRIS project ends.

Initially, on the DSH home page, the user had to choose a role, and then they were able to see the role-specific content, which was highly objected to as when a user enters the DSH, they will find information only directly related to them, but they might need information from other actors as well. They might not recognize that they have to change their role; therefore, the need to choose a role was eliminated from the DSH home page. Moreover, jargon such as quadruple helix actor or silver economy should not be used on the DSH as these are academic terms and not for common use. In addition to this, the participants pointed out that a section in About Us should be added that explains the silver economy, its challenges, and how the DSH contributes to its development. The discussion forum initially was not a common forum, which means that actors could only access it in their own local languages but could not communicate with other innovators from other countries. Therefore, it was suggested that there should be two forums, transnational and local, as it is very important to support transnational knowledge sharing and collaboration for the DSH to successfully fulfill its goals. Lastly, the DSH should be more user-friendly than it was at the time. Every step should be explained what the DSH is all about (in particular) and well guided in terms of where it could take the user (in the given space reported). This should not be only a fancy mobile tool for 'diginomadic´ professionals rather, it is important to show that the DSH is created and being under construction to care about reflecting the older adults.

The second information session was conducted when all the functionalities were incorporated into the DSH and were ready for user testing. Participants toured and explored the platform in detail, and any feedback was recorded. It was identified that the majority of the functionalities of the DSH were in place; however, chat, idea sharing, feedback, and collaboration tools were missing from the prototype, which would need further investment for development. Participants appreciated the changes to the discussion forum as it is now possible to use the forum in English or their local languages. However, Innovation Supporting Tools were also made available for the transnational clusters as well as regional Smart Silver Labs, which included the Innovation Development toolkit, Financing Mechanism, and Knowledge Diffusion Toolkit. The tools are readily accessible; however, how they can be used to develop an innovative idea on the DSH is yet to be decided. Therefore, it was decided that further information sessions should be conducted to evaluate a running case on the DSH which means that an innovative idea will be worked on and developed on the DSH to further enhance and expand its functionalities.

7.2 Future Work

For any platform to be successful, it has to be kept up-to-date and maintained. In the future, it is imperative to analyze and implement measures to ensure the sustainability of the DSH. The DSH is built on a high-quality information structure. Therefore, it must be sustainable and flexible in order to accommodate changes in processes, organizations, and capabilities as innovative products and services are developed, as well as to ensure user and stakeholder support while maximizing long-term impact. Therefore, the next step for the DSH is to discuss, analyze, implement, and evaluate measures to ensure sustainability and maintainability. Moreover, to analyze the full potential of the DSH, a running case must be evaluated whereby an innovative idea is built further to become a full-fledged service with the help of the collaboration between different actors from the quadruple helix model on the DSH. This helps identify the gaps and loopholes in the DSH that can be readily fixed. Further functionalities, needed to support the development of the ideas, can emerge and be built in the DSH. Once the DSH is fully developed and up and running, it can be launched, and different actors using it will be able to give their feedback on the performance of the DSH. This way, user satisfaction can be tested, and the performance of the DSH can be evaluated to help improve it further. The evaluation criterion and methodology on how user satisfaction and performance of the DSH will be measured is yet to be identified and are the next important steps.

Chapter 8

Conclusion

As the world's population continues to age, there is a growing need to address the challenges faced by the silver generation. To this end, several initiatives are underway to incorporate smart solutions that can improve the quality of life for older adults. One such initiative is the DSH, a digital collaborative CI platform that has been developed specifically to focus on creating and boosting user-centered technological innovations.

The DSH uses the Smart Specialization approach to develop solutions that are tailored to the needs of older adults. By encouraging collaboration and partnerships between different actors from the quadruple helix model, the platform is designed to facilitate the co-creation of innovative solutions that can improve the lives of the silver generation.

To achieve this goal, the DSH provides a range of features to its users. These include the Smart Silver Labs, partner search, innovation supporting tools, collaboration tools, training programs, information repository, events, and more. Each of these features is designed to support the co-creation of innovative solutions by bringing together different stakeholders and enabling them to work collaboratively towards a common goal.

To ensure the DSH's sustainability and maintainability, policies, daily practices, and user workflows must be flexible and autonomous. This will allow the platform to adapt to changing needs and circumstances, and ensure that it continues to provide value to its users over the long term.

The impact of the DSH extends beyond the BSR and can serve as a model for other platforms seeking to develop user-centred functionalities for seniors. By focusing on the needs of older adults and leveraging the power of technology to meet those needs, the DSH is helping to create a more age-friendly world.

Chapter 9

Acronyms

ICT	Information and Communication Technology
IT	Information Technology
ADR	Action Design Research
CI	Collective Intelligence
BSR	Baltic Sea Region
EU	European Union
DSH	Digital Silver Hub
UX	User Experience
UI	User Interface
SSL	Smart Silver Lab
SSF	Smart Silver Framework
UML	Unified Modelling Language
I/O	input/output
MVP	Minimum Viable Product
OSIRIS	Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth

Chapter 10

Glossary

Silver economy	All economic activity related to the needs of people aged 50 and over [26].
User profile	A description of a person, group, or organization that contains all the details that someone needs.[1]
Quadruple Helix Model	A concept emphasizing broad collaboration in innovation between government, academic research, business, and society [31].
Triple Helix model of innovation	A concept "to foster regional economic growth and promote entrepreneurship, through understanding the dynamics of interactions between three institutional spheres of university, industry, and government." [13]
Forum	A place on the internet where people can leave messages or discuss particular subjects with other people at the same time.[2]
Partner search	Forming part of a pair or set.[3]
Online chatting	The process of communicating, interacting and/or exchanging messages over the Internet. It involves two or more individuals that communicate through a chat-enabled service or software.[4]
Newsletter	A tool used to communicate regularly with your subscribers, delivering the information you want in your email boxes; these messages can contain simple text or a structure composed of images and formatted text.[5]
Documents sharing	The situation in which two or more people use the internet or a piece of software to access a document at the same time.[6]
Publications	The profession or business of producing and selling a book, magazine, or newspaper.[7]

[1] https://www.macmillandictionary.com/dictionary/british/profile_1
[2] https://dictionary.cambridge.org/dictionary/english/forum
[3] https://www.merriam-webster.com/dictionary/matching
[4] https://www.techopedia.com/definition/387/chat
[5] https://blog.e-goi.com/what-is-a-newsletter/
[6] https://dictionary.cambridge.org/dictionary/english/document-sharing
[7] https://dictionary.cambridge.org/dictionary/english/publishing

Resource centre	A place which provides information, equipment and support.[8]
Partnering network	The patterns of interpersonal relations emerging from entrepreneurial activities. In their everyday activities, entrepreneurs get in contact with a variety of other actors, playing important roles in the functioning of their business. EN can be analytically distinguished from interorganizational networks, whose nodes are firms and whose ties are, for instance, interlocking directorates, contracts, goods and services exchanges, communications, alliances, or ownership control relations [15].
Crowdsourcing	The act of outsourcing tasks originally performed inside an organization, or assigned externally in form of a business relationship, to an undefinably large, heterogeneous mass of potential actors. This happens by means of an open call via the Internet for the purpose of free, value creative use. The incentive to participate can be monetary and/or non-monetary in nature [23].
Functionality	The platform's ability to provide users with the necessary tools and resources to achieve their intended objectives [36].
Agile methodology	An approach to software development that involves a collection of practices centered around incremental and iterative development. It emphasizes the values of collaboration, communication, feedback, and adaptation to change.[9]
User dialogue models	"An abstract model that is used to describe the structure of the dialogue between a user and an interactive computer system." [22]

[8] https://www.collinsdictionary.com/dictionary/english/resource-centre
[9] https://agilemanifesto.org/iso/en/manifesto.html

Chapter 11

Authors

Sidra Azmat Butt received a Bachelor's degree in Business Administration in 2015 from the National University of Science and Technology, Pakistan. In 2019, she finished her master's degree in E=governance Services and Technologies from Tallinn University of Technology, Estonia. She then started her PhD in 2019 at Tallinn University of Technology in Estonia. The Ph.D. topic focuses on designing a digital collaborative platform that integrates the quadruple helix actors: the private sector, the public sector, academic institutions, and the end-user. In this research, the end-user is the silver generation (older adults), and the platform is designed using the collective intelligence (CI) framework to facilitate interaction between innovation actors and create specific co-creation and learning environments for generating new innovative solutions to tackle aging challenges and to avail silver economy opportunities. Her research interest focuses on digital transformation, the silver economy, the design and implementation of information systems, and collective intelligence.

Ingrid Pappel is Assoc. Prof. at the Department of Software Science and Vice-Dean for Master's studies at the School of IT, Taltech. Having more than 20 years of experience in different development projects related to e-governance solutions, she is also a head of the Digi-State Technologies and Architecture research group[1] which addresses complexity related to how governments can satisfy the demands of their citizens in times of need. Her research focuses on digital government ecosystems by investigating technologies that support digital transformation. That includes the understanding of architectural needs and the requirements of engineering considering enterprise architecture.

Dirk Draheim received a Diploma in Computer Science from Technische Universität Berlin, Germany, a PhD from Freie Universität Berlin, and a habilitation from Universität Mannheim, Germany. Currently, he is a full professor of information society technology at Tallinn University of Technology and head of the Information Systems Group, at Tallinn University of Technology, Estonia. The Information Systems Group conducts research in large and ultra-large-scale IT systems. Dirk is also an initiator and leader of numerous digital transformation initiatives. Dirk is the author of the Springer books "Business Process Technology", "Semantics of the Probabilistic Typed Lambda Calculus" and "Generalized Jeffrey Conditionalization", and co-author of the Springer book "Form-Oriented Analysis".

[1] https://egov.ee/nextgen-group/

Bibliography

[1] Aarsten, A., Brugali, D., Menga, G.: Patterns for three-tier client/server applications. Proceedings of the IEEE (1996), https://api.semanticscholar.org/CorpusID:9453588

[2] Alsaqqa, S., Sawalha, S., Abdel-Nabi, H.: Agile software development: Methodologies and trends. International Journal of Interactive Mobile Technologies (iJIM) **14**(11), 246–270 (2020). https://doi.org/10.3991/ijim.v14i11.13269

[3] Altunel, P.H.: Agile project management in product life cycle. International Journal of Information Technology Project Management **8**(2), 50–63 (2017). https://doi.org/10.4018/IJITPM.2017040104

[4] Atkinson, C., Draheim, D., Geist, V.: Typed business process specification. In: Proceedings of EDOC'2010 – the 14th IEEE International Enterprise Computing Conference. pp. 69–78. IEEE (2010)

[5] Babar, M.A.: Chapter 1 - Making software architecture and agile approaches work together: Foundations and approaches. In: Babar, M.A., Brown, A.W., Mistrik, I. (eds.) Agile Software Architecture, pp. 1–22. Morgan Kaufmann, Boston (2014). https://doi.org/10.1016/B978-0-12-407772-0.00001-0

[6] Butt, S.A., Draheim, D.: Ethical challenges of ICT for the silver economy. In: Proceeding of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment. pp. 152–155. IEEE (2021)

[7] Butt, S.A., Elhadjamor, E.A., Pappel, I., Õunapuu, E., Draheim, D.: A knowledge map for ICT integration in the silver economy. In: Proceedings of CENTERIS 2020 – the 8th International Conference on Enterprise Information Systems. Procedia Computer Science, vol. 181, pp. 693–701. Elsevier (2020)

[8] Butt, S.A., Lips, S., Sharma, R., Pappel, I., Draheim, D.: Barriers to digital transformation of the silver economy: Challenges to adopting digital skills by the silver generation. In: Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics. vol. 97, pp. 151–163. Springer (2023)

[9] Butt, S.A., Pappel, I., Draheim, D.: Exploring the functionalities and evaluation of the Digital Silver Hub: A collaborative platform for innovative solutions in the silver economy. In: Proceedings of ICEGOV 2023 - the 16th International Conference on Theory and Practice of Electronic Governance. Association for Computing Machinery (2023)

[10] Butt, S.A., Pappel, I., Õunapuu, E.: Potential for increasing the ICT adaption and identifying technology readiness in the silver economy: Case of Estonia. In: Proceedings of EGOSE 2020 – the 7th International Conference on Electronic Governance and Open Society: Challenges in Eurasia. pp. 139–155. Springer International Publishing (2020)

[11] Butt, S.A., Rava, R., Kangilaski, T., Pappel, I., Draheim, D.: Designing a digital collaborative platform for the silver economy: Inception and conceptualization. In: Proceedings of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment. pp. 47–54. IEEE (2021)

[12] Butt, S.A., Suran, S., Pappel, I., Smærup, M., Krimmer, R., Draheim, D.: A digital collaborative platform for the silver economy: Functionalities required by stakeholders in a multinational Baltic Sea Region project. Digital Government: Research and Practice **4**(2), 1–20 (2023). https://doi.org/10.1145/3592618

[13] Cai, Y., Etzkowitz, H.: Theorizing the triple helix model: Past, present, and future. Triple Helix **7**(1), 189–226 (2020)

[14] Carayannis, E., Campbell, D.: Open innovation diplomacy and a 21st century fractal research, education and innovation (FREIE) ecosystem: Building on the quadruple and quintuple helix innovation concepts and the "mode 3" knowledge production system. Journal of the Knowledge Economy **2**(3), 327–372 (2011)

[15] Chiesi, A.M.: Entrepreneurial Networks, pp. 759–763. Springer New York, New York, NY (2018)

[16] Davis, F.D.: Perceived usefulness, perceived ease of use, and user acceptance of Information Technology. MIS Quarterly **13**(3), 319–340 (1989). https://doi.org/10.2307/249008

[17] Draheim, D., Weber, G.: Modeling submit/response style systems with form charts and dialogue constraints. In: On The Move to Meaningful Internet Systems 2003: OTM 2003 Workshops. pp. 267–278. Springer (2003)

[18] Dybå, T., Dingsøyr, T., Moe, N.B.: Agile Project Management, chap. 11. Springer-Verlag (2014)

[19] Factor, M., Meth, K.Z., Naor, D., Satran, J.: Object storage: The future building block for storage systems. In: Local to Global Data Interoperability - Challenges and Technologies, 2005. pp. 119–123. IEEE (2005). https://doi.org/10.1109/LGDI.2005.1612479

[20] Gacek, C., Abd-Allah, A., Clark, B.K., Boehm, B.W.: On the definition of software system architecture. In: Proceedings of the 2009 International Conference on Software Engineering (2009), https://api.semanticscholar.org/CorpusID:7309276

[21] Gordon, C.: A Silver Economy: The Value of Living Longer. SUPA-NZ (2017)

[22] Green, M.: A survey of three dialogue models. ACM Transactions on Graphics **5**(3), 244–275 (1986). https://doi.org/10.1145/24054.24057

[23] Hammon, L., Hippner, H.: Crowdsourcing. Business & Information Systems Engineering **4**(1) (2012). https://doi.org/10.1007/s12599-012-0215-7

[24] Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Quarterly: Management Information Systems **28**(1), 75–105 (2004). https://doi.org/10.2307/25148625

[25] Kistijantoro, A.I., Morgan, G., Shrivastava, S.K., Little, M.C.: Enhancing an application server to support available components. IEEE Transactions on Software Engineering **34**(4), 531–545 (2008). https://doi.org/10.1109/TSE.2008.38

[26] Linz, S., Stula, S.: Demographic change in Europe - An overview. Tech. Rep. Working paper no. 4, Observatory for Sociopolitical Developments in Europe (2010)

[27] Molhanec, M.: Towards an agile project management in product design. In: Proceedings of ISSE 2009 – the 32nd International Spring Seminar on Electronics Technology. pp. 1–4. IEEE (2009). https://doi.org/10.1109/ISSE.2009.5206948

[28] Oussous, A., Benjelloun, F., Ait Lahcen, A., Belfkih, S.: Nosql databases for big data. International Journal of Big Data Intelligence **4**(3), 171–188 (2017). https://doi.org/10.1504/IJBDI.2017.085537

[29] Peffers, K., Tuunanen, T., Rothenberger, M., Chatterjee, S.: A design science research methodology for information systems research. Journal of Management Information Systems **24**(3), 45–77 (2007)

[30] Schuldt, H.: Multi-Tier Architecture, pp. 1862–1865. Springer US, Boston, MA

[31] Schütz, F., Heidingsfelder, M.L., Schraudner, M.: Co-shaping the future in quadruple helix innovation systems: Uncovering public preferences toward participatory research and innovation. She Ji: The Journal of Design, Economics, and Innovation **5**(2), 128–146 (2019). https://doi.org/10.1016/j.sheji.2019.04.002

[32] Sein, M., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action design research. MIS Quarterly **35**(1), 37–56 (2011). https://doi.org/10.2307/23043488

[33] Stare, A.: Agile project management in product development projects. Procedia - Social and Behavioral Sciences **119**, 295–304 (2014). https://doi.org/10.1016/j.sbspro.2014.03.034

[34] Suran, S., Pattanaik, V., Draheim, D.: Frameworks for collective intelligence: A systematic literature review. ACM Computing Surveys **53**(1), 1–36 (2020). https://doi.org/10.1145/3368986

[35] Venkatesh, V., Davis, F.D.: A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management Science **46**(2), 186–204 (2000). https://doi.org/10.1287/mnsc.46.2.186.11926

[36] Yudina, T., Geliskhanov, I.Z.: Features of digital platforms functioning in information-digital economy. In: Proceedings of IOP 2019 – International Conference Series Materials Science and Engineering. p. 012104. IOP Publishing (2019). https://doi.org/10.1088/1757-899X/497/1/012104

Appendix VI

[VI]
Sidra A. Butt, Shweta Suran, Ingrid Pappel, Michael Smærup, Robert Krimmer, and Dirk Draheim. A digital collaborative platform for the silver economy: Functionalities required by stakeholders in a multinational Baltic Sea Region project. *Digital Government: Research and Practice*, 4(2):1–20, 2023

A Digital Collaborative Platform for the Silver Economy: Functionalities Required by Stakeholders in a Multinational Baltic Sea Region Project

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8

This article develops functionalities for a digital collaborative platform, called the Digital Silver Hub, which aims to serve as an ecosystem for the quadruple helix actors (private sector, public sector, academic institutions, and senior citizens) to participate in knowledge exchange, collaboration, and co-creation of innovative technological solutions to facilitate the elderly population. In service of that, we have conducted 30 interviews from the partner heads of an EU-funded project as well as quadruple helix actors from each region in the Baltic Sea Region (Estonia, Latvia, Finland, Lithuania, Denmark, and St. Petersburg) to deeply understand the functionalities that are needed to be offered by the platform. A deductive thematic analysis has been conducted to analyse these functionalities in terms of collective intelligence (CI) components (namely staffing, processes, goals, and motivation) based on a most recent generic CI model. The functionalities were further evaluated by experts working in the field of science and technology in the silver economy. Overall, this article offers insights into the functionalities that are required for a digital collaborative platform to support the elderly population and facilitate co-creation among quadruple helix actors, as well as provides a foundation for future work on designing and implementing such a platform.

CCS Concepts: • **Information systems** → *Social networking sites*; • **Human-centered computing** → *Collaborative and social computing systems and tools*; • **Social and professional topics** → *Seniors;*

Additional Key Words and Phrases: Information and communication technology, collective intelligence, silver economy, digital platform

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1 INTRODUCTION

Improvements in the quality of life in the more developed nations of the world have been responsible for extending the life expectancy of their citizens that in turn has led to a higher ratio of senior citizens amongst the population of these countries [Conway Lenihan et al. 2015]. Based on estimates presented in a United Nations report, 1 of 6 people will be over the age of 65 by the year 2050 [Istudor and Petrescu 2016]. This warrants significant changes that are likely to affect the economic, social, and technological fabric of developed nations such as North America and Europe [Felix 2016].

Both the private and the public sectors as well as academia have been working towards solutions that help enhance the quality of life of the silver generation [Kohlbacher et al. 2015]. The OSIRIS project - 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth'[1] is one such initiative that is part of the myriad efforts streamlined to address the challenges of the ageing population in the Baltic Sea Region (BSR) countries. The BSR countries involved in the project are: Estonia, Latvia, Lithuania, Finland, Denmark and St. Petersburg [Butt et al. 2021]. The project aims to develop a digital collaborative platform referred to as the **Digital Silver Hub (DSH)** to serve as an ecosystem to develop and accelerate the uptake of innovative solutions to the challenges faced by the elderly population to help them live an active and independent life. The platform aims to foster user-centered technological innovations based on the Smart Specialization approach, facilitate interaction between innovation actors, and create specific co-creation and learning environments. Additionally, the platform bridges companies and research organizations to generate new innovative solutions to tackle ageing challenges and involve end-users. The DSH also facilitates knowledge transfer and ensures access to any stakeholder or target group from the BSR. Overall, the rationale behind the DSH is to utilize **Information and Communication Technology (ICT)** to provide viable solutions for the ageing society and improve their quality of life.

In this article, we focus on building the features and functionalities for the DSH, based on the generic **collective intelligence (CI)** model of Suran et al., which will be then evaluated by experts and professionals. The DSH incorporates the participation of the quadruple helix innovation actors (academia, the public sector, the private sector, and end-users (senior citizens)) for the development of ICT innovations. This ensures a collaborative exchange of ideas and solutions to address the emerging needs of the ageing populations of the world [Butt et al. 2021]. However, when the processes do not require the involvement of the elderly but only from the businesses, public sector authorities, and academicians, this trio will be referred to as the "triple helix actors" [Butt et al. 2020]. Nonetheless, this issue of demographic shift requires a systematic approach similar to CI to develop ICT solutions through interconnected processes that are fuelled by input from all the stakeholders involved [Louis 2015].

In Section 2, we provide the literature review as well as the theoretical background of the article. In Section 3, we describe the used research methodology. In Section 4, we present the results of the study. In Section 5, we provide an evaluation of the results with future direction in Section 6. We finish with a conclusion in Section 7.

2 RELATED WORK

2.1 Digital Platforms for the Silver Economy

The silver economy has been identified as a pocket of opportunity and innovation to address the demands of a rapidly ageing global population [Zaidi 2014]. In general, the term silver economy refers to all the products and services related to individuals above 55 years of age [Linz and Stula 2010]. Older age is associated with higher risks of chronic disease, dependability, disability, and a need for assistance. Another integral challenge for the elderly is the need to participate in economic and social activities. It is essential to develop systems to ensure that the needs of the ageing population are met efficiently [Grundy and Murphy 2017]. Technological innovations pertaining to robotics, artificial intelligence, cloud computing, and digital infrastructure can help

[1] OSIRIS - Smart Silver Economy.

facilitate healthy and active ageing as well as independent living solutions for the elderly [Plaza-Hernandez et al. 2021].

There have been quite a lot of initiatives by several public and private bodies to tackle the challenges of the silver economy by involving tech innovations and digital frameworks [Aspridis et al. 2013]. The *Digital Agenda for Europe 2020* by the EU, highlights e-health and ageing as significant areas to develop with special attention to *ageing well with ICT* [Anderberg 2020]. The GRUNDTVIG programme was initiated in 2000 by the EU to support the goal of lifelong learning for the ageing population of Europe. It incorporates all forms and levels of learning; formal, non-formal and informal, especially for senior citizens.[2] The EU's Seventh Framework Programme also promoted projects that relied on ICT applications to provide solutions to older people or those with special needs [Linz and Stula 2010]. OASIS was another noteworthy project by the EU, employing digital technologies for the benefit of the elderly that ended in 2012. It aimed to create an innovative system, with an open reference architecture to provide interoperable utilities of content from various services and ontologies [European Commission 2012].

Several other digital solutions have surfaced that aim to address the demographic shift and the ageing populations. Ojala posits that digital solutions for elderly care are cost efficient and can provide meaningful interaction across the board [Ojala 2021]. He also identified the following three digital services in Finland that are proving to be valuable for the silver economy in Finland:

- Gubbe,[3] founded in 2018, is an online platform for home-care services for the elderly that employs the young and encourages active ageing for the elderly. Through the platform, the elderly can avail the services of a trusted friend or Gubbe who visits them regularly and helps with their day-to-day activities. The Gubbe also keeps the family/relatives updated about the condition of the elderly person through the app.
- VideoVisit[4] is a software that supports remote care for the elderly by incorporating digital visits into their nursing care plans. Nurses can interact with their patients in a virtual setting and remind them of their daily medicine and healthcare routines.
- Fiksari[5] is another technology startup in Finland that aims to make the lives of the elderly more technology fluent. It provides tech assistance services to senior citizens, including keeping in touch with relatives, e-banking and e-health services, and keeps a check on the deals that the elderly get from service providers, which include communicating with relatives, taking care of routine banking or medical services online, and taking a good hard look at the deals an elderly person has bought from service providers.

Many of the digital solutions were developed and tested over the course of the pandemic as it was particularly challenging for the elderly. Bhavani highlights a digital literacy platform in India, *Tech Easy Hai* for the senior citizens, which was launched by Bengaluru-based sisters Shreya and Surbhi Bajaj. In an era of social distancing, they helped more than 9,000 people deal with various components of digital literacy. Most of their students were over the age of 60.

Boll and Brune suggested that an online service integrated with a social network platform can immensely support the elderly in their daily lives. They argued that by merging together the functionalities of an online social network and online services description, retrieval and composition related to healthcare can help improve the lives of elderly in terms of accessing healthcare [Boll and Brune 2016]. Feng et al. proposed a silver tourism digital industry service platform in Chongming based on the Blockchain, Internet of Things, and Big Data [Feng et al. 2021]. Their platform design included various functions such as product customization, marketing, feedback, security, scenic spots introduction, as well as a consumption payment function.

[2] Grundtvig Programme.
[3] Gubbe.
[4] VideoVisit.
[5] Fiksari.

Social isolation is a major challenge for the elderly to overcome as they age [Boll and Brune 2016]. According to Smith, Nesta's Challenge Prize Centre and AAL Programme collaborated for a Smart Ageing Prize, to encourage tech-based solutions to improve the social lives of older people and foster their well being [Smith 2018]. Some of the start-up ideas selected as the semi finalists for the prize from various participating regions are as follows:

- EUPHORIA, Greece: This digital platform was co-designed by Active Third Age leisure travelers being the primary users of the platform. It supported social interaction by motivating them to stay active longer.
- Internet of Supporting Things, United Kingdom: It is a digital tool including step-by-step video guides for those with memory loss to help them socialize and work independently.
- KeepSocial, Greece: This platform incorporates smart tracking hardware to identify the location and direction of sight of individuals in indoor settings.
- KOMP, Norway: This is a digital one button computer that supports photo sharing, messages and video calls amongst multiple generations.
- Life-Manager, Denmark: This tool helps optimize caregivers' planning and resources while facilitating contact with family for individuals in need of care.
- Link-ages, United Kingdom: This is another learning app suite for the elderly that supports learning about online communication and staying in touch with family using digital tools.
- MijnBuurtagenda, Netherlands: This is another application to help the elderly live an independent and happy life by being socially active in their neighborhood communities.
- PlaceCal, United Kingdom: It is a partnership of several stakeholders of the silver economy such as community organizations, public services, social housing providers, healthcare services, and citizens to generate and utilize community data for better connected neighborhoods.
- Silverskills, Switzerland: This digital platform helps build the self esteem of older individuals by providing them opportunities to volunteer for skill-based activities. It brings together people looking for these skills with the elderly who can provide these skills [Smith 2018].

Hence, developing the silver economy can help generate new jobs for all working age groups and the most important step to involve senior citizens in this economy is by providing them social mobility. Compared to other platforms, DSH stands out for its focus on collaboration and multidisciplinary problem-solving. While other platforms may focus on specific aspects of the silver economy, such as healthcare or social networks, DSH takes a comprehensive approach by bringing together experts from a range of fields to develop holistic solutions such as networking opportunities, digital skills training, funding opportunities, and support for startups and SMEs. Additionally, the DSH provides a comprehensive database of resources that can be used by researchers, policymakers, and businesses to inform their work.

2.2 Generic Collective Intelligence Model

Collective Intelligence has been a part of scientific discussions ever since Condorcet's jury theorem [Landemore and Elster 2012]. Since this era, CI applications and related concepts such as crowdsourcing, open innovation, and collective behaviour [Mulgan 2018] have expanded throughout a broad range of research fields, organizations, and management. CI platforms are used for problem-solving, decision making, prediction, and information exchange that benefit both society and individuals [Malone and Bernstein 2015; Malone and Klein 2007]. The progression in ICT technologies and the social web has enabled mass collaboration [Segaran 2007] and led to novel CI platforms such Wikipedia, Climate CoLab (to solve global climate issues), Tippanee [Pattanaik et al. 2019] (to annotate the new content on the web), InnoCentive [Malone and Bernstein 2015] (to tackle societal issues), and Reddit [Weninger 2014] (sharing of passions and interests). Researchers have proposed many CI models such as the "genome model" [Malone et al. 2009], "a new model for CI in organizations" [Boder 2006], and the "resource allocation framework for CI system engineering" [Vergados et al. 2010]; unfortunately, these

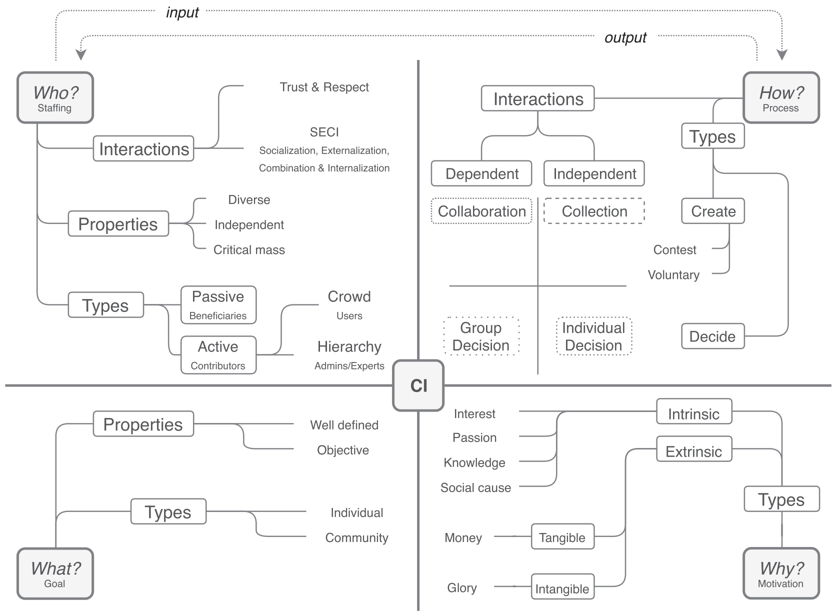

Fig. 1. "Generic" CI model of Suran et al.

models are domain specific or use-case specific [Suran et al. 2019] and also explained using different metaphors such as "genes, system-specific elements, principles, attributes, requirements, or their combinations" [Suran et al. 2020, 2019]. To overcome these problems, Suran et al. proposed a generic CI framework (see Figure 1) that allows for combining different components of the model to develop new CI platforms more effectively and efficiently. The CI model is based on four components (sub-divided into types, properties, and interactions):

- Staffing (who is performing the task?): Based on their roles and responsibilities, the users of a CI platform can be divided into *contributors* and *beneficiaries*. Contributors use their knowledge and expertise to solve problems. They can be further categorized as belonging to the *hierarchy* or the *crowd*. The members of a hierarchy are mainly experts who manage work allocation, whereas members of the crowd actively contribute new artefacts and information. There are some key properties of the crowd. Its members should have diverse backgrounds, i.e., different cultures, economic, and social backgrounds; the users should be independent of each other, i.e., they should not influence each others' opinions. Furtermore, the crowd should have a "critical mass." Last, the members of the crowd should trust and respect each other to promote co-creation of knowledge.
- Goals (what is being accomplished?): Goals can be categorized as *individual goals* and *community goals*. Goals should be *objective* and *well defined*.
- Processes (how is it being done?): Processes are categorized via types (*create* vs. *decide*) and interactions (*dependent* vs. *independent*). Combining these categories, processes can be classified as *collection*, *collaboration*, *group decisions*, and *individual decisions*. Collection stands for independent activities, where an individual innovates solutions without being member of a community. In group tasks, however, individuals come together on the platform to create new knowledge and solutions.

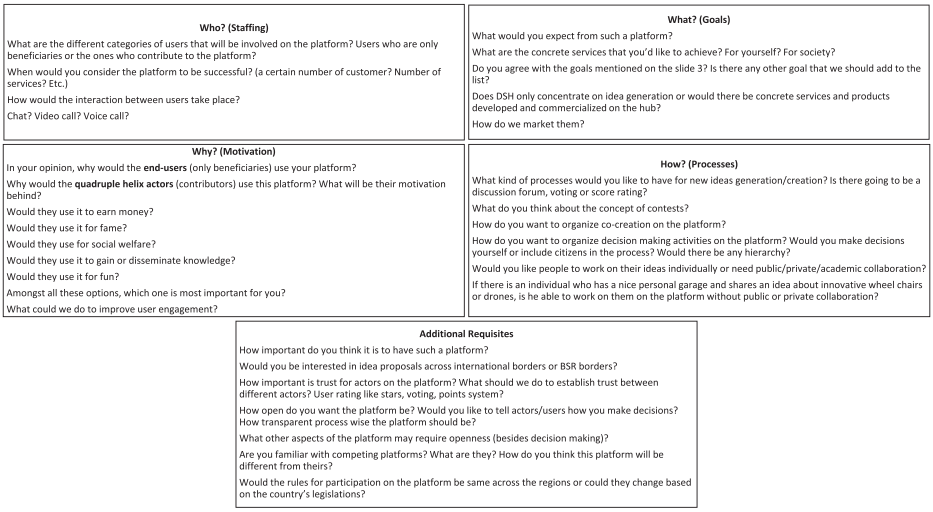

Fig. 2. Interview questions.

- Motivation (why they are doing it?): *Intrinsic motivations* (*passion*, *interest*, gaining *knowledge*, and *social cause* encourage users to develop themselves or to collaborate for the betterment of the society. *Extrinsic motivations* encourage users to contribute in chance of obtaining *tangible* or *intangible* incentives.

3 METHODOLOGY

This article aims at devising the functionalities for a digital collaborative platform built to facilitate independent living for the elderly population of the BSR and therefore employs a qualitative research methodology. Mohajan explained qualitative research as a type of social science research that seeks to interpret meaning from non-numerical data that helps us to make sense of social phenomenon through the study of targeted populations or places [Mohajan 2018]. Such qualitative approaches undertake a comprehensive and in-depth outlook to analyze the situation at hand from various perspectives. A primary feature of this method is its flexibility to incorporate varying "world-views" of the actors involved.[6] Bryman associated qualitative research with "participant observation, semi- and unstructured interviewing, focus groups, the qualitative examination of texts, and various language-based techniques like conversation and discourse analysis" [Bryman 2017].

For this research, we have conducted 30 interviews from quadruple helix actors (from businesses, academia, government, and senior citizens) as well as the project heads of the OSIRIS project, representing BSR countries (Estonia, Finland, Latvia, Lithuania, Denmark, and St. Petersburg). Interview participants' roles and organizations are listed in Table 1. The interviews were conducted online via Zoom in July 2021, and each lasted on average 45 min. The interview approach was semi-structured, consisting of a predetermined set of questions based on the generic CI model of Suran et al., allowing the interviewees to expand on their responses (see Figure 2). All interviews were transcribed, and we conducted a tool-based thematic analysis [Braun and Clarke 2012] with the help of NVIVO [Jackson and Bazeley 2019], where we were following the analysis process suggested by

[6] Taylor & Francis Group.

Table 1. Interview Participants' Roles and Organizations

Role	Organization
Head of Project department	Klaipėda State University of Applied Sciences
Sales Manager	IAMUS-Innovative IoT Software
National Contact Point	Agency for Science, Innovation and Technology
Associate professor	Klaipėda State University of Applied Sciences
Senior Citizen	
Project Manager	Center for Assisted Living Technology
Chief Executive Officer	Kanda
PhD and Associate Professor	VIA University College
Special Advisor	Aarhus Kommune
Senior Citizen	
Principal Research Scientist	Häme University of Applied Sciences
Chief Executive Officer	Asv Arctic Smart Village Oy
Principal Research Scientist	Häme University of Applied Sciences
Senior Advisor, Regional Development	Hämeen liitto/Regional Council of Häme
Senior Citizen	
Member of Social Enterprise Commission	Ministry of Welfare of Latvia
Deputy Chairman	Rīgas Uzņēmēju Biedrība
Rector	Ventspils University of Applied Sciences
Rector	Transport and Telecommunication Institute
Senior Citizen	
Head of International Programs	ITMO University
Business Incubator Ingria	JSC St. Petersburg Technopark
Social Psychologist	ITMO University
Senior Researcher	Tsentr Razvitiya Negosudarstvennykh
Senior Citizen	
Project Assistant	Next Gen Digital State Research Group, Taltech
Founder, CEO, Head of Product	EnLife OÜ
Researcher	Tallinn University of Technology
Advisor in Employment Affairs	Ministry of Social Affairs
Senior Citizen	

Braun et al. In our analysis, we followed a deductive approach [Braun and Clarke 2012], drawing themes from the concepts of the utilized generic CI model of Suran et al.

4 RESULTS

The DSH is currently in the system design phase, and the CI model provides a strong foundation for effective functionalities. Several codes were identified (see Figure 3) and categorized into the following themes: (i) staffing, (ii) goals, (iii) processes, (iv) motivation, and (v) additional requisites.

4.1 Staffing

For any platform to run effectively, staffing is an important consideration, as it determines the *who* dimension that includes the individuals and groups that are directly or indirectly involved in the activities executed on the platform. The key actors are the project heads, as they are paramount in determining the resources required to

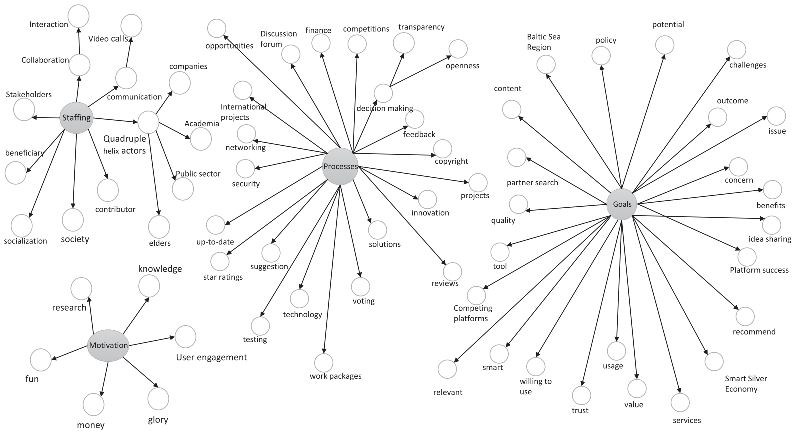

Fig. 3. Thematic map.

create, operate, manage, and utilize the platform. Given that, several other stakeholders participate in the project referred to as the quadruple helix actors that ensure that the platform is used for the intended purpose and that goals are successfully achieved and executed.

All interviewees were questioned about their willingness to use the DSH, and almost all of them acknowledged the utility of the platform and confirmed their readiness to use and participate in its functionalities. The public sector authority representative from Finland mentioned:

> *. . . there are more and more elderly people in our region. And there is a need for developing better services. It would be very good to have a platform that would provide information for the funding opportunities, seeking partners, already existing services, and for developing innovations.* (1)

However, a few interviewees also highlighted that they would only be willing to use the platform if it serves a specific purpose of their business. However, the majority of the senior citizens were very delighted by the idea of a platform that was focused on their well-being and looked forward to its inception.

The triple helix actors were very interested in playing their roles as both contributors and beneficiaries of the ecosystem created through the DSH. The majority of the senior citizens were also very ecstatic about contributing to the platform and being part of the innovation processes as the representative of senior citizens from Latvia mentioned; "I can do mentorship for maybe one to two hours per month on a social basis as my social input." However, a few of the senior citizens appeared reluctant to comprehend their part as contributors to the platform, though they did not seem to mind using it for their benefit. The representatives belonging to the academic sector were interested in both using and contributing to the DSH for their research, testing products, sharing their ideas, receiving feedback and finding partners.

According to the responses from the interviews, the areas where stakeholders were willing to contribute were idea sharing, providing feedback, testing ideas and services, discussion forums, training/mentoring, market researching, and updating/sharing information on new events and innovations.

Another consideration regarding the staffing and possible options for contributors and beneficiaries of the DSH is determining the success of the ecosystem. Measurement of success for any platform eventually becomes its **Key Performance Indicators (KPIs)**, which should be determined and tracked to be able to provide value

Table 2. Number of Votes for Each Medium of Communication

Medium	No. of Votes
Chat	6
Voice call	4
Video call	2
Combination of all three	6
Integrated system (Zoom, Skype, etc.)	11
No socialization	1

to platform users. While some recommended gauging the success of the platform based on its number of users, others put forward the notion of determining the capacity of the platform to push a certain number of innovations in the market for the ageing population. As one interviewee suggested, "it is not about having a lot of users registered, but to have active users." A senior citizen said that he would consider the platform successful if it became a part of his everyday life just like Facebook. The success of the platform meant different things for different innovation actors. While one interviewee thought that "1,000 unique visitors every day" should be the critical mass for the success of the platform, another one suggested a focus on "active elders." As the revenue generation is not directly involved, determining platform KPIs is not straightforward; however, according to the responses from the interviews, the main KPIs identified are as follows:

- Newly published content per month
- Number of onboarded users per month
- Degree of user-friendliness
- Activity on the platform per day
- Number of innovative ideas/solutions
- Number of reported defects
- Number of reported user errors
- Users' attitude to published content

Interaction and socialization are imperative between actors to enable knowledge creation on the platform. For a smooth flow of knowledge, it is important that actors trust each other's abilities and treat each other with respect. Organizational knowledge is a combination of tacit and explicit knowledge, therefore the Socialization, Externalization, Combination, and Internalization dimensions from Nonaka and Takeuchi's model were used to promote sustainable innovation and enable competency development in actors on the platform. When interviewees were asked if they will be willing to socialize with other innovation actors or senior citizens, the majority of them showed immense interest and found it to be necessary for the platform's success. Interviewees highlighted the fact that this platform can serve as a very useful intermediary for different stakeholders to find people from the same field and collaborate using the different communication mediums. Moreover, this platform can be helpful especially for academicians working on the silver economy to find their target group for research.

Having said this, it is also important to identify the medium of interaction that is most efficient and suitable for such an innovation platform to function. There was a mixed response from the interviewees regarding the socialization function of the platform. Some of them considered it a good idea to include the chat function and video call options to socialize through the DSH. One interviewee even expressed his preference for video calls over the chat function due to the personal nature of it. However, a considerable number of interviewees thought that these services were already being provided by many other platforms and applications. Academia representative from Estonia stated, "like, nowadays, we have MS Teams, Zoom and Skype; maybe there is no need for special, inbuilt video/chat systems." Table 2 summarizes the responses from interviewees into a number of votes against each medium.

4.2 Goals

According to the generic CI model of Suran et al., it is important to identify accomplishments and desired results bound to objectives in a given time frame. During the first phases of the research, a list of goals was identified and

Table 3. Existing Services for Elderly in BSR

Region	Existing projects
Finland	AGE platform Europe; ACTIVAGE Project; This is Finland; Agingcare.com; Axxess
Estonia	Caremate; CARMA; EUROcarers; Tallinn.ee; Estonian Chamber of Disabled People
Latvia	Carer+; Riga Active Seniors Alliance
Lithuania	Fabijoniškės Social Service Home; Lithuania – Long-term care
Denmark	Danish Assistive Technology Database; Danish.Care; Danish Life Science Cluster

a majority of the interviewees agreed that these goals matched their expectations regarding the DSH. According to them, the major goals revolved around providing innovative solutions for the silver generation in the BSR countries, fostering a collaborative knowledge exchange across the innovation actors, knowledge sharing, and the generation of feedback through the involvement of the end-users of the platform.

Given these aims, interviewees were asked what they expected from the platform in terms of the eventual outcome. Various innovation actors had differing opinions related to the main focus of the hub. One of the partner heads stated that the DSH would just be concentrating on developing new ideas. Another candidate explained,

> *. . . it'll bring together companies and research organizations for generating new innovative solutions. There would be debates regarding funding schemes in order to respond to these innovation ecosystem needs. It will also facilitate knowledge transfer. You could share your ideas and, if you have a certain idea, you and your business organization can look for an academic person to help you with research.* (2)

An academia representative from Lithuania mentioned that this platform could serve as a one-stop-shop for all the information related to the elderly and serve as a repository for all the available services in the market targeted to the silver economy. While the business representative from Latvia perceived that the platform would serve as a hub where new ideas will be worked on by different teams across different borders.

Interviewees from all helixes had some ideas about the concrete services that the DSH should provide not only for an individual but also for the community. The senior citizen representative from Denmark mentioned that the "platform should provide information about healthcare and legislation, as in what are your rights and what way to go if one needs help." Most of the actors from the business, public sector, and academia helixes were interested in services where they could conduct their research, test their findings, collaborate, and partner search for team building for innovative solutions that will eventually be targeted to the elderly people and contribute to the overall society.

The policymaker from Estonia explained that they are interested in trying to understand the system of labour market services, specifically services that fit the needs of middle-aged and older people. The focus is to try to help the unemployed or people at the high risk of unemployment. It is already evident that the biggest challenge this target group faces are outdated skills but tackling this problem means getting them to participate in skill-building to find employment or suitable skills to help them remain on their employment. He mentioned that

> *. . . if there are initiatives on the DSH that managed to overcome this, for instance from the labour market training perspective, have good training and skill-building workshops, it will be highly valuable.* (3)

A majority of the interviewees admitted that they had not used a similar platform before. However, a few partner heads, researchers, and policymakers had been involved in related projects that were not transnational yet supported some kind of collaborative efforts from the participants and users for idea generation and knowledge sharing (see Table 3).

4.3 Processes

The third theme generated through the qualitative analysis of the interview data is the processes that govern the development, operations, and management of the DSH. Understanding these processes provides insight into the nature of the DSH through the CI framework. The proposed model describes CI processes as types of activities (create/decide) and interactions (dependent/independent). From the data gathered from the interviews as well as previous workshops, it is evident that the DSH serves as a platform that aims to enhance the generation of new and innovative ideas through co-creation and collaboration *(create)*. These ideas are then further enhanced by other innovation actors and/or experts who express their opinion in terms of likes/dislikes, loopholes, feasibility, and other factors *(decide)*.

When interviewees were asked if they would be willing to share their ideas with other innovation actors, the majority of them agreed; however, they pointed out that the platform should provide protection and patent rights to their ideas so that they are not copied by others in the market. An academic representative from Denmark said the following:

> *I would be a little afraid of sharing ideas as I have to be pretty sure that my idea or service will not be copied. But if there is copyright or if your ideas are protected, then I would be willing to share it. I would find it quite beneficial to work together with other innovation actors because I see a lot of potential in the whole idea of this project.* (4)

This portrays *Collection* (i.e., create plus independent), whereby actors contribute their independent work to the system. In addition to this, interviewees were asked if they do agree to share their ideas on the platform, would they be willing to work on the idea themselves after they have received their feedback or would they like to collaborate with other innovation actors and co-create? There was a ratio of 4:1 who agreed to *collaborate* (i.e., create plus dependent) instead of independently working on their ideas as the academic representative from Latvia expressed, “collaboration is the key for successful development of innovative solutions.”

Although generating and sharing innovative ideas has emerged as an important function of the platform, there is a need to determine the process of how these ideas will be shared and further developed. The data from the interviews suggest that several methods could be employed to choose the best ideas. However, one of the interviewees mentioned that it was an “open innovation platform” where nobody was forced to share or implement their ideas. There are no hierarchies for decision-making, as this would be an open ecosystem where all the stakeholders come together to co-create, test, and maybe fund their innovative ideas.

A practical solution that emerged through the interview data was the possibility of discussion forums, votes, and contests. While looking for ways to foster creativity and settle conflicting ideas amongst the quadruple helix, an interesting example surfaced pertaining to a T-shirt company, Threadless,[7] that organizes virtual contests, asking people to submit T-shirt designs related to a certain theme. Voting takes place on their website, where the best designs are chosen based on the number of votes and score ratings for each design. Interviewees were optimistic that a similar approach could be applied to the DSH to generate new ideas, choose the best ideas, and encourage participation from the quadruple helix, as experts from different fields could judge according to their expertise. However, it was also mentioned that despite the ideas of voting and score rating, it is also imperative to add a comment section and further enhance the idea by taking it to the discussion forum as the business representative from Denmark suggested, “that depends on what we are evaluating, so if you have a logo or sign design or subjectively relevant, I think voting is perfectly fine. Because it is very quick to get an intuitive understanding—you either like it or you don’t. Whereas, for example, what is the best wheelchair might require a little bit more detail with all the specifications and details, and with the innovative ideas, it is always best to have discussions and critical debates.”

[7] Threadless.

While most of the candidates were willing to participate in score rating, voting, and discussion forums to resolve the conflict of ideas and identify the best ones, some were reluctant to give input in matters they thought they did not have *expertise* in. A majority of the end-users or the senior citizens wanted to pitch in their opinions and feedback on services and products that concerned them, but a few did not seem very excited about the possibility of discussion forums and votes. There were also concerns amongst some candidates regarding the relevance of the people participating in the voting and discussion forums to the product/service/idea in question. An interviewee implied that a large number of people in one region cannot make good decisions about products or services that would be most suitable for another region. The end-users, the researchers, and the private and public sectors all would have to come together and collaborate for knowledge creation and decision making.

Gamification has been emerging as a successful strategy to encourage user engagement with a product/service [Bitrián et al. 2021]. Keeping this in mind, interviewees were asked if they would be willing to participate in different contests or competitions on the platform and, surprisingly, the majority of them, including the senior citizens, were very enthusiastic about it. An academic representative from Finland stated the following:

> . . . *all kinds of competitions, they are quite good hooks for the hubs, so that if people have a chance to win something and even if it is some small prize, there is a high probability that they will come back. If the DSH conducts such competitions frequently, for example, once a month then it will help to grow the user base.* (5)

A majority of the interviewees seemed to endorse a democratic decision-making process [group decision (i.e., decide plus dependent)], eliminating the need for bureaucratic hierarchies. However, one of the interviewees highlighted the significance of experts and informed decisions. He suggested that "decisions might be made, not by a majority of laymen, but by qualified people; not delegated by others but by real experts where we will be able to make qualified decisions." The decision-making process was very well described by the lead partner head from Finland, as she explained that whatever information is on the platform should be accessible for everyone depending on what role they choose. Basically, it should be open and with open access comes the risk of losing information or giving out too much information. In this case, platform users will be trusted that they will make wise decisions and move their discussions to more private facilities when discussing intricate details. Another significant factor that was brought to notice by the majority of the quadruple helix actors was trust. They pointed out that people and businesses will willingly share their ideas for discussion and feedback only if they have trust in the platform. While innovation centres and researches related to the silver economy might be operating separately in different regions, a platform that brought together the BSR countries through collaboration would require sufficient efforts to build its credibility.

4.4 Motivation

This theme tends to investigate and understand the motive behind stakeholder engagement and usage of the DSH. To develop a platform that facilitates transnational knowledge sharing and co-creation for the lifestyle improvement of the silver generation, it is imperative to comprehend the motives each innovation actor has behind engaging with the platform.

Since the research aims to include multiple stakeholders and innovation actors, each actor of the helix may have varying reasons behind their involvement with the platform. It is important to understand here that the senior citizens are the ultimate end-users of the innovative services and products listed on the DSH, while all four of the quadruple helix actors are the users of the DSH. One of the main aims of the DSH is to provide opportunities for the silver generation to improve the quality of their everyday life. To shed light on why the users would use the platform in the first place, the data suggest that most of them were interested in the knowledge dissemination function. Some wanted to share their experiences and ideas with others for the overall well-being of society, while others wanted to help maintain their own self-esteem and feel like contributing members of society. A few also displayed an inclination toward the financial benefits of sharing their knowledge and experience through the digital space.

Almost all of the quadruple helix and the partner heads identified dissemination of knowledge as a chief motivator for them. However, the private sector also considered money and profits as a very convincing reason for them to show interest in the DSH. An interviewee even declared that you need to make money to keep things running and that without generating profits/revenues, it would be difficult to achieve sustainability for the platform.

To attract a user base and encourage participation on the DSH, extrinsic motivational factors were considered more valuable as the majority of interviewees claimed that they will be more willing to contribute if they know that this platform will provide them with some kind of reward. Tangible and/or intangible rewards, both were chosen over social welfare.

The academic representative from Finland stated,

> *It would save my time and effort for finding information related to the silver economy on this hub. I think that some people may have already covered the relevant information so that I do not have to do it myself anymore. In this position where I am now, it would be to gain and disseminate knowledge, but if I would get an opportunity to earn money, that's also good, however, not so much for social welfare.* (6)

The interviewees were also asked about what should be done to ensure that the platform engages them for a longer period and keeps them coming back to the platform. It is very important for any CI platform's success that it encourages participation and users' active involvement; however, not all platforms can do so. It was identified that several factors can impact such engagement levels such as the onboarding process optimization, customer support, regular updates, new content, feedback collection, and convenient user interface. One of the interviewees suggested that he was interested in the content, interesting solutions, other people's achievements, and success stories. The senior citizens were more concerned about the user-friendliness of the platform. One of them agreed that he would continue using the platform if "it is working, if it is easy, if it is convenient, sort of efficient, offers an easy way to do things, and gets the answers I am searching for." A senior citizen from Lithuania also said, "the user interface if it is interactive, it is attractive. It is interesting. That is something that would always encourage me to come back." However, the public sector authority representative from Denmark suggested that if the quality of the outcome is up to the mark and if desired results were achieved from the DSH, then user engagement will not be a problem.

4.5 Additional Requisites

It has already been established that idea generation and knowledge sharing are amongst the most important aims of the platform. Hence, it is important to investigate whether the platform users, contributors and beneficiaries, would be interested in ideas generated elsewhere in the world. A vast majority of the interviewees did not have any hesitation in accepting ideas from countries beyond the BSR. But a few of the policymakers identified a need to establish laws and procedures pertaining to such knowledge exchange such as security protocol and copyrights.

The Project partner heads were also concerned about the decision-making process and ways to establish trust amongst the users. Some suggested the use of ratings or review systems to ensure transparency and credibility. Although it has already been established that the platform would be employing an open innovation system, there were some reservations amongst interviewees related to the degree of openness and transparency.

The business partners were also concerned about the financial mechanism and the marketing functionalities of the system, as the DSH would serve as a platform for collaboration and co-creation for innovative solutions, most of the interviewees were concerned about how the funding will take place. Government, incubation centres, and private sectors (sponsorship) should be interested in financing such a platform, and we use an example

Table 4. Expert Names with Their Roles and Organizations

Expert Name	Role	Organization
Leena Lemola	Project Manager	Riihimäki Business Development Company
Eglė Brezgytė	Head of Project department	Klaipėda State University of Applied Sciences
Taivo kangilaski	Senior Researcher	Laboratory for Proactive Technologies
Michael Smærup	PhD and Associate Professor	VIA University College
Marina Weck	Principal Research Scientist	Häme University of Applied Sciences
Kirsten Maibom	Research Manager	Research Centre in Health and Welfare Tecnology
Egils Rupeks	Member of Social Enterprise Commission	Ministry of Welfare of Latvia
Søren Aalykke	Project Manager	Center for Assisted Living Technology
Erik kangilaski	Software Developer	Tallinn University of Technology
Syed H. Hassan	Financial Crime Investigator	Wise PLC

from Lithuania: GovTech Lab[8] seeks to solve societal challenges using technology. It is powered by the Agency for Science, Innovation and Technology and has received funding from the European Regional Development Fund. Other official partners include the Ministry of the Economy and Innovation of the Republic of Lithuania, Lithuanian Airport, Regulatory Authority of the Republic of Lithuania, Statistics Lithuania, Vilnius Sveikiau, Ministry of Social Security and Labour, and many more.

5 EVALUATION AND DISCUSSION

The identified functionalities from the thematic analysis were validated by experts to analyse which functionalities are the best fit to achieve the desired objectives of the DSH. Therefore, several experts were approached working in different fields of technology and science targeted to the silver economy (see Table 4). These experts also served in the expert committee to the OSIRIS project for requirement evaluation and prototype testing. Evaluation of the functionalities was gathered using an evaluation form whereby they had to go through each feature and they could agree/disagree and also state the reason for their preference. Building on the aforementioned motivations, this section highlights the main functionalities and their evaluation from the experts that is then further translated to an illustration of the components of the DSH using the Generic CI model in Figure 4.

The DSH functionalities are developed based on the generic CI model of Suran et al., which means that an environment has to be conditioned to enable quadruple helix actors (who) to develop innovative ideas and solutions (what) with the help of resources and knowledge exchange and co-creation techniques (how) to help the elderly live an independent and active life (why).

5.1 The "Who" Dimension

The key actors on the platform are stakeholders and innovation actors. At the beginning of the project, it was considered that all stakeholders, including the partner heads, will contribute as well as benefit from the DSH to ensure sustainability of the system. Through the interview responses and expert evaluations, it was revealed that the role of project heads in the implementation of the platform is limited. Instead, the responsibility of ensuring that the platform is effectively used for its intended purpose falls on the quadruple helix actors, including private sector representatives, academicians, policymakers, and senior citizens. While private sector representatives and academicians may use the platform for investing, research, collaboration, and partner search, policymakers are among the most important users of the platform. As representatives of the public sector and government, they can use the platform to deliver public value to the community and engage the elderly population. By collaborating with other actors such as academicians, they can identify shortcomings in the current system and gaps in the market that, if fulfilled, can benefit the elderly population. Therefore, policymakers play a crucial role in ensuring

[8] GovTech Lab.

the success of the platform and delivering maximum benefits to the intended beneficiaries. However, the majority of senior citizens may be reluctant to comprehend their part as contributors to the platform, though they would not seem to mind using it for their benefit. However, the senior citizens may not perceive DSH as directly useful to them but they are very important for all the other helixes and their representative. Therefore, they need to be convinced to participate in some manner as consultants on senior needs. On the contrary, in some regions such as Finland, senior citizens are very active and are willing to use the platform in providing own contribution to the development of innovative solutions.

There are several areas where actors can participate and contribute to the platform. As mentioned in (1), it can be in the form of sharing innovative ideas and discussing their feasibility. An innovation actor may use the platform to discuss the idea, gain feedback, and search for partners for joint collaboration. The DSH can also be used to organize training/mentoring programs not only to educate about the changing technology to innovation actors but also to create technology readiness amongst the elderly. Information on these training programs, along with other events and innovations have to be updated and shared on the platform. Other areas where stakeholder can contribute is to give new perspectives to the discussions; to share the end users' perspectives and needs; to market innovations, services, and products for other platform members; and to provide networks to larger companies that might be interested in purchasing or cooperating with smaller companies or innovators.

It is also important to identify KPIs for any platform to gauge success and to ensure that the objectives are being met. According to the expert evaluation, the number of loyal users should be the main KPI as they determine most of the activity on the platform and keep it running. Moreover, new content has to be published and kept updated. The example of Facebook came forward, as it attracts its users and retains them by keeping its newsfeed fresh and crisp.

The majority of interviewees are willing to socialize with other innovation actors or senior citizens on the platform and find it to be necessary for the platform's success. However, according to the experts' evaluation, socialization in isolation may not have any value unless it is translated into collaboration in innovation and business development. Moreover, it was also highlighted that there might be a problem of such "cross-helix" communication, given the different backgrounds of users and a more inclusive approach has to be put into practice, which may require further research and understanding. The medium of communication also plays an important role in making users comfortable with socialization. According to thematic analysis results, integrated systems like Zoom/Skype/Teams may play a vital role in ensuring smooth interaction between the innovation actors; however, according to the experts, inbuilt chat systems should also enable instant interaction with convenience. It was also suggested that the social media platforms like LinkedIn and Facebook should also be merged to channel networking and build public relations. Chatting is preferred over video and voice calls, because it allows stakeholders to keep their privacy intact to some extent. The only problem is that if the communication is on a transnational level, some senior citizens do not trust themselves to participate in English.

5.2 The "What" Dimension

The goals of the DSH are set by project heads and quadruple helix actors at different workshops in the earlier stages of research, and therefore, it was necessary to enquire from the quadruple helix actors from BSR about their own views of the outcome of the DSH to ensure that their expectations meet the goals. The main expectations from the platform identified were building innovative solutions to the problems faced by the elderly people in their everyday life and also enhancing knowledge transfer and exchange amongst the innovation actors. Moreover, the DSH provides an opportunity to build cooperation and collaborations between not only different actors from the different helixes but also from different countries in the BSR. The triple helix were interested in services where they could conduct their research, test their findings, collaborate, and partner search for team-building for innovative solutions that will eventually be targeted to the elderly people and contribute to the overall society.

5.3 The "How" Dimension

The DSH would serve as an ecosystem where innovative solutions are not only developed but also discussed, criticized, tested, and also open for collaboration. With an open innovation approach, ideas are shared with all and/or chosen stakeholders at the platform, and therefore, patent rights have to be provided to protect their ideas from being copied in the market. However, with such open innovation development, it is also imperative for the innovation actors to understand the risks and be aware of their own rights. Nonetheless, the platform will be able to achieve its objectives and goals if an environment of trust has been established. Stakeholders need to feel protected to be able to share and work on their ideas on the DSH, and therefore, patenting and copyrights have to be thoroughly incorporated.

As it is an open innovation platform, there will be a democratic structure with no hierarchies for decision making; instead, everyone will be trusted to make the right decisions for themselves and act responsibly on the platform. Such an open ecosystem usually allows more creativity and ingenuity [Suran et al. 2022]. But when there are so many ideas, how can one decide which is better than the other? It is, therefore, necessary to have a system to foster inspiration, settle a dispute, or choose the best ideas. It was recognized that when someone has an innovative idea, a proposal, or a visual display to present on the DSH, other experts and innovation actors can vote or score rate them as the famous quote says, "Majority is authority." Since technological solutions are more complicated and need more in-depth reviews, it is also imperative to add a comment section alongside it to be able to add detailed comments and also, if possible, further enhance the idea by taking it to the discussion forum. Furthermore, to attract new users or to encourage the existing users to let their creative juices flow and come up with innovative ideas, the expert evaluation also agreed that the contests should be held. These contests intrigue an element of competition and lay a positive impact on the process of idea generation. Winners can be awarded with a reasonable amount of cash or a gift card. According to the experts' evaluation, senior citizens would also like to participate in the contests as they have time and resources and they want to be involved in community activities and product and service developments for themselves and feel useful for the society.

5.4 The "Why" Dimension

Stakeholders and innovation actors need the motivation to participate on the platform and contribute to the development of innovative solutions for elderly people. It has been identified that extrinsic motivation factors play an important role in driving their behaviour. External rewards, including tangible rewards, such as money, and intangible rewards, such as fame, can prove to be very beneficial in encouraging the actors to make their contributions. Although intrinsic factors like social welfare cannot be completely ignored, these factors may play a part in motivating the innovation actors to invest their efforts and help DSH achieve its objectives. For the elderly, there are a number of benefits that DSH would offer that may encourage them to participate on the hub. By involving them in the innovation development process, the elderly can feel significant and included in the creation of products and services that meet their needs. This sense of involvement and accomplishment can boost their confidence and overall well-being. Furthermore, the DSH can also help combat social isolation and loneliness by connecting the elderly with innovation actors at different stages of innovation development. This can create opportunities for social interaction and community building, which can enhance their quality of life. In addition to facilitating innovation, the DSH will also serve as a repository for existing services targeted at the elderly. This will provide them with a convenient and centralized platform for accessing these services online rather than having to search for them on various websites. Moreover, the DSH can provide educational resources and training programs that are tailored to the needs of the elderly. This can help them acquire new skills and knowledge, which can lead to new opportunities and greater independence. Finally, the DSH can also provide access to assistive technologies and tools that can enhance the quality of life for the elderly. For example, it can provide access to health and wellness tools, communication and socialization platforms, and mobility aids, among other things.

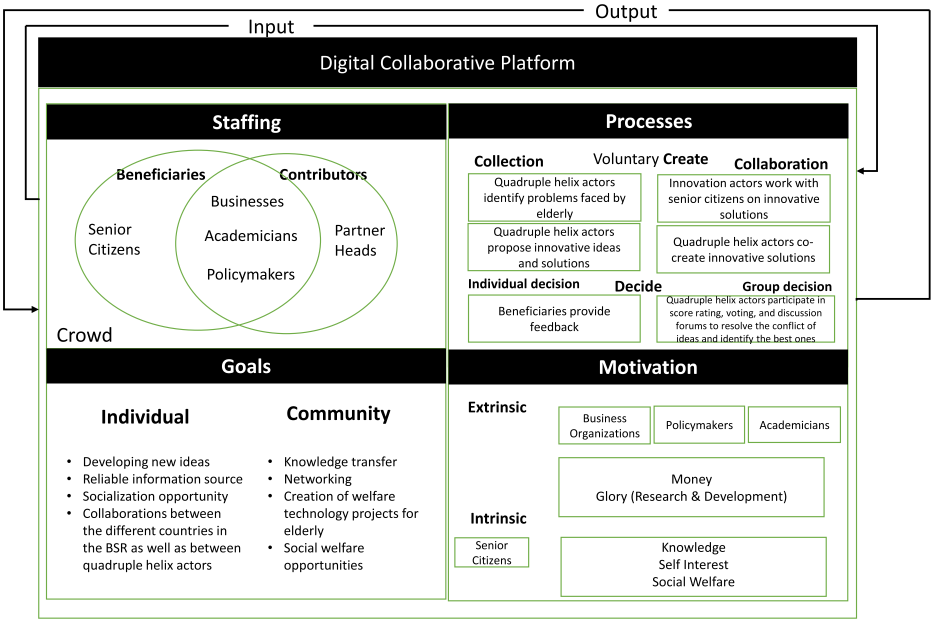

Fig. 4. Components of DSH illustrated using the generic CI Model of Suran et al.

When an innovation actor is convinced to sign up for the DSH, it is imperative that the platform is engaging and helps in user retention. According to the experts' evaluation, users will be engaged if they feel or find the platform useful, i.e., platform can satisfy their needs and support their innovation development processes. It should also be convenient to sign up for, enter the DSH and navigate the system to impact user engagement levels positively. The platform should include interesting innovations and contacts that may interest financiers, enterprises, public stakeholders, and so on. To support innovation development processes and market uptake of innovative solutions and to tackle the social challenges, the government, incubation centres and private sectors (sponsorship) should be interested in financing such a platform.

6 FUTURE WORK

Stakeholder analysis is an essential component of any project management process [Lippe and Kim 2010]. The identification and prioritization of stakeholders' needs and expectations are crucial for project success. **Analytic Hierarchy Process (AHP)** is a decision-making technique that enables project managers to identify and prioritize critical factors among stakeholders [Saaty 1990]. AHP breaks down complex decision problems into smaller, more manageable parts and allows decision-makers to compare and evaluate factors based on their relative importance. By using AHP techniques, project managers can determine which stakeholders have the most significant impact on the project's success and prioritize their needs accordingly. Therefore, important factors will be extracted among stakeholders analysis from the derived results using AHP techniques that would ultimately lead to more effective stakeholder engagement, better decision-making, and increased project success.

After defining the required functionalities for the DSH, the next step is to translate them into concrete features and workflows on the platform. This is done by developing user-dialogue models for each functionality, which are documented in the system's documentation [Butt and Draheim 2022]. The user dialogues are designed using a form-oriented dialogue model [Atkinson et al. 2010; Auer et al. 2009; Draheim and Weber 2005]. Moreover, a web-based implementation of the Silver Hub collaborative platform is created.[9] The platform's features are evaluated using dimensions from the generic CI model (staffing, process, goals, and motivation along with additional requisites) [Suran et al. 2020] as well as dimensions from Technology Acceptance Model 2 such as Perceived Usefulness and Perceived Ease of Use [Venkatesh and Davis 2000]. Attitude toward technology is also an important factor to evaluate when developing a platform like the DSH. By considering the needs and preferences of the target user group and leveraging existing research in the field, the DSH platform can be designed to meet the needs of its users effectively and efficiently.

7 CONCLUSION

To conclude, the main aim of the DSH is to enable the ageing population to find solutions to their everyday problems and resolve them independently. This article identifies the main functionalities based on the generic CI model and identifies the main actors, processes, goals, and motivations that the DSH should fulfil to be accepted as a CI platform. These functionalities were validated and evaluated by different experts in the BSR working in different fields of science and technology in the silver economy. The DSH's novelty lies in the fact that it is a transnational digital platform that involves the quadruple helix actors and use their expertise and knowledge to develop technological solutions for the silver economy. However, the attitudes of the elderly community toward digital platforms could vary across different regions and countries. The findings presented in this study are specific to the BSR and may not necessarily be applicable to other parts of the world. For instance, elderly individuals in other countries may not be as willing or interested in seeking out solutions for their needs on digital platforms. Thus, further research is needed to explore the potential differences in attitudes and preferences toward digital solutions among elderly populations in different regions. Additionally, it would be interesting to investigate the factors that influence these attitudes and preferences, such as cultural and societal norms, education levels, and access to technology.

REFERENCES

P. Anderberg. 2020. Gerontechnology, digitalization, and the silver economy. *XRDS: Crossroads, the ACM Magazine for Students* 26, 3 (2020), 46–49.

G. Aspridis, L. Anthopoulos, and L. Sdrolias. 2013. 2012: European year of active ageing workforce. What happens to project managers over 60? In *4th International Conference on International Business.*

C. Atkinson, D. Draheim, and V. Geist. 2010. Typed business process specification. In *Proceedings of the 14th IEEE International Enterprise Distributed Object Computing Conference.* IEEE, 69–78.

D. Auer, V. Geist, and D. Draheim. 2009. Extending BPMN with submit/response-style user interaction modeling. In *Proceedings of the IEEE Conference on Commerce and Enterprise Computing.* IEEE, 368–374.

D. K. Bhavani. 2020. The New IT Crowd Is Here: Meet Tech Easy Hai. The Hindu. Retrieved from https://www.thehindu.com/sci-tech/technology/tech-easy-hai-teaches-technology-to-indians-during-and-after-lockdown/article33057788.ece.

P. Bitrián, I. Buil, and S. Catalán. 2021. Enhancing user engagement: The role of gamification in mobile apps. *J. Bus. Res.* 132, C (2021), 170–185.

A. Boder. 2006. Collective intelligence: A keystone in knowledge management. *J. Knowl. Manage.* 10, 1 (2006), 81–93.

F. Boll and P. Brune. 2016. Online support for the elderly—why service and social network platforms should be integrated. *Proc. Comput. Sci.* 98 (2016), 395–400. https://www.sciencedirect.com/science/article/pii/S1877050916322050.

V. Braun and V. Clarke. 2012. *Thematic Analysis.* American Psychological Association, 57–71.

V. Braun, V. Clarke, N. Hayfield, and G. Terry. 2019. Thematic analysis. In *Handbook of Research Methods in Health Social Sciences.* Springer, 843–860.

Alan Bryman. 2017. Quantitative and qualitative research: Further reflections on their integration. In *Mixing Methods: Qualitative and Quantitative Research.* Routledge, London, 22.

[9] SilverHub.

S. Butt, I. Pappel, and E. Ounapuu. 2020. Potential for increasing the ICT adaption and identifying technology readiness in the silver economy: Case of estonia. In *Electronic Governance and Open Society: Challenges in Eurasia (EGOSE'20)*. Springer International, St. Petersburg, 139–155.

S. Butt, K. Rava, T. Kangilaski, I. Pappel, and D. Draheim. 2021. Designing a digital collaborative platform for the silver economy: Inception and conceptualization. In *Proceedings of the 8th International Conference on eDemocracy and eGovernment (ICEDEG'21)*. IEEE, 47–54.

S. A. Butt and D. Draheim. 2022. Digital Silver Hub: User Dialogue Model Technical Document. TechRxiv. Preprint (2022). https://doi.org/10.36227/techrxiv.19875031.v1

A. Conway Lenihan, N. Woods, K. Kennally, T. Andreas, and M. Ryan. 2015. The implications of regional and national demographic projections for future GMS costs in Ireland through to 2026. *BMC Health Serv. Res.* 14, 1 (02 2015), 477.

D. Draheim and G. Weber. 2005. Modeling form-based interfaces with bipartite state machines. *Interact. Comput.* 17, 2 (2005), 207–228.

European Commission. 2012. ICT for Ageing Well: OASIS Final Report. Final Report. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/a616192f-8b52-11e1-84b9-01aa75ed71a1/language-en.

J. Felix. 2016. Silver economy: Opportunities and challenges to Brazil adopt the European Union's strategy. *Eur. J. Soc. Sci. Res.* 29, 2 (04 2016), 1–19.

L. Feng, Q. Yiting, Z. Xiaohan, Z. Yuqi, and L. Shiyi. 2021. Formulation of silver tourism digital industry service platform based on blockchain and Internet of Things: Taking shanghai chongming Island as an example. In *Proceedings of the IEEE International Conference on Consumer Electronics and Computer Engineering (ICCECE'21)*. IEEE, 688–694.

E. M. Grundy and M. Murphy. 2017. Population ageing in Europe. In *Oxford Textbook of Geriatric Medicine* (3 ed.), Jean-Pierre Michel, B. Lynn Beattie, Finbarr C. Martin, and Jeremy D. Walston (Eds.). Oxford University Press, Oxford, 11–18.

N. Istudor and I. E. Petrescu. 2016. Sustainable business opportunities in rural areas. *Quality* 17, S1 (03 2016), 14–19.

K. Jackson and P. Bazeley. 2019. *Qualitative Data Analysis with NVivo*. Sage.

F. Kohlbacher, C. Herstatt, and N. Levsen. 2015. Golden opportunities for silver innovation: How demographic changes give rise to entrepreneurial opportunities to meet the needs of older people. *Technovation* 39-40, 1 (2015), 73–82.

H. Landemore and J. Elster. 2012. *Collective Wisdom: Principles and Mechanisms*. Cambridge University Press, Cambridge.

K. Linz and S. Stula. 2010. Demographic change in Europe-an overview. *Observ. Sociopol. Dev. Eur.* 4, 1 (2010), 2–10.

S. Lippe and D. Kim. 2010. Stakeholder analysis: An important tool for strategic decision making. *Manage. Decis.* 48, 5 (2010), 731–744.

N. Louis. 2015. By any means? Questioning the link between gerontechnological innovation and older people's wish to live at home. *Technol. Forecast. Soc. Change* 93 (2015), 32–43.

T. W. Malone and M. S. Bernstein. 2015. *Handbook of Collective Intelligence*. MIT Press.

T. W. Malone and M. Klein. 2007. Harnessing collective intelligence to address global climate change. *Inn. Technol. Gov. Global.* 2, 3 (2007), 15–26.

T. W. Malone, R. Laubacher, and C. N. Dellarocas. 2009. Harnessing crowds: Mapping the genome of collective intelligence. *SSRN Electr. J.* 1, 4732 (2009), 9.

H. Mohajan. 2018. Qualitative research methodology in social sciences and related subjects. *J. Econ. Dev. Environ. People* 7, 1 (03 2018), 23–48.

G. Mulgan. 2018. *Big Mind: How Collective Intelligence can Change Our World*. Princeton University Press, Princeton, NJ.

I. Nonaka and H. Takeuchi. 1995. *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford University Press.

S. Ojala. 2021. Elderly Care Finds Solutions in Digital. Good News Finland. Retrieved from https://www.goodnewsfinland.com/feature/elderly-care-finds-solutions-in-digital/.

V. Pattanaik, S. Suran, and D. Draheim. 2019. Enabling social information exchange via dynamically robust annotations. In *Proceedings of the 21st International Conference on Information Integration and Web-Based Applications and Services (iiWAS'19)*. ACM, 176–184.

M. Plaza-Hernandez, I. Sittón-Candanedo, R. S. Alonso, L. C. Martínez-de Iturrate, J. Prieto, K. Kravari, and J. M. Corchado. 2021. Edge computing and Internet of Things based platform to improve the quality of life of the silver economy on leisure cruise ships. In *Proceedings of the International Symposium on Computer Science and Intelligent Controls (ISCSIC'21)*. IEEE, 159–163.

T. L. Saaty. 1990. How to make a decision: The analytic hierarchy process. *Eur. J. Oper. Res.* 48, 1 (1990), 9–26.

T. Segaran. 2007. *Programming Collective Intelligence: Building Smart Web 2.0 Applications*. O'Reilly.

P. Smith. 2018. 15 digital solutions to support the lives of older people. Blog Post. Retrieved from https://www.nesta.org.uk/blog/15-digital-solutions-support-social-lives-older-people/.

S. Suran, V. Pattanaik, and D. Draheim. 2020. Frameworks for collective intelligence: A systematic literature review. *Comput. Surv.* 53, 1 (2020), 1–36.

S. Suran, V. Pattanaik, R. Kurvers, C. A. Hallin, A. de Liddo, R. Krimmer, and D. Draheim. 2022. Building global societies on collective intelligence: Challenges and opportunities. *Digit. Gov.: Res. Pract.* 3, 4 (2022), 1–7. https://doi.org/10.1145/3568169

S. Suran, V. Pattanaik, S. Ben Yahia, and D. Draheim. 2019. Exploratory analysis of collective intelligence projects developed within the EU Horizon 2020 framework. In *Proceedings of the 11th International Conference on Computational Collective Intelligence (ICCCI'19)*, LNAI, Vol. 11684. Springer, 285–296.

V. Venkatesh and F. Davis. 2000. A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Manage. Sci.* 46, 2 (2000), 186–204.

D. J. Vergados, I. Lykourentzou, and E. Kapetanios. 2010. A resource allocation framework for collective intelligence system engineering. In *Proceedings of the 2nd International Conference on Management of Emergent Digital Ecosystems (MEDES'10).* ACM, 182–188.

T. Weninger. 2014. An exploration of submissions and discussions in social news: Mining collective intelligence of Reddit. *Soc. Netw. Analy. Min.* 4, 1 (2014), 173.

A. Zaidi. 2014. Mobilising the potential of active ageing and silver economy in European countries. *Eur. Pap. New Welf.* http://eng.newwelfare.org/2014/09/07/mobilising-the-potential-of-active-ageing-and-silver-economy-in-european-countries/.

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Appendix VII

[VII]
Sidra A. Butt, Ingrid Pappel, and Dirk Draheim. Exploring the functionalities and evaluation of the Digital Silver Hub: A collaborative platform for innovative solutions in the silver economy. In *Proceedings of ICEGOV 2023 - the 16th International Conference on Theory and Practice of Electronic Governance*. Association for Computing Machinery, 2023

Exploring the Functionalities and Evaluation of the Digital Silver Hub: A Collaborative Platform for Innovative Solutions in the Silver Economy

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The European Union, in collaboration with the Baltic Sea Region, vigorously participates in research on active aging and technology-driven services to enable the silver population to live an independent life. One such EU-funded initiative is the OSIRIS project, which undertakes the development of a collective intelligence platform called the *Digital Silver Hub*, an ecosystem aimed at providing innovative technological solutions to the challenges faced by the silver population. The platform aims to facilitate knowledge exchange, collaboration, and co-creation among platform actors to boost technological innovations that accommodate the needs and preferences of the silver population. This research paper provides a comprehensive analysis of the main functionalities and features of the Digital Silver Hub, including Smart Silver labs, innovation toolkit, collaboration tools, and more. It also identifies the various stakeholders involved in the Digital Silver Hub, such as senior citizens, businesses, researchers, and policymakers, and examines their roles. The paper then evaluates the functionalities of the platform in terms of their performance, effectiveness, and usability. The findings of this research can serve as a useful reference for developing similar collaborative platforms in other regions for the silver economy.

CCS Concepts: • **Information systems → Collaborative and social computing systems and tools**; • **Human-centered computing** → *Collaborative and social computing systems and tools*; • **Social and professional topics** → Age.

Additional Key Words and Phrases: Silver Economy, Digital Collaborative Platform, Collective Intelligence, Information and Communication Technology, Smart Specialization Approach, Baltic Sea Region, Quadruple Helix Model

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1 INTRODUCTION

The global longevity trend is a noteworthy phenomenon with far-reaching repercussions. With the advancement in the social, economic, and medical spheres, life expectancy amongst the global population has increased, especially among those in the more developed areas of the world [28]. Amongst the European Union (EU), the Baltic Sea Region (BSR) countries are termed amongst the "*most aged areas of the world*" [37].

While aging presents many challenges in the public and private domains, the concept of the silver economy caters to a holistic approach toward aging and related opportunities. It reflects the future direction of policies and developments to address issues like old-age employment, preventative healthcare, life-long learning, and smart technologies to improve the quality of life of the silver population while sustaining the economy [17]. OSIRIS - 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth'[1] is also one such EU-funded project that responds to the changing needs of the silver population of the BSR. It aims to

[1] https://osiris-smartsilvereconomy.eu/about-project/

develop a digital collaborative Collective Intelligence (CI) platform called the Digital Silver Hub (DSH) to serve as an ecosystem to develop and accelerate the uptake of innovative solutions to the challenges faced by the silver population to help them live an active and independent life. The DSH involves the quadruple helix actors [14], which include the private sector, public sector, academic institutions, and senior citizens.

This research paper focuses on the DSH and provides an in-depth and comprehensive analysis of the main functionalities and features of the platform. This includes a detailed examination of how the DSH functions, how it is used, and its key features. Additionally, the paper identifies the stakeholders involved in the DSH, such as senior citizens, businesses, researchers, and policymakers, and examines their roles. Finally, the paper evaluates the functionalities in terms of their performance, effectiveness, and usability.

The paper proceeds as follows. In Sect. 2, we discuss related word. In Sect. 3, we describe the research methodology. In Section 4, we present the results. In Section 5, we present the evaluation of functionalities. We finish the paper with a conclusion in Section 6.

2 RELATED WORK

The silver economy offers a plethora of opportunities for addressing the demands of a rapidly aging global population [1, 35]. Here, *silver economy* refers to all products and services for individuals older than 55 years[18, 21, 23, 36]. Technology plays a central role in creating viable, high-quality solutions for the silver population. Older age bears higher risks of chronic disease, dependability, and disability [33]. Therefore, it is often challenging for senior citizens to engage in economic and social activities. Therefore, it is important to develop systems to ensure that the silver population's needs are met efficiently [20]. Technological innovations, including robotics, artificial intelligence (AI), cloud computing, and digital infrastructure [25] can help facilitate healthy and active aging and independent living solutions for the silver population [30, 32].

A series of initiatives by public and private bodies tackle the challenges of the silver economy by involving tech innovations and digital frameworks. The EU *Digital Agenda for Europe 2020* highlights e-health and aging as significant areas, with special attention on *aging well with ICT* [1]. The GRUNDTVIG program was initiated in 2000 by the EU to support the goal of life-long learning (LLP) for the aging population[2]. The programme incorporates various forms and levels of learning, especially for senior citizens. The EU's Seventh Framework Programme (FP7) promoted projects that rely on ICT applications to provide solutions for the silver population and those with special needs [23]. The EU project OASIS (Open Architecture for Accessible Services Integration and Standardisation) employed digital technologies to benefit older adults. It aimed to create an innovative system with an open reference architecture to provide interoperable utilities of content from various services and ontologies[3].

In Finland, several digital services that are valuable for the silver economy have been identified by [27], i.e., Gubbe[4], an online platform for home-care services for senior citizens, VideoVisit[5], a software that supports remote care for seniors by incorporating digital visits into their nursing care plans, and Fiksari[6] aiming to make the lives of seniors more technology-fluent.

[2]https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Grundtvig_programme
[3]https://www.age-platform.eu/project/oasis-project-overview-and-conclusions
[4]https://www.gubbe.com/
[5]https://www.videovisit.fi/
[6]https://www.fiksari.fi/

In [4], Boll and Brune argue that merging the functionalities of an online social network and online services' description, retrieval, and composition related to healthcare can help to improve the lives of seniors in terms of accessing healthcare.

In [19], Feng et al. propose a silver tourism platform based on blockchain technology, the Internet of Things, and Big Data. Their platform design includes various functions such as product customization, marketing, feedback, security, scenic spot introduction, and a consumption payment function.

In [29], Pinzón-Pulido et al. (2019) describe the "EnBuenaEdad"[7,8], a digital initiative for healthy and active aging by the Regional Ministry of Health of Andalusia. The platform employs a co-thinking design for its content creation process and builds on the pillars of the WHO policy framework for healthy and active aging, i.e., health, participation, security, and lifelong learning[9].

Digital platforms face specific challenges and limitations. A basic issue can be a lack of Internet access. The platforms themselves may also lack accessibility, e.g., due to small font sizes or confusing navigation systems [15]. Regarding personalizing experiences, it can be challenging to serve seniors due to their varying health conditions, technological literacy, and cultural backgrounds [24]. Finally, seniors value privacy, security, and trust when using digital platforms [31].

3 RESEARCH METHODOLOGY

In previous work [12], a consolidated generic CI framework [34] was used to build the requirements for the DSH; see Fig 1.

Based on these requirements [12], concrete functionalities and features are developed and incorporated into the DSH.

For the study, 22 focus group discussions [26] have been conducted with project partners and subject matter experts. Due to the pandemic, the meetings have been conducted online (Zoom). Each focus group meeting was, on average, 2 hours long and comprised of semi-structured discussions. The outcome of these discussions was combined with evidence from previous work [12, 34] to develop the functionalities, features, and processes of the DSH.

These functionalities were then evaluated in two phases: two information sessions with 30 participants and four focus group discussions with 25 participants. Participants included the project members and quadruple helix actors from the six regions of the BSR participating in the OSIRIS project. The first information session was conducted online due to the pandemic, and the second was in person. The four focus group discussions were solely online. In each session, our team started with a comprehensive introduction to the core concept of the DSH and its various functionalities. This introduction consisted of the following:

- A presentation of the system's documented user dialogues [7] in terms of a form-oriented dialogue model [2, 3, 16].
- A demonstration of the recent web-based implementation of the Silverhub collaborative platform[10].

The first information session was conducted in February 2021, and the second information session was conducted in September 2021. The four focus group discussions were conducted in January 2023. Evaluations were conducted from time to time, and feedback was incorporated into the DSH. For the information sessions, evaluation was based on the user's first impressions of the DSH and their overall opinion about different functionalities. For the focus group

[7]https://www.enbuenaedad.es/en
[8]https://futurium.ec.europa.eu/en/active-and-healthy-living-digital-world/wellbeing-and-health-promotion/best-practices/enbuenaedad-promotion-healthy-aging-through-digital-solutions-andalusia
[9]https://apps.who.int/iris/handle/10665/67215
[10]https://silverhub.eu/

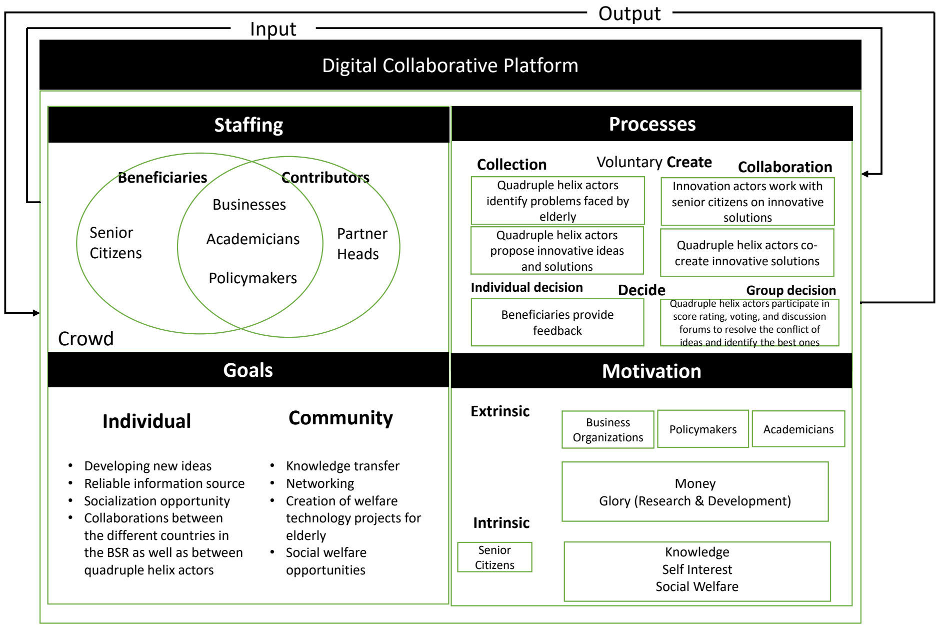

Fig. 1. Components of the Digital Silver Hub [12] according to the Generic CI Model from [34].

discussions, we used dimensions of the Technology Acceptance Model (TAM2), Perceived Usefulness, Perceived Ease of Use, and Attitude Towards Using the technology, along with dimensions of generic CI framework, staffing, processes, goals, and motivation to evaluate the DSH.

4 RESULTS

Based on the outcomes from previous research[5–13, 22] and expert focus groups, we define the DSH as "*an environment where different stakeholders can collaborate in innovation processes using a methodology based on knowledge exchange, co-creation/co-creation/co-production techniques, and participatory methods.*" The DSH aims to unlock regional and inter-regional cooperation between different innovation actors to achieve common goals and enhance growth using a smart specialization[11] approach. Smart specialization means an approach that enables regions to focus on their strengths and comparative advantages and to invest in carefully chosen priorities to boost regional enterprise innovation. Furthermore, the DSH bridges companies and research organizations to generate new innovative solutions to tackle aging challenges and exploit silver economy opportunities.

But what are the functionalities and features of the DSH that enable an ecosystem to serve collaboration, knowledge transfer, regional and inter-regional communication, innovations, end-user participation, and more? In the sequel, we delve into the functionalities and elaborate on the features of the DSH.

[11]https://s3platform.jrc.ec.europa.eu/what-we-do

4.1 Smart Silver Framework

A Smart Silver Framework[12] has been developed, representing a pilot cooperation model to enable collaboration between stakeholders. The Smart Silver Framework consists of three layers. The first layer consists of the quadruple helix actors. The development of the silver economy cannot be done in isolation and therefore requires input from all the major sectors of the economy that are identified in the quadruple helix model of innovation[13]. The model identifies four innovation actors, i.e., the academic sector (research institutions), the private sector (businesses and companies), the public sector (government and policymakers), and end-users (in this case: senior citizens). An integrated response from all the helices improves the efficient utilization of resources. The second layer of the Smart Silver Framework consists of the infrastructure focus areas for each helix actor. These focus areas can vary and depend on the actors' priorities, which can be determined by analyzing their region's silver market characteristics. The third layer consists of classification and references. The Smart Silver Framework was further evaluated and validated by each region, and it was concluded that the framework is flexible, scalable, and transferable – for a detailed report see here[12].

4.2 Smart Silver Lab

The Smart Silver Lab is a multi-level governance structure that employs the Smart Silver Framework and serves as an open innovation ecosystem. The Lab focuses on innovation actors and enables them to connect, coordinate, and build collaboration to develop innovative products and services for the silver economy in the BSR. The Smart Silver Lab uses the DSH to communicate and establish collaborations amongst its first layer of governance, which is the quadruple helix actors, to identify new "*trajectories, which each region may need to acquire to access new forms of knowledge, create new recombinations of their resources, and move from path extension to new path-creation.*" The second layer of governance is the Transnational Cluster, which is composed of each regional Smart Silver Lab and supports innovation actors[14]. Smart Silver Labs will also serve as the repository for all the innovative ideas that have been shared by the innovation actors, given feedback on and concluded, as well as the new and upcoming ideas. Ideas will be presented in a list sorted by the following attributes: Publication date, top reactions, or relevance. A search bar to find a certain idea using the keywords will also be available. To share an idea or give feedback, the user has to sign up and log in. When an actor shares an idea, participants can vote for it in two ways: either up-vote it, which will be depicted as a thumbs-up signaling that they like the idea, or down-vote it, which will be depicted as the thumb down, signaling dislike towards the idea. The number of votes (up or down) defines the top reaction and the most voted idea. Along with voting, participants can comment on the idea in the comment box to reason their vote and give suggestions. Participants can sort the ideas from the list by relevance, which will be determined by the ideas on which they would have commented. If ideas have to be thoroughly discussed, these ideas can be taken to the discussion forums where all participants can argue, give their critique or praise, and offer to build a partnership.

According to the focus group discussions, DSH comprises a Transnational Cluster page and a regional Smart Silver Lab page. General functionalities accessible on both pages are becoming a DSH member (by creating an account), getting familiar with the DSH and the organizations behind it (About Us), and corresponding contact persons (Contact Us).

In addition to Smart Silver Labs, the DSH main page structure and related functionalities consist of the following:

[12] https://osiris-smartsilvereconomy.eu/smart-silver-framework/
[13] https://northsearegion.eu/media/11651/a-quadruple-helix-guide-for-innovations.pdf
[14] https://osiris-smartsilvereconomy.eu/smart-silver-lab/

(1) Innovation Supporting Tools including: (i) Open Innovation toolkit, (ii) Financing mechanism, (iii) Knowledge diffusion toolkit
(2) Networking and Collaboration Opportunities including: (i) Transnational forum, and (ii) Partner search
(3) Publications and Events
(4) Collaboration Tools
(5) Other Functionalities

4.3 Innovation Supporting Tools

With the DSH promising to provide an ecosystem to collaborate and coordinate to develop innovative solutions to the challenges faced by the silver population, innovation management becomes imperative. Innovation actors and teams can generate new ideas that must be analyzed for their feasibility and practicality as viable products and services. Analyzing ideas can be challenging, and therefore, innovation-supporting tools are put to use.

4.3.1 Open Innovation Toolkit. The project developed the Open Innovation Toolkit by conducting innovation camps, and the selection of tools was based on a scoping view. The toolkit consists of tools and services that serve innovation actors in knowledge creation, transfer, and reuse. The tools in the Open Innovation toolkit support the development of innovations and help with prototyping, accelerating market uptake, and enhancing partnerships. Innovation is said to go through different development phases and require various tools in different stages. At the DSH, innovation development goes through four phases: discovering and ideating, designing and prototyping, assessing and going to market, and scaling up and networking.

The Open Innovation toolkit is developed following the four phases of innovation development and the quadruple helix actors. Specific tools and useful methodologies are highlighted along with other tools categorized as survey tools, community feedback tools, the voice of the customer tools, online review tools, user testing tools, and visual feedback tools. The categories are further elaborated based on type, customer use, ease of administration, customization, native language, advantages, disadvantages, most relevant to actors, and purpose. Each category further elaborates on up to seven different tools based on product details, best for, contact details, pricing overview, starting price, free demo, deployment, and features. The toolkit can be accessed online[15].

4.3.2 Financing Mechanism. The Silver Financing Mechanism, which is referred to as a set of specific tools to connect the innovation actors with the investment market, is another very important functionality of the DSH. It aims to cater to the financing needs of the innovation actors in project regions to enable entrepreneurial opportunities and innovative ideas to translate into viable products and services for the silver economy. The financing instruments are categorized according to the financiers, quadruple helix members, and development phases. Through the following two main pillars, the Silver Financing Mechanism connects innovation actors with various funding instruments as well as investment organizations:

- *Investment readiness:* The owners of innovation projects in phases of discovering and ideating, designing, and prototyping of innovation require assistance in preparing to pitch to investors and obtaining funding.
- *Scale up:* The companies and organizations in phases assessing and going to market, scaling up, and networking of innovation development need assistance comparing financing instruments and financiers' offers. It will facilitate

[15] https://silverhub.eu/ww/c/10054/p/1

access to instruments, financing, and market expansion networks and support to access venture capital, strategic investors, partners, and smart money.

The financing instruments are numerous in the market, and new ones are also coming, which means that the financing mechanism has to be updated regularly. The Silver Financing Mechanism can be accessed on the DSH from here[16].

4.3.3 Knowledge Diffusion Toolkit. The Knowledge Diffusion Toolkit enhances the knowledge utilization, transfer, and reuse amongst the innovation actors at the regional and transnational levels. It aims to highlight good practices and benchmarks so that innovation actors and end-users take guidance and learn to collaborate more efficiently and utilize knowledge resources to develop useful innovative ideas to tackle challenges faced by the silver population. The toolkit is aimed at the quadruple helix actors and is categorized according to the tools and event types. The event types include conferences, congress, forums, fairs and exhibitions, festivals, and others, and tools are categorized as international events, national events, media channels, and training. The toolkit is available online[17].

4.4 Networking and Collaboration Opportunities

The focus group discussions highlighted that the DSH is a collaborative platform; therefore, networking should be an integral part. Quadruple helix actors should be able to interact with each other, discuss important ideas, and argue about their practicality. Moreover, if an innovation actor wants to work further on their idea and needs to search for a relevant actor to partner with, the DSH should be able to find a solution.

4.4.1 Discussion Forums. There are regional forums and an international forum on the DSH. Regional forums use the local language, and international forums are in English. Like every forum, it has categories and topics. With participants from quadruple helixes, with diverse experiences and backgrounds, coming together on the DSH, innovation actors find themselves well-connected and pre-eminent. Discussion forums serve as chatrooms and a social platform to discuss ideas, problems faced by older adults, their solutions, and practicality. If any comment is against the terms and conditions and rendered offensive, users can report it to an admin, who will be notified and have the right to remove or delete the comment.

4.4.2 Partner Searching. The DSH is a collaborative platform that aims to build a network of innovation actors from the quadruple helix model to come together and work on innovative ideas that are aimed to help the silver population in the BSR to live a healthy and independent life. Specific functionalities for the partnering network include getting a potential partner and searching for partner contact information.

4.5 Publications and Events

The DSH also provides information regarding different events in the six regions. These events may include hackathons, conferences, workshops, and other 'innovation/technology-themed meetups. News regarding other innovations for the silver economy will be displayed in the newsletter along with upcoming events, seminars, webinars, etc., organized in different regions, where senior citizens and other actors can participate and contribute. Different actors can also use this platform to market their upcoming innovative solutions and events they are organizing to attract their audience.

[16] https://silverhub.eu/et/c/10064/p/1
[17] https://silverhub.eu/et/c/10284/p/1

4.5.1 Silver Market Characteristics. The DSH consists of all the characteristics of a regional business or market environment, including all the factors, forces, and institutions that directly or indirectly influence the interactions between various innovation actors in the silver economy. Users can also comment, give feedback, and suggest updates to the list. The user doesn't have to sign up to access the library and should be able to access it from the regional Smart Silver Lab. Every region will have its list, and users can get an overview of regional silver markets, their characteristics, and descriptions, and also propose new regional silver market characteristics' descriptions or modifications of existing ones. The silver market characteristics consist of different categories: actors and organizations, common practice, development of new technologies, ethics, family and extended family, funding mechanisms, growth drivers, legislation and laws, market analysis, motivation, professionals, and users and citizens.

4.6 Collaboration Tools

Collaboration tools are the most important functionality of the DSH, as it is the core aim of the platform to help the innovation actors collaborate on ideas and work together as one team. The collaboration tool consists of the following features:

- Invite/add new partners: As the users discover new partners to collaborate with, they can add them to their projects as new members.
- Assign tasks: Different tasks can be added by the project owner or manager and assigned to the project partners. Each task can be associated with a workflow and has its own agenda, deadlines set, and groups organized according to the tasks.
- Make agenda: Project managers can create an agenda for the whole project and different tasks. Deadlines, calendars, and workflows can be associated with each agenda. This helps develop a direction for the project and assists members in understanding their tasks and timelines.
- Build workflows: The user should be able to create and manage activities at different stages of the workflow and keep track of all the tasks within a project. Users can use an inbuilt default workflow with three stages: Backlog, Ongoing, and Done, or create customized workflows.
- Discussion: This is connected to the discussion forum functionality, where the users can initiate their topics and choose to either make them private for their team only or public to gather opinions from other actors on the DSH.
- Zoom meetings: This is a more personalized communication medium and lets project members communicate in real time. Members can individually interact with one another or form groups, and Zoom allows chats, voice calls, and video calls.
- Schedule on the calendar: For the teams and individual members to organize their tasks and events like meetings and deadlines, the calendar helps them to have them in one place.
- Time Deadlines: The project manager should be able to add deadlines to each task and monitor the estimated and logged time. Timesheets can be created to record logged time, and project progress can be analyzed.
- Make notes: Project members can leave notes for private use or to share with the whole team or selected team members. Notes can be made under each project or task and are easily accessible.
- Upload important files: The DSH makes it very convenient for users to save and share their files linked to the project or even smaller tasks. Files can be attached directly from the user's computer or other applications like

Google Drive, Dropbox etc. The files attached to the project or team will be visible to all the members within that certain group. Zoom chat should be used to share the files with an individual over the DSH privately.

- Archive project: Projects that have concluded or no longer require collaboration over the DSH can be easily archived and removed from the dashboard.

4.7 Other Functionalities

4.7.1 Sign Up and Login. The prerequisite to using some of the functionalities on the DSH requires a user to sign up and log in. When a user signs up, the correct email and password format must be used. If entered incorrectly, the user will be redirected to an error message and be asked to re-enter their credentials. When entered correctly, the system will check if data already exists in the system. If it doesn't, a verification email will be sent with a link that redirects to the login page where, after putting in the correct credentials, the user should be able to log in and view the home page. Once users sign up and log in, they should be able to manage their accounts, edit their data, and change their passwords through the platform.

4.7.2 Conduct Market Research. If users want to test an idea before considering investing in a minimum viable product (MVP) or a tangible product, they can do it on the DSH. The goal of testing an idea is to understand the customer needs, viability, and practicality of the idea and, eventually, to improve the idea. Testing can either be conducted with the consumers (senior citizens) or with other innovation actors to understand the market. There are three ways in which the idea can be tested on the DSH: one-one discussions, surveys, and focus group discussions. To encourage participation in the testing, it is also possible to offer participants gift cards or any other interesting rewards. This usually helps enhance motivation, increase participation, and stimulate careful responses.

4.7.3 Competitions. Competitions are a great way to increase the user base and grow a community of like-minded people. Moreover, it can motivate the participants to come up with interesting ideas and contribute to the cause of the DSH. Competitions can be held on various themes related to the silver economy: healthcare, leisure, social life, living environment, safety, etc. According to the theme, a problem will be highlighted that participants can decipher through innovative ideas for solutions. Competitions will be posted on the DSH, and actors already on the DSH or new members can join to participate in the contest. Upcoming competitions and details will be presented on the main landing page. The prerequisite to entering the competition would be to sign up and log in, after which the user can click on competitions, read the details, and participate. Participation would require the user to build a proposal and sketch an innovative idea to solve a certain problem. Competitions allow creative juices to flow, and rewards like gift cards, prize money, or the opportunity to collaborate with a private firm to fund the idea can be highly motivating.

4.7.4 Information Library. Like any yellow pages, the DSH will also be a directory for all the services and products for senior citizens. The user doesn't have to sign up to access the library and should be able to access it from the landing page. Every region will have its list, and this helps older adults to find all related items in one place and choose the most appropriate one. Brief descriptions for each service will be provided, and the name will be a hyperlink that will redirect to the main service provider from where the user can avail of the service outside the DSH.

4.7.5 Training. Different training and mentoring programs will be held at the DSH to help seniors learn technical skills. Certified trainers from each quadruple helix can offer personal training and attract an audience from the DSH. Other training being held in the user's region will also be announced in this section. Users should be able to access this webpage without signing up or logging in. In addition to this, an alert module has been added to emphasize some content. There is a possibility to elect the country where the alert is displayed. For example, if there is an OSIRIS event in Estonia and when a user starts to use Estonia's content, the title bar will be displayed with corresponding content and a URL to the custom page.

5 EVALUATION

5.1 Feedback from Focus Group Discussions

The users of the platform have discovered several goals that they were striving to achieve, which included collaboration, research, and innovation, and finding partners and markets for silver solutions. They found a variety of features and services on the platform that have been incredibly helpful and useful, such as interconnected databases for financing, feedback from different experts on innovative ideas, the ability to search for partners and communicate with them, a collaboration tool for product development, a discussion forum, financial possibilities and consultations, information about open EU projects, links to relevant social media channels, and an events calendar. According to the respondents, the platform supported diversity and encouraged collaboration among all quadruple helix actors for mutual support. The respondents identified various factors that positively impacted their attitude, including the added value of the platform, supportive platform, trust towards actors on the platform, and the opportunity to grow ideas into sustainable market products. The majority of respondents found the platform useful in helping them achieve their goals, and many expected it to enhance the quality of their work. Overall, the respondents had a positive attitude toward the platform and were likely to continue using it. Some areas that required improvement included enhancing collaboration and networking opportunities, maintaining a positive and supportive culture, and adding functionalities such as newsletter subscriptions and access to new business opportunities. Also, the users suggested improving the user interface of the web implementation of the platform as, currently, it was not user-friendly or convenient, especially if senior citizens have to use it.

For a more detailed discussion of the evaluation results, see [13].

5.2 Feedback from Information Session 1

Initially, on the DSH home page, the user had to choose a role. Then, they were able to see the role-specific content, which was highly objected to as when a user enters the DSH, they will find information only directly related to them. Still, they might need input from other actors as well. They might not recognize that they must change their role; therefore, the need to choose a role was eliminated from the DSH home page. Moreover, jargon such as quadruple helix actor or silver economy should not be used on the DSH as these are academic terms and not for common use. In addition, the participants pointed out that a section in About Us should be added that explains the silver economy, its challenges, and how the DSH contributes to its development. Initially, the discussion forum was not common, meaning that actors could only access it in their own local languages but could not communicate with other innovators from other countries. Therefore, it was suggested that there should be two forums, transnational and local, as it is very important to support transnational knowledge sharing and collaboration for the DSH to fulfill its goals successfully. Lastly, the DSH should be more user-friendly than it was at the time. Every step should be explained what DSH is all about (in particular) and well guided in terms of where it could take the user (in the given space reported).

5.3 Feedback from Information Session 2

The second information session was conducted when all the functionalities were identified, and web-based implementation of the Silverhub collaborative platform was developed. Participants toured and explored the website in detail, and any feedback was recorded. It was identified that the majority of the functionalities of the DSH were in place; however, chat, idea sharing, feedback, and collaboration tools were missing from the platform, which would need further investment for development. Participants appreciated the changes to the discussion forum as it is now possible to use the forum in English or their local languages. Moreover, Innovation Supporting Tools were also available for the transnational clusters and regional Smart Silver Labs, including the Innovation Development toolkit, Financing Mechanism, and Knowledge Diffusion Toolkit. The tools were readily accessible; however, how they can be used to develop an innovative idea on the DSH is yet to be decided. Therefore, it was agreed that further information sessions should be conducted to evaluate a running case on the DSH. This means an innovative idea should be practically developed on the DSH to further enhance and expand its functionalities.

6 CONCLUSION

Several initiatives are in progress to incorporate smart solutions to the challenges faced by the silver population. A digital collaborative CI platform, the DSH, has been developed, aiming to focus on creating and boosting user-centered technological innovations to improve the quality of life of senior citizens using the Smart Specialization approach. The platform is designed to encourage collaboration and partnerships between different actors from the quadruple helix model. The DSH provides various features such as the Smart Silver Lab, Partner Search, Innovation Supporting Tools, Collaboration Tool, Training Programs, Information Repository, and Events to facilitate the co-creation of innovative solutions. To ensure the DSH's sustainability and maintainability, policies, daily practices, and user workflow should be made flexible and autonomous. The DSH's impact goes beyond the BSR and can serve as a model for other platforms seeking to develop user-centric functionalities for seniors.

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REFERENCES

[1] P. Anderberg. 2020. Gerontechnology, digitalization, and the silver economy. *XRDS: Crossroads, The ACM Magazine for Students* 26 (04 2020), 46–49.

[2] Colin Atkinson, Dirk Draheim, and Verena Geist. 2010. Typed Business Process Specification. In *Proc. of EDOC'2010 – the 14th IEEE International Enterprise Computing Conference*. IEEE, 69–78.

[3] Dagmar Auer, Dirk Draheim, and Verena Geist. 2009. Extending BPMN with Submit/Response-style User Interaction Modeling. In *Proc. of BPMN Workshop, CEC'09 – the 11th IEEE Conference on Commerce and Enterprise Computing*. IEEE, 368–374.

[4] F. Boll and P. Brune. 2016. Online Support for the Elderly ? Why Service and Social Network Platforms should be Integrated. *Procedia Computer Science* 98 (12 2016), 395–400.

[5] S. A. Butt, Elhadjamor. E. A., I. Pappel, E. Õunapuu, and D. Draheim. 2020. A Knowledge Map for ICT Integration in the Silver Economy. In *Proceeding of CENTERIS 2020 – the 8th International Conference on Enterprise Information Systems (Procedia Computer Science, Vol. 181)*. Elsevier, 693–701.

[6] S. A. Butt and D. Draheim. 2021. Ethical Challenges of ICT for the Silver Economy. In *Proceeding of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*. IEEE, 152–155.

[7] S. A. Butt and D. Draheim. 2022. Digital Silver Hub: User Dialogue Model Technical Document. *TechRxiv. Preprint* (2022). https://doi.org/10.36227/techrxiv.19875031.v1

[8] S. A. Butt, T. Kangilaski, and D. Draheim. 2023. Lessons Learned from a Multi-National Project on Developing a Platform for the Silver Economy. In *Proceedings of Projman 2023 - the 7th International Conference on Project Management (Procedia Computer Science)*. Elsevier.

[9] S. A. Butt, S. Lips, R. Sharma, I. Pappel, and D. Draheim. 2023. Barriers to Digital Transformation of the Silver Economy: Challenges to Adopting Digital Skills by the Silver Generation. In *Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics*. Springer.

[10] S. A. Butt, I. Pappel, and E. Õunapuu. 2020. Potential for Increasing the ICT Adaption and Identifying Technology Readiness in the Silver Economy: Case of Estonia. In *Proceedings of EGOSE 2020 – the 7th International Conference on Electronic Governance and Open Society: Challenges in Eurasia*. Springer International Publishing, 139–155.

[11] S. A. Butt, K. Rava, T. Kangilaski, I. Pappel, and D. Draheim. 2021. Designing A Digital Collaborative Platform for the Silver Economy: Inception and Conceptualization. In *Proceedings of ICEDEG 2021 – the Eighth International Conference on eDemocracy & eGovernment*. IEEE, 47–54.

[12] S. A. Butt, S. Suran, I. Pappel, M. Smærup, R. Krimmer, and D. Draheim. 2023. A Digital Collaborative Platform for the Silver Economy: Functionalities Required by Stakeholders in a Multinational Baltic Sea Region Project. *Digital Government: Research and Practice* 4, 2 (2023).

[13] S. A. Butt, M. Weck, I. Pappel, and D. Draheim. 2023. Multifaceted Evaluation of the Digital Silver Hub to Validate the Platform Requirements. In *Proceedings of AHFE 2023 - 14th International Conference on Applied Human Factors and Ergonomics*. Springer.

[14] E. Carayannis and D. Campbell. 2011. Open Innovation Diplomacy and a 21st Century Fractal Research, Education and Innovation (FREIE) Ecosystem: Building on the Quadruple and Quintuple Helix Innovation Concepts and the "Mode 3" Knowledge Production System. *Journal of the Knowledge Economy* 2 (09 2011), 327–372.

[15] D. Castilla, A. Garcia-Palacios, N. Miralles, J. Bretón-López, E. Parra, S. Rodriguez-Berges, and C. Botella. 2016. Effect of Web navigation style in elderly users. *Computers in Human Behavior* 55 (02 2016), 909–920.

[16] Dirk Draheim and Gerald Weber. 2003. Modeling Submit/Response Style Systems with Form Charts and Dialogue Constraints. In *On The Move to Meaningful Internet Systems 2003: OTM 2003 Workshops*. Springer, 267–278.

[17] D. Eatock. 2015. *The silver economy: Opportunities from ageing*. Technical Report. EPRS: European Parliamentary Research Service.

[18] A. Erceg and I. Barkovic Bojanic. 2017. Silver Economy: Demographic Change and Economic Opportunity. In *INTERDISCIPLINARY MANAGEMENT RESEARCH CONFERENCE XIII*.

[19] L. Feng, Q. Yiting, Z. Xiaohan, Z. Yuqi, and L. Shiyi. 2021. Formulation of Silver Tourism Digital Industry Service Platform Based on Blockchain and Internet of Things : Taking Shanghai Chongming Island as an Example. In *2021 IEEE International Conference on Consumer Electronics and Computer Engineering (ICCECE)*. 688–694.

[20] E. M. Grundy and M. Murphy. 2017. *Population ageing in Europe* (3rd ed.). Oxford University Press.

[21] Andrzej K. 2021. The Silver Economy as a Constructive Response in Public Policy on Aging. In *Strategic Approach to Aging Population: Experiences and Challenges*, Ivana Barković Bojanić and Aleksandar Erceg (Eds.). J.J. Strossmayer University of Osijek, 19–35.

[22] T. Kangilaski, S. A. Butt, I. Pappel, and E. Kangilaski. 2021. Overcoming Challenges in the Silver Economy by Connecting Services in the Silver Hub: The Tool to Provide the Basis for the Innovative Solutions. In *Proceedings of ICEGOV 2021 – the 14th International Conference on Theory and Practice of Electronic Governance*. Association for Computing Machinery, 231–237. https://doi.org/10.1145/3494193.3494225

[23] K. Linz and S. Stula. 2010. Demographic change in Europe-an overview. *Observatory for Sociopolitical Developments in Europe* 4 (2010), 2–10.

[24] Q. Ma, A. Chan, and P. Teh. 2020. Bridging the Digital Divide for Older Adults via Observational Training: Effects of Model Identity From a Generational Perspective. *Sustainability* 12 (06 2020), 4555.

[25] Janek Metsallik, Peeter Ross, Dirk Draheim, and Gunnar Piho. 2019. Ten Years of the e-Health System in Estonia. In *Proceedings of MMHS 2018 – Workshop on (Meta)Modelling for Healthcare Systems (CEUR Workshop Proceedings, Vol. 2336)*. CEUR.

[26] T. Nyumba, C. Derrick, and N. Mukherjee. 2018. The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution* 9 (01 2018), 20–32.

[27] Samuli Ojala. 2021. Elderly Care finds Solutions in Digital. Good News from Finland, 07.04.2021. [last acccessed 31.08.2023] https://www.goodnewsfinland.com/en/articles/feature/2021/elderly-care-finds-solutions-in-digital/.

[28] I. Pauhofova and G. Dovalova. 2015. Potential of Silver Economy in the European Union (Selected Views). *European Scientific Journal, ESJ* 11, 10 (2015).

[29] S. Pinzón-Pulido, M. Padial-Espinosa, L. López-Samaniego, B. Navarro-Matillas, P. San Juan-Lozano, J. M. Espinosa-Almendro, J. Ruiz-Fernández, and F. Garrido-Peña. 2019. Creation Process of the Digital Platform to Foster Healthy and Active Aging: EnBuenaEdad. *Frontiers in Public Health* 7 (2019).

[30] M. Plaza-Hernández, I. Sittón-Candanedo, R. S. Alonso, L. C. Martínez-de Iturrate, J. Prieto, K. Kravari, T. Kosmanis, G. Katranas, M. P. Silva, and J. M. Corchado. 2021. Edge Computing and Internet of Things Based Platform to Improve the Quality of Life of the Silver Economy on Leisure Cruise Ships. In *2021 International Symposium on Computer Science and Intelligent Controls (ISCSIC)*. 159–163.

[31] E. Schomakers, C. Lidynia, L. Vervier, A. Gadeib, and M. Ziefle. 2017. Online Privacy Perceptions of Older Adults. 181–200.

[32] R. Schulz and J. Heckhausen. 1996. A Life Span Model of Successful Aging. *The American Psychologist* 51 (08 1996), 702–14.

[33] R. Settersten and J. Angel. 2011. *Trends in the Sociology of Aging: Thirty Year Observations*. 3–13.

[34] S. Suran, V. Pattanaik, and D. Draheim. 2020. Frameworks for Collective Intelligence: A Systematic Literature Review. *Comput. Surveys* 53, 1 (2020), 1–36.

[35] A. Zaidi. 2014. Mobilising the Potential of Active Ageing and Silver Economy in European Countries. *European Papers on the New Welfare* (2014).

[36] M. Zsarnoczky. 2016. The New Hope for the EU – Silver Economy.

[37] P. Zvidriņš. 2012. Demographic Development in the Baltic Sea Region. *Latvijas Zinātņu Akadēmijas Vēstis–A* 5, 6 (2012).

Appendix VIII

[VIII]
Sidra A. Butt, Silvia Lips, Rahul Sharma, Ingrid Pappel, and Dirk Draheim. Barriers to digital transformation of the silver economy: Challenges to adopting digital skills by the silver generation. In *Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics*, volume 97, pages 151–163. Springer, 2023

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Barriers to Digital Transformation of the Silver Economy: Challenges to Adopting Digital Skills by the Silver Generation

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ABSTRACT

In the European Union (EU) and the Baltic Sea Region (BSR), life expectancy amongst the population has increased. As the population ages and the percentage of older people in the total population upsurges, there is a dire requisite to address their needs such as higher risks of chronic disease, dependability, disability and a requirement for assistance. Another integral challenge for the elderly is the need to participate in economic and social activities. It is essential to develop systems to ensure that the needs of the ageing population are met efficiently. Information and Communication Technology (ICT) and innovations such as robotics, artificial intelligence (AI), cloud computing and digital infrastructure help facilitate healthy and active ageing, as well as independent living solutions for the elderly. With all these technological advancements being introduced, the silver generation must be also capable of adopting them. The innovative solutions can be deemed a waste of resources if the target group is incapable of benefitting from them. In this research, a systematic literature review is conducted to identify the technology readiness, technology acceptance and level of digital skills of the silver generation as well as the barriers and challenges towards the adoption of digital transformation in the silver economy. The resulting articles are analysed using thematic analysis with NVIVO and the main outcomes help in identifying and analyzing the attitude of the silver generation towards ICT, barriers and challenges to ICT adoption and the existing digital tools and solutions that are easily adopted by the silver generation to serve as benchmarks to introduce further innovations for the silver economy. Moreover, recommendations are provided on how digital transformation can be used as a tool to engage the elderly in the economy by addressing the hindering factors to ICT adoption. Overall, the findings of this research contribute to the literature and can serve as a useful resource for other regions facing similar challenges in addressing the needs of an ageing society.

Keywords: Information and Communication Technology, Silver Economy, Digital Transformation, Digital Skills, Technology Adoption

INTRODUCTION

With the advancement in the social, economic and medical spheres, life expectancy amongst the global population, especially those in the more developed areas of the world has increased (Pauhofova & Dovalova, 2015). This change is explained in population demographics as modifications in the age structure based on improvements in their living circumstances (Linz & Stula, 2010). While this demographic change is affecting the entire global population, it is more evident in the developed areas of the world like Europe and North America (Georgantzi, 2018).

According to the United Nations (2020), the number of persons aged 65 and above was 727 million in 2020, which is expected to reach 1.5 billion by the mid-century (United Nations, 2020). This implies that by 2050, 1 out of 6 people in the world will be aged 65 or above. The percentage of older people in the population had already drastically increased between the years 1950 and 2000, especially in European countries (Grundy & Murphy, 2017). Amongst the EU, the Baltic Sea Region (BSR) countries are termed among the *"most ageing areas of the world"* (Berzins & Zvidrins, 2011).

As the ratio of working-age to retired citizens dwindles in developed economies like the EU and BSR, the only way forward is to capitalize on the opportunities created by technology (Anderberg, 2020). Innovations in the technological landscape can be harnessed to address the needs of the silver generation as they age. ICT can be a viable solution to fulfil the needs of the ageing society. According to Obi et al (2013), the Ministry of Internal Affairs and Communications and the Ministry of Health and Welfare in Japan have been promoting the *"active life strategy"* to improve the lives of their senior citizens (Obi, et al., 2013). Based on this strategy, they are promoting the development of societies and townships that employ sensor wireless and cloud technologies to address the challenges associated with ageing populations. Hence, ICT innovations like mobile, cloud computing, and social media can work as enablers or catalysts for silver economy development.

In order for these innovations to successfully help the silver generation, it is imperative to understand the technology readiness of this particular population segment. The innovative solutions can be deemed a waste of resources if the target group is incapable of benefitting from them. In this research, a systematic literature review is conducted to analyse the technology readiness of the silver generation and the barriers and challenges faced by the silver economy towards digital transformation. As a result, these barriers can be addressed to serve as the basis for new entrepreneurial opportunities. For this study, the silver economy refers to the economic activities, businesses, and investments related to the '55+' demographic and the provision of products and services for older adults (European Commission, 2021). The term "silver generation" typically refers to individuals who are 55 years old and above and are still active and engaged in society (United Nations, 2017). This demographic is often characterized by their wealth, experience, and purchasing power, making them an important market segment for businesses.

In particular, the research questions of the study are:

1. What is the level of the technology readiness of the silver generation?
2. What are the barriers and challenges towards ICT adoption and digital transformation in the silver economy?
3. How can these barriers and challenges towards digital transformation be addressed to increase the technology readiness of the silver generation?

The remaining paper is organized as follows: Sect. 2 outlines the research methodology used for the systematic literature review. Results are elaborated in Sect. 3 and discussion and recommendations are provided in Sect. 4 and finish the paper with a conclusion in Sect. 5.

RESEARCH METHODOLOGY

A Systematic Literature Review (SLR) will be used to condense and systematically present scientific results on the research topic that might be scattered over a significant number of sources. Kitchenham's "Guidelines for performing Systematic Literature Reviews in Software Engineering" is used as a basis to achieve the research goals through a transparent and objective approach (Kitchenham & Charters, 2007).

Based on Kitchenham's guidelines, an SLR is performed in five stages: (i) Search Strategy, (ii) Study Selection, (iii) Study Quality Assessment, (iv) Data Extraction, (v) Data Synthesis (Kitchenham & Charters, 2007).

Search Strategy

A set of search terms are selected based on the research questions identified in the Sect. 1. The next step is to create a search string using "AND" and "OR" combinations to look for pertinent scientific papers in the database.

Search Terms: Often, senior citizens, silver economy, ageing population, elderly, seniors, and ageing are all synonymously used and therefore are the primary search terms. ICT adaptation and Technology adoption and other terms for technology acceptance are used synonymously for technology readiness and therefore, are the secondary search terms and also include keywords such as barrier, challenges, difficulties, obstacles and more. Combining search terms with "AND" and "OR" operators resulted in the following search string:

("Silver economy" OR "Senior Citizens" OR "ageing population" OR "elderly" OR "seniors" OR "ageing" OR "old population" OR "55+" OR "Older adults" OR "grey population") AND ("ICT acceptance" OR "Assistive technology" OR "ICT" OR "technology" OR "Smart Technology" OR "Smart homes" OR "Acceptance" OR "Usability" OR "Use" OR "Adoption" OR "behavioural intention" "usability of technology" OR "technology usage" OR "technology acceptance" OR "technology readiness" OR "innovation acceptance" OR "resistance to change" OR "ICT adaptation" OR "Technology adoption") AND ("barriers" OR "challenges" OR "difficulties" OR "obstacles" OR "problems" OR "perception" OR "influencing factors" OR "willingness to use" OR "willingness to adopt" OR "Factors to adopt" OR "barriers to adopt")

Search Process: The resulting search string was used to search for the relevant articles in the Scopus database. Scopus is a bibliographic database that covers a wide range of academic disciplines, including science, technology, medicine, social sciences, and arts and humanities. It is one of the largest databases of peer-reviewed literature, with over 76 million records, and is widely used by researchers, students, and librarians around the world (Scopus, 2023). According to the initial selection criteria, 800 articles were found between 2000 and 2022. The documents were sorted by the most cited articles in the database.

Study Selection

The next stage is the selection of articles. In this research, a two-stage selection of articles for research was applied.

Selection Phase 1: During this stage, one researcher reviewed the titles of articles and, based on the inclusion criteria set out in Table 1, assessed them to include in the research. In case of doubt, the researcher also was acquainted with the keywords and abstract of the studies. After the completion of this stage, 48 articles were chosen.

Selection Phase 2: Further, quality assessment criteria were formed (Table 2) and used to further narrow down the articles selected from Phase 1. After quality assessment, 13 articles remained and any article that was from before 2010 was also excluded. At this stage, 9 articles were selected.

Table 1: Inclusion Criteria for Selection Phase 1

Criteria ID	**Inclusion Criteria**
IC1	The article focuses on the technology readiness of the silver generation.
IC2	The article explains the importance of technology for the silver generation.
IC3	The article describes different use cases of technology adoption of the silver generation.
IC4	The article includes different types of technologies and digital tools for the silver generation.
IC5	The article focuses on barriers and challenges of technology adoption for the silver generation.
IC6	The article explains the theoretical foundations of technology adoption and acceptance by the silver generation.
IC7	The article outlines the perceptions of the silver generation towards technology.

Table 2: Quality Criteria Checklist for Selection Phase 2

Criteria ID	**Quality Criteria Check-List**
QC1	Are the research objectives clearly defined in the study?
QC2	Does the study propose methods or solutions to improve the technology readiness of the silver generation?
QC3	Are the challenges to technology adoption clearly defined in the study?
QC4	Does the study provide insights into different stakeholders and their roles in increasing the technology readiness of the silver generation?
QC5	Does the study highlight the potential benefits of using technology for the silver generation?
QC6	Are different perceptions of the silver generation towards technology and ICT adoption highlighted?
QC7	Does the study highlight different types of technologies and digital tools for the silver generation?
QC8	Does the study investigate the different factors that lead to acceptance of the digital tools by the silver generation?

Study Quality Assessment

At this stage, two independent researchers from Tallinn University of Technology, Estonia (Silvia Lips and Rahul Sharma) evaluated the articles selected from the previous stage based on the Quality Criteria Checklist in Table 2. Each article was rated on a 5-point Likert scale, where the answers were coded as follows: 1 – entirely disagree, 2 – disagree, 3 – neutral, 4 – agree, and 5 – entirely agree. In order to evaluate each article, it was necessary to meet all the pre-established Quality Criteria and, depending on the answer to the question, assign points to each article according to the evaluation system. All articles scoring three or higher were included in the further review. Below is a table from all three independent researchers with the average of all ratings (Kitchenham & Charters, 2007).

Table 3: Quality Score of Selected Studies Total Average

Study ID	QC1	QC2	QC3	QC4	QC5	QC6	QC7	QC8	Total Average Score
S1	5	3	4	3	3	3	3	5	3.625
S2	5	3	4	3	3	5	4	4	3.875
S3	4	3	4	3	3	4	3	4	3.5
S4	5	4	4	3	3	5	4	3	3.875
S5	4	3	5	3	3	4	3	4	3.625
S6	5	4	3	3	4	4	3	3	3.625
S7	5	4	4	3	3	3	4	4	3.75
S8	4	4	3	4	3	4	3	3	3.5
S9	5	4	5	3	4	4	4	4	4.125

Data Extraction and Synthesis

Data extraction represents the process by which the researcher obtains the necessary information about the characteristics of the study and the results included in the study. Table 4 presents a list of final selected studies with study titles, publication types, authors and years. Also, for each article, an individual ID was selected.

Table 4: List of Final Selected Studies

Study ID	Study Title	Authors	Year	Publication Type
S1	A Study on Elderly Individuals' Attitude towards ICTs **(Pargaonkar, et al., 2019)**	Pargaonkar, A.; Mishra, W.; Kadam, S.	2019	Book Chapter
S2	Interviews with digital seniors: ICT use in the context of everyday life **(Quan-Haase, et al., 2016)**	Quan-Haase, A.; Martin, K.; Schreurs K.	2016	Journal Article
S3	Coming of (old) age in the Digital Age: ICT Usage and Non-Usage among Older Adults **(Neves, et al., 2013)**	Neves, B. B.; Amaro, F.; Fonseca, J.	2013	Journal Article
S4	Technology Adoption and Learning Preferences for Older Adults: Evolving Perceptions, Ongoing Challenges, and	Pang, C.; Collin Wang, Z.; McGrenere, J.; Leung, R.; Dai, J.; Mofatt, K.	2021	Conference Paper

	Emerging Design Opportunities **(Pang, et al., 2021)**			
S5	Exploring how Internet services can enhance elderly well-being **(Bianchi, 2021)**	Bianchi, C.	2021	Journal Article
S6	Inclusion of Older Adults in the Research and Design of Digital Technology **(Mannheim, et al., 2019)**	Mannheim, I.; Schwartz, E.; Xi, W.; Buttigieg, S. C.; McDonnell-Naughton, M.; Wouters, E. J. M.; Zaalen, Y. V.	2019	Journal Article
S7	"These devices have not been made for older people's needs" – Older adults' perceptions of digital technologies in Finland and Ireland **(Pirhonen, et al., 2020)**	Pirhonen, J.; Lolich, L.; Tuominen, K.; Jolanki, O.; Timonen, V.	2019	Journal Article
S8	The use of information and communication technologies by older people with cognitive impairments: from barriers to benefits **(Blok, et al., 2020)**	Marije Blok, M.; Ingen, E.; Boer, A. H.; Slootman, M.	2020	Journal Article
S9	Technology to Support Aging in Place: Older Adults' Perspectives **(Wang, et al., 2019)**	Shengzhi Wang, S.; Bolling, K.; Mao, K.; Reichstadt, J.; Jeste, D.; Kim, H.; Nebeker, C.	2019	Article

Thematic Analysis

At the stage of data synthesis, summation and comparison of data obtained from selected studies are performed using the method of thematic analysis from Braun and Clarke (Braun & Clarke, 2006). The thematic analysis makes it possible to identify and highlight repetitive patterns, themes, and meanings in the data. Thematic analysis was done using NVIVO. Further, based on the findings, research questions are answered.

RESULTS

The literature review analysis revealed several key themes; the attitude towards ICTs, barriers to adoption, age and education, and design and inclusion. These themes provide insights into the factors that influence older adults' adoption and use of ICTs, the ways they use ICTs, and the importance of considering older adults' perspectives and needs when designing technology for them.

Attitude towards ICTs:

The elderly population generally has a positive attitude towards the use of ICT technologies and recognizes their potential benefits. However, various factors can affect this attitude, such as perceived willingness to learn, willingness to ask for assistance, perceived self-efficacy in learning, and willingness to invest time and money in new technology (S1).

One of the main reasons for this positive attitude is the belief that ICTs can help overcome social isolation, with many respondents reporting feeling closer to family and friends due to the use of technology (S1). Support and assistance from family and peers also have a positive influence on the attitude of the elderly towards adopting ICT (S1).

The literature also indicates that the elderly population primarily uses ICT for gaining knowledge and information, but often adopts a hybrid approach, using both technology and traditional methods such as books (S2). Google is the most commonly used search engine, and genealogy is the most common type of research conducted online (S2). Audiobooks are also gaining popularity among the elderly as a reading format due to changes in physical capabilities such as reducing vision and blurred eyesight (S2).

The motivation to use ICT technology also comes in the form of peer pressure from friends and family, with many participants having a social media presence due to recommendations from family members (S2). Skype is commonly used for staying in touch with families and is found to be more useful than other platforms like Facebook and Twitter (S2).

The literature also shows that the majority of the elderly population owns a mobile phone and uses it for communication with family, and friends, and in emergencies (S3). This provides benefits such as family proximity, safety and convenience (S3). The elderly feel more comfortable with new technology when they first try it independently, and if they are not able to understand it, they often turn to family for assistance (S4). There is also a general interest among the elderly to learn about ICT and new technologies (S4).

Additionally, the literature suggests that the elderly prefer to use the internet on their phones or tablets rather than laptops (S5). They use internet services regularly for communication, paying bills and e-commerce (S7), with Facebook and WhatsApp being the most common platforms used (S5). Adopting new technologies leads to better well-being in terms of enjoyment, personal growth, environmental mastery, autonomy, and social connectedness (S5).

Lastly, a study from Finland and Ireland suggests that the elderly recognize the potential benefits of technology in their everyday lives, such as convenience and an incredible source of information. They use the internet to find information on illnesses, services, practical guidance as well as hobbies and social contacts. In Ireland, the elderly were more interested in services where their medical records could be accessed by different healthcare providers instead of repeating the same information every time. Whatsapp and Skype were most commonly used for communication purposes (S7).

Barriers to Adoption

Age-related health issues, such as vision impairment, cognitive decline, and decreased motor control, were found to be the main reason for elderly individuals finding it difficult to learn new technology (S1). Additionally, a sense of security and lack of trust were also considered potential barriers to ICT adoption (S2).

Participants in these studies also expressed concerns about the cost, functionality, and size of technology, such as mobile phones and computers (S3). The perceived dangers associated with the internet, such as fraud and paedophilia, also played a role in the reluctance of some elderly individuals to adopt ICTs (S3). Attitudinal and functional factors were found to play a major role in ICT usage among the elderly, rather than physical factors (S3).

Comfort, familiarity, and easy access to traditional non-digital tools, such as notepads and paper calendars, were found to be major reasons for the elderly preferring these tools over digital alternatives when it comes to tracking their health (S4). A lack of knowledge and awareness about new technologies, such as smartwatches, was also identified as a barrier to adoption (S4). The elderly also expressed concerns about the cost of devices, as well as the complexity of manuals and instructions associated with new technologies (S4).

Anxiety and frustration were also found to be major barriers to ICT adoption among the elderly, particularly for those who were never exposed to such technology and lacked the adequate skills to use them (S5). The traditional ways of doing things, such as visiting retail stores and banks, were found to be more enjoyable experiences for the elderly than interacting with technology (S5). Cognitive and physical impairments, such as the decline in memory or inability to follow instructions, also affected ICT adoption among the elderly (S5).

Elderly participants from Ireland mentioned how technology is rapidly changing and invading every aspect of their lives which adds to their anxiety (S7). The age-based decline in functional abilities of the elderly also leads to resistance to ICT adoption (S7). Unreadable tiny screens and uninviting user interfaces were also found to be major causes of technology not enticing the elderly (S7).

S9 identified several key barriers towards ICT adoption and digital platforms which include technology unusability, technology illiteracy, poor data management and lack of privacy and not involving the elderly in technology design.

Age and Education

According to research, the frequency of internet use is highly correlated to age, gender, and employment status among the elderly population. A disparity was observed between those in the age group of 55-65 and those over 65. It was found that the 55-65 age group was more positive, motivated, and confident in using ICT, and had adopted it better than those over 65 (S1).

It was also found that a typical ICT user among the elderly population is typically a male in the age group of 55-74 who has at least secondary education and has previously worked or had experience in specialized or technical fields (S3). On the other hand, a typical non-user is more likely to be a female over 75 with less than secondary education, retired, and previous experience in non-technical fields such as agriculture. Additionally, as age increases, the likelihood of using smart devices decreases (S3).

Literature also highlights the presence of a digital divide among different age groups within the ageing population. Younger elderly individuals were found to be more comfortable with using new technology than older ones (S5). Research (S7) found that in Finland, younger and societally active participants were more active on the internet, particularly on social media. However, in Ireland, internet penetration in everyday life is not as extensive, but younger elderly in the age group of 55-65 with higher education were found to be more comfortable with technology than older and less educated individuals.

Design and Inclusion

Firstly, it is important to take into account the distinction between the two divisions in the age group of the elderly; 55-65 and 65+ (S1). This distinction provides varying insights and is helpful when developing new design standards and user research guidelines.

Secondly, it is important to find agency when understanding the ICT use of the elderly as they critically consider different options and then make choices based on convenience, affordability and preferences (S2). Designing innovative solutions for the elderly should therefore include giving them the flexibility to choose from different options and decide how they would like to engage with them.

Thirdly, functional factors such as lack of literacy and unavailability of computer/internet access can be very important barriers to ICT adoption among the elderly, and therefore e-inclusion strategies should be considered (S3). These may include training programs tailored for the elderly as well as public policies that facilitate ICT access and usage. It is suggested that policies could include ensuring the availability of computers and internet in community centres and special programs for the elderly to make such equipment affordable for them, such as credit terms or discounts.

The design of products targeted at the elderly should be kept simple and less intrusive (S4). New technologies should come with manuals or easy instructions to walk them through the onboarding and setup phase, and the majority of the elderly prefer interacting with a support person on live mediums like video chat, phone or instant messaging. It is also important for the service providers to understand that the elderly are vulnerable consumers and require assistance when using the internet and e-services (S5). Therefore, including their family members or having a support team to help them get onboarded with digital services will be highly beneficial.

S6 provides ethical considerations along with guidelines for the inclusion of the elderly in research and design of digital technology. It is summarized in the table below:

Table 5: Summary of ethical considerations and guidelines for inclusion

Ethical Aspects	**Guidelines for Inclusion**
Awareness of stereotypes and ageism	(i) Pay attention to appearance and aesthetics. (ii) Disguise technology as an everyday device. (iii) Universal design
Consent and re-consent	(i) Use a broader and more holistic conceptualization of competence; Simplify consent forms. (ii) Account for the setting
Autonomy, trust and respect	(i) Assess a person's needs and wants at a particular time and place. (ii) Provide an "exit" option. (iii) Establish trust and respect for choices
Research methods and tools	Control for the sensory decline. (ii) Adequate instruction on the use and maintenance of devices.

	(iii) Avoid negative age stereotypes. (iv) Qualitative methods preferred.
Privacy and Confidentiality	(i) Include older adults in the development of invasive devices. (ii) Provide control over access to sensitive information
Safety and Security	(i) Design and study digital technologies in the natural environment. (ii) Include older adults with different conditions and health statuses.

It is recommended that individual characteristics such as age and social position should be considered when designing digital services (S7). Moreover, it is also important to consider issues at the social level "such as guidelines and regulations on age-friendly design (e.g. size of screens and buttons) and intuitive software." They also recommend incorporating the writing style of websites that could be understood by a 9-year-old and developing more intuitive technology. Moreover, training, support and easy access to helplines are required when deploying digital services for the elderly population (S8).

S9 highlights different barriers and recommends how these could be improved to increase technology readiness and ICT adoption of the elderly in Table 6.

Table 6: Recommendations to lower barriers to ICT adoption

Barrier	Solution
Technology Usability	• Simple instructions, fewer buttons, larger fonts, and speech-activated tools to be used in smart devices. • A universal remote to operate the television and peripheral devices—technologies.
Technology Literacy	• "How to" manuals that accompany technology devices. • Support personnel to help onboard with new technologies.
Data Management and Privacy	• Provision of feedback as a return on the value of data collected from the elderly.
Technology co-design	• Develop a co-design process that incorporates technology education as a component to increase "tech literacy."

DISCUSSION

Based on the findings from the literature review it is possible to answer the research questions.

1. *What is the level of technology readiness of the silver generation?*

The literature suggests that the level of technology readiness of the silver generation is mixed. On one hand, studies (S1, S2, S3) have found that older adults are increasingly using technology and are interested in using technology to improve their daily lives. They are also willing to learn and adapt to new technologies, especially if they see the benefits and convenience they can bring to them. On the other hand, studies (S4, S5, S6, S7, S9) have also identified several barriers and challenges that hinder the technology readiness and adoption of the silver generation.

2. *What are the barriers and challenges towards ICT adoption and digital transformation in the silver economy?*

The literature identified several barriers and challenges towards ICT adoption and digital transformation in the silver economy. These include:
Technology usability: Studies (S4, S5, S7, S9) have found that older adults often find technology difficult to use and navigate. They may have difficulty reading small fonts, using multiple buttons, or understanding complex instructions.
Technology literacy: Studies (S3, S5, S7, S9) have found that many older adults have limited knowledge and understanding of technology. They may not be familiar with basic concepts such as the internet, email, or social media.
Data management and privacy: Studies (S5, S7, S9) have found that older adults may be concerned about their personal information being shared or used without their consent. They may also be concerned about the security of their personal information when using technology.
Social and cultural factors: Studies (S2, S3, S7) have found that older adults may be influenced by social and cultural factors such as their age, gender, education, and income when it comes to their technology use. They may also be influenced by the attitudes and perceptions of others towards technology.
Lack of access: Studies (S3, S9) have found that lack of access to technology, as well as lack of infrastructure, can be a significant barrier to ICT adoption for older adults. This includes a lack of access to computers, the internet and digital devices, as well as a lack of access to training, support and easy access helplines.

3. *How can these barriers and challenges towards digital transformation be addressed to increase the technology readiness of the silver generation?*

The literature suggests several ways to address the barriers and challenges towards digital transformation in the silver economy. These include:
Technology usability: Studies (S4, S5, S7, S9) recommend designing technology with larger fonts, fewer buttons, and speech-activated tools to make it easier for older adults to use. They also recommend providing simple instructions and training to help older adults understand how to use technology. Moreover, including the elderly in the technology design and validation process will be highly beneficial as they know best what they need.
Technology literacy: Studies (S3, S5, S7, S9) recommend providing training and support to help older adults understand and use technology. This can include providing "how-to" manuals, support personnel to help onboard with new technologies and technology education to increase "tech literacy".
Data management and privacy: Studies (S5, S7, S9) recommend providing clear and transparent information about data collection and usage. Additionally, providing feedback as a return on the value of data collected from the elderly can also increase their trust and understanding of technology.
Social and cultural factors: Studies (S2, S3, S7) recommend considering individual characteristics such as age and socioeconomic status, as well as cultural and social factors when designing and implementing digital technologies for the silver generation. This can include providing language and cultural support, as well as considering the needs of different socioeconomic groups. Additionally, involving

older adults in the design and development process can help ensure that technology meets their needs and is more likely to be adopted.

Infrastructure and accessibility: Studies (S1, S2, S7) recommend investing in infrastructure and making technology accessible to older adults, including providing access to high-speed internet, mobile devices, and digital services in communities where older adults live. This can also include providing transportation and mobility support to help older adults access technology and digital services.

Government and policy support: Studies (S1, S2, S6) recommend involving government and policymakers in the digital transformation of the silver economy. This can include providing funding for technology and digital service development, creating policies that support the use of technology by older adults, and promoting partnerships between the private sector and older adults.

CONCLUSION

The literature reviewed in this paper suggests that the technology readiness of the silver generation is currently at a moderate level, with some older adults being able to effectively use technology and others facing barriers and challenges. These barriers and challenges include issues with technology usability, technology literacy, data management and privacy, and social and cultural factors. To address these barriers and challenges, several strategies have been proposed, such as designing technology with larger fonts and fewer buttons, providing training and support to help older adults understand and use technology, including the elderly in the co-creation of technology and considering individual characteristics such as age and cultural background when designing technology and providing support.

Overall, it is clear that there is a need for further in-depth research and development in this area, as well as greater collaboration between technology developers, private businesses, policymakers, academicians and older adults themselves to ensure that the technology being developed is inclusive and accessible to all older adults. By addressing the barriers and challenges that older adults face in using technology, we can help to improve their quality of life and ensure that they can fully participate in the digital age.

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REFERENCES

Anderberg, P., 2020. Gerontechnology, digitalization, and the silver economy. *XRDS: Crossroads, the ACM Magazine for Students,* 26(3), pp. 46-49.

Berzins, A. & Zvidrins, P., 2011. Depopulation in the Baltic States. *Lithuanian Journal of Statistics,* 50(1).

Bianchi, C., 2021. Exploring how internet services can enhance elderly well-being. *Journal of Services Marketing.*

Blok, M., Ingen, E. V., Boer, A. D. & Slootman, M. W., 2020. The use of information and communication technologies by older people with cognitive impairments: from barriers to benefits. *Computers in Human Behavior,* Volume 104, p. 106173.

Braun, V. & Clarke, V., 2006. Using thematic analysis in Psychology. *Qualitative Research in Psychology*, 3(2), pp. 77-101.

European Commission, 2021. *The Silver Economy in Europe: Opportunities for growth and jobs in the age of demographic change.* [Online] Available at: https://ec.europa.eu/growth/sectors/silver-economy_en [Accessed 2 January 2023].

Georgantzi, N., 2018. The European union's approach towards ageism. In: L. Ayalon & C. Tesch-Römer, eds. *Contemporary perspectives on ageism.* Cham: Springer, pp. 341-368.

Grundy, E. M. & Murphy, M., 2017. Population ageing in Europe . In: J. Michel , B. L. Beattie & F. Martin , eds. *Oxford Textbook of Geriatric Medicine.* Oxford: Oxford University Press, pp. 11-18..

Kitchenham, B. & Charters, S., 2007. Guidelines for performing Systematic Literature Reviews in Software Engineering.

Linz, K. & Stula, S., 2010. Demographic change in Europe - An overview. *Observatory for Sociopolitical Developements in Europe,* 4(1), pp. 2-10.

Mannheim, I. et al., 2019. Inclusion of Older Adults in the Research and Design of Digital Technology. *International journal of environmental research and public health,* 16(19).

Neves, B. B., Amaro, F. & Fonseca, J. R., 2013. Coming of (Old) Age in the Digital Age: ICT Usage and Non-Usage among Older Adults. *Sociological Research Online,* Volume 18, pp. 22-35.

Obi, T., Auffret, J. P. & Iwasaki, N., 2013. *Aging society and ICT: Global silver innovation.* 5 ed. s.l.:IOS Press.

Pang, C., Wang, Z. C., McGrenere, J. & Leung, R. A., 2021. *Technology Adoption and Learning Preferences for Older Adults:: Evolving Perceptions, Ongoing Challenges, and Emerging Design Opportunities..* s.l., Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems.

Pargaonkar, A., Mishra, W. & Kadam, s., 2019. *A Study on Elderly Individuals' Attitude Towards ICTs.* s.l., Proceedings of ICoRD 2019 Volume 2.

Pauhofova, I. & Dovalova, G., 2015. Potential of silver economy in the European Union (selected views). *European Scientific Journal,* 11(10).

Pirhonen, J. et al., 2020. "These devices have not been made for older people's needs" – Older adults' perceptions of digital technologies in Finland and Ireland. *Technology in Society,* Volume 62, p. 101287..

Quan-Haase, A., Martin, K. & Schreurs, K., 2016. Interviews with digital seniors: ICT use in the context of everyday life. *Information, Communication & Society,* Volume 19, pp. 691-707.

Scopus, 2021. *What is Scopus? Elsevier.* [Online]
Available at: https://www.elsevier.com/solutions/scopus [Accessed 1 December 2022].

Scopus, 2023. *Overview.* [Online]
Available at: https://www.scopus.com/search/form.uri?display=basic#basic [Accessed 1 December 2022].

United Nations, 2017. *World Population Ageing 2017 Highlights. Department of Economic and Social Affairs, Population Division.* [Online] Available at: https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf [Accessed 23 March 2023].

United Nations, 2020. *World Population Ageing 2020 Highlights. Department of Economic and Social Affairs..* [Online] Available at: https://www.un.org/development/desa/pd/ [Accessed 27 January 2023].

Wang, S. et al., 2019. Technology to Support Aging in Place: Older Adults' Perspectives. *Healthcare,* Volume 7.

Appendix IX

[IX]
Sidra A. Butt, Marina Weck, Ingrid Pappel, and Dirk Draheim. Multifaceted evaluation of the Digital Silver Hub to validate the platform requirements. In *Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics*, pages 164–177. Springer, 2023

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Multi-Faceted Evaluation of the Digital Silver Hub to Validate its Platform Requirements

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ABSTRACT

The silver economy is heavily reliant on technical advancements and Information and Communication Technology (ICT) due to the changing demographics and increases in the older population. There have been quite a lot of initiatives by several public and private bodies to tackle the challenges of the silver economy by involving technological innovations and digital frameworks. One such initiative is the Digital Silver Hub (DSH) by the Interreg Baltic Sea Region (BSR) OSIRIS Project, which serves as an ecosystem to develop and accelerate the adoption of innovative solutions to the challenges encountered by the ageing population so they may lead an active and independent life. It involves transnational functionalities that enable collaboration, co-creation and knowledge diffusion amongst the BSR. The DSH connects companies and research institutes to develop new innovative solutions to the challenges of ageing while promoting end-user engagement. However, it is imperative to ensure that the DSH functionalities are effective and useful and also sufficient for the users to develop innovative solutions. In this paper, the DSH is evaluated based on its usability and the effectiveness of its functionalities as well as ease of use and user perception to validate that the platform requirements match with the derived results. We use dimensions of the Technology Acceptance Model (TAM2); “Perceived Usefulness”, “Perceived Ease of Use”, and “Attitude Towards Using” the technology along with dimensions of generic Collective Intelligence (CI) framework; staffing, processes, goals and motivation to evaluate the DSH. The outcomes of the research are aimed to help develop and evaluate similar platforms meant for the silver economy.

Keywords: Information and Communication Technology, Digital Collaboration Platform, Platform Evaluation, Generic Collective Intelligence Model, Technology Acceptance Model

INTRODUCTION

The demographic makeup of the European Union (EU) is becoming predominantly *grey* in the coming decades (European Commission, 2021). The 65+ age group is considered by Euromonitor (2018) to be the *fastest-growing age cohort* with an expected 3.7% per annum growth (Euromonitor, 2018). Hence, this silver generation of older adults is healthier, more informed, and financially independent. They are interested in innovative solutions to improve their quality of life and are willing to spend on them. (Pauhofova & Dovalova, 2015). With the rapid evolution of technology, developed economies such as the EU and Baltic Sea Region (BSR) must capitalize on opportunities to address the challenges faced by ageing citizens (Anderberg, 2020).

The "Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth" – Interreg BSR OSIRIS project[1] was an initiative in the BSR countries to address the needs of ageing citizens by applying smart specialization approaches. The Digital Silver Hub (DSH)[2], a digital collaborative platform was created to develop and accelerate the uptake of innovative solutions to the challenges faced by the elderly population, promoting end-user engagement (Butt, et al., 2021). The DSH connects innovation actors representing the Quadruple Helix model (government, academia, industry, and civil society) to develop new innovative solutions (Arnkil, et al., 2010). The platform can also be used to issue invitations and arrange end-user participation at various stages of product development. It facilitates knowledge transfer and serves as an important tool for reaching out to other Baltics (Butt, et al., 2022). However, the evaluation of the DSH and its functionalities is imperative to ensure that the platform meets the expectations of its users and delivers effective and useful solutions.

Therefore, this study incorporates the evaluation of the DSH and how users respond to it using dimensions of the Technology Acceptance Model (TAM2): "Perceived Usefulness", "Perceived Ease of Use" and "Attitude towards using the technology" along with dimensions of generic Collective Intelligence (CI) framework: staffing, process, goals, and motivation. The remaining paper is organized as follows: section 2 describes the literature review, and section 3 outlines the research methodology used for the evaluation of the DSH. Results are elaborated in section 4 and discussion and recommendations are provided in section 5 and finish the paper with a conclusion in section 6.

LITERATURE REVIEW

Silver Economy and ICT

According to the United Nations (2020), the number of persons aged 65 and above was 727 million in 2020, which is expected to reach 1.5 billion by the mid-century (United Nations, 2020). This implies that by 2050, 1 out of 6 people in the world will be aged 65 or above. Grundy and Murphy (2017) posit that the percentage of older people in the population had already drastically increased between the years 1950 and 2000, especially in European countries (Grundy & Murphy, 2017). This demographic transition amongst the EU countries is also evident through their increasing median age; from 2000 to 2013, it has increased by a value of 3.9 years to 41.9 years. In 2021, the median age was 44.1 years which meant that half of the EU population was below 44 years and the other half was above 44 years of age. This median age is expected to rise to 48.8 years in 2100 (European Commission, 2021). Amongst the EU, the Baltic Sea Region (BSR) countries are termed among the *"most ageing areas of the world"* (Zvidriņš & Berziņš, 2012).

As the population ages and the percentage of older people in the total population increases, there is a dire need to address their needs. Pauhofova & Dovalova (2015) have identified two approaches towards this demographic shift. The first approach focuses on the negative impact of the ageing population on public finances and

[1] https://osiris-smartsilvereconomy.eu/about-project/

[2] https://silverhub.eu/

work dependency ratios. The second approach underscores the economic and social opportunities that accompany this longevity revolution. This approach has led to the emergence of the concept of a *"silver economy"* (Pauhofova & Dovalova, 2015). For this research, we use the definition by the European Commission as cited by Bran et al. (2016), *"silver economy is the amount of the economic opportunities arising from the public and consumer expenditure related to population ageing and the specific needs of the population over 50"* (Bran, et al., 2016).

The term ICT is multifaceted and has many implications in various disciplines. It stands for Information and Communication Technologies. According to Zhang et al. (2008), ICTs are *"technologies used by people and organizations for their information processing and communication purposes"* (Zuppo, 2012). ICT is a broad term that encompasses technologies that facilitate access to information via telecommunications. It includes a wide array of communication capabilities in the form of IoT (Internet of Things), wireless networks, cell phones/smartphones, and other similar information transmission media (Zuppo, 2012).

Eatock (2015) has identified the following sectors where ICT can help nurture the silver economy:

- healthcare sector (especially medical devices, pharmaceuticals and eHealth);
- construction of smart homes which provide independent living solutions
- personal and autonomous transport (incorporating ICT innovations to facilitate access of aged/disabled people to public transport services)
- personal banking and e-banking services
- tourism sector (entertainment and leisure activities for retired age citizens) (Eatock, 2015)

Collective Intelligence

Collective intelligence is referred to as the ability of a group of individuals to solve problems, make decisions, and achieve goals in a way that is greater than the sum of their abilities (Lazer, et al., 2009). According to Malone (1997), it is gaining popularity because of the ever-decreasing costs of communication that lead to new forms of decentralization as well as collaboration in organizations (Malone, 1997). CI has been studied through various perspectives including decision-making in organizations (Bodenhausen, et al., 1998), problem-solving in groups (Woolley, et al., 2010), and collective action in social movements (Friedkin & McLain, 2015).

Diversity is one of the key factors of CI as it brings new ideas and opinions on a subject matter (Surowiecki, 2004) (Bonabeau, 2009). Diverse groups as compared to homogenous groups outperform on tasks requiring collective intelligence (Page, 2007). Homogenous groups are at a higher risk of group-level biases but diversity helps as it adds perspectives and constructs an enabling environment to raise opinions. Moreover, communication patterns within a group play a critical role within CI as they are directly proportionate. The more the level of communication amongst the group, the more the collective intelligence (Kittur, et al., 2007).

According to Vaccaro et al (2016), online platforms like social media networks and collaboration tools have enhanced CI's functionality through real-time information sharing and collaboration on tasks (Vaccaro, et al., 2016). Early examples of CI platforms include WikiWikiWeb (Malone & Bernstein, 2015) (the first wiki) and GoldCorp (Bonabeau, 2009) (which utilized the collective knowledge of web users to identify new gold mining locations). Since then, progression in ICT technologies like the social web has enabled mass collaboration (Segaran, 2007) and led to the development of novel CI platforms like Wikipedia (Malone & Bernstein, 2015) (use the wisdom of the crowd to develop an online encyclopedia), Climate CoLab (Malone & Bernstein, 2015) (harness the collective knowledge of people to solve global climate issues), Tippanee (Pattanaik, et al., 2019) (harness the collaborative knowledge of web users to annotate the new content on the web), InnoCentive (Malone & Bernstein, 2015) (use the collective knowledge of the individuals to tackle societal issues) and Reddit (Weninger, 2014) (enable sharing of hobbies, ideas, passions and interests). To build these platforms, researchers have proposed many CI models or frameworks. CI frameworks help in understanding and explaining the concept of CI and its functionalities. Several frameworks have been introduced and some of them are listed in the table below.

Table 1: Summary of CI Frameworks

Framework/Model	**Author(s)**	**Description**
Wisdom of the Crowd (Galton, 1906)	Francis Galton	A concept that suggests that large groups of people are often better at making decisions and solving problems than individuals or small groups
Delphi method (Dalkey & Helmer, 1963)	Olaf Helmer and Norman Dalkey	A structured method for eliciting and synthesizing opinions from a panel of experts
Groupthink (Janis, 1991)	Irving Janis	A phenomenon that occurs when a group of people makes faulty decisions because group pressures lead to a lack of dissent
Social Comparison Theory (Festinger, 1954)	Leon Festinger	A theory that suggests that people evaluate their abilities and opinions by comparing themselves to others
Information Pooling (Lazer, et al., 2014)	Various	A type of collective intelligence that refers to the process of combining and integrating information from multiple sources to make more accurate decisions or solve problems
Collective Intelligence Quotient (CIQ) (Rouet, et al., 2006)	Jean-François Rouet and others	A measure of the collective intelligence of a group or system often used to evaluate the effectiveness of collaborative efforts
Genome Model (Malone, et al., 2010)	Thomas W. Malone and others	A model for understanding and predicting the behaviour of complex systems, inspired by the structure and function of genetic material in biology

Resource Allocation Framework for CI System Engineering (Vergados, et al., 2010)	Dimitrios J. Vergados and others	A framework for designing and evaluating collective intelligence systems that focuses on the allocation of resources such as time, money, and human capital to achieve specific goals or outcomes.

While there are several frameworks and models for CI, unfortunately, these models are domain-specific or use case-specific (Suran, et al., 2020), and also explained using different metaphors such as *"genes, system-specific elements, principles, attributes, requirements, or their combinations"* (Suran, et al., 2020). To overcome this problem (i.e, lack of a generic CI framework), Suran et al. proposed a 'generic' CI framework that allows researchers and stakeholders to simply combine different components of the model to develop the new CI platforms (irrespective of their domains) more effectively and efficiently.

The proposed DSH uses the dimensions from the generic CI framework proposed by Suran et al to evaluate and validate the platform. The CI model is based on four components: Staffing i.e., Who is Performing the Task?, Goals i.e., What is Being Accomplished?, Processes i.e., How is It Being Done?, and Motivation i.e., Why They are Doing It?; and these are again divided into types, properties, and interactions (Suran, et al., 2020).

Technology Acceptance Model

Davis, Bagozzi and Warshaw first introduced TAM in 1989 and since then it has been widely used to explain user acceptance behaviour (Davis, et al., 1989). According to this model, two factors that determine an individual's intention to use technology are; *Perceived usefulness (PU)* which is an individual's belief that using technology will help them to perform a task more efficiently and effectively. *Perceived ease of use (PEOU)* is an individual's belief that using the technology will be simple and convenient to use.

These factors contribute to the individual's intention to use and accept a technology which eventually translates to their actual use of the technology. However, TAM has also been widely criticized as it does not take into account the impact of external factors such as the availability of technical support or the presence of social influence, on an individual's intention to use technology. Therefore, further extensions to TAM have been introduced to fit the characteristics of different technologies and contexts (See Table 2).

Table 2: Key Constructs of TAM Extensions

Variant	Key Constructs	Additional Constructs	Key Features
TAM (Original) (Davis, et al., 1989)	Perceived usefulness (PU)		Developed to predict the acceptance and use of computer-based systems
	Perceived ease of use (PEOU)		
TAM2 (Venkatesh & Davis, 2000)	PU	Attitude towards using	Extends the original model by adding the AT construct, which represents an

		the technology (AT)	individual's overall evaluation of a technology
	PEOU	Subjective norm (SN)	SN represents the perceived social pressure to use the technology
TAM3 (Venkatesh, et al., 2003)	PU	Facilitating conditions (FC)	Extends the original model by adding the FC construct, which represents the external factors that facilitate or hinder the use of a technology
	PEOU		
Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, et al., 2012)	PU	Performance expectancy (PE)	Integrates several other theories of technology adoption into a single model
	PEOU	Effort expectancy (EE)	PE represents the belief that using technology will lead to improved performance
		Social influence (SI)	EE represents the belief that using technology will be relatively easy
		Facilitating conditions (FC)	SI represents the influence of others on an individual's adoption decision
			FC represents the external factors that facilitate or hinder the use of a technology

METHODOLOGY

For this research, we use dimensions of PU, PEOU and AT along with a generic CI framework to evaluate the DSH. The generic CI framework is a consolidated framework that is specifically designed to evaluate collective intelligence in groups and organizations, which is a key consideration for any platform that aims to facilitate collaboration and group decision-making. Moreover, the four components of the framework; staffing, process, goals and motivation along with additional requisites provide a comprehensive view of the factors that influence CI and further identify specific areas for improvement. While on the other hand, TAM is a well-established and widely used model for understanding how individuals adopt and use new technologies. By assessing perceived usefulness, perceived ease of use and attitude towards use, TAM2 can provide insight into how well the platform is meeting the needs and expectations of individual users. Both frameworks are grounded in solid theoretical foundations and have been tested and validated in numerous research studies. This provides confidence in the reliability and validity of the results obtained using these frameworks.

Four focus group sessions have been conducted in January 2023 with a total of 25 participants. In each focus group session, our team started with a comprehensive introduction to the core concept of the DSH and its various functionalities. This introduction consisted of:

- A presentation of the system's documented user dialogues (Butt & Draheim, 2022) in terms of a form-oriented dialogue model (Draheim & Weber, 2005), (Auer, et al., 2009), (Atkinson, et al., 2010).
- A demonstration of the recent web-based implementation of the Silverhub collaborative platform[3].

They were then given a questionnaire with close-ended questions that were developed based on the dimensions of the generic CI model and TAM2. After that, focus group interviews were conducted where structured questions, as well as open-ended questions, were asked of each participant. Focus group interviews are a qualitative research method to gather insights, opinions and attitudes of participants on a specific topic (Krueger & Morgan, 1997). Participants were from quadruple helix sectors; industry, government, academia and society (e,g., senior citizens) from the regions involved in the Interreg BSR OSIRIS project – Finland, Estonia, Denmark, Latvia, Lithuania and St. Petersburg. The interview responses were then analyzed using thematic analysis.

RESULTS

Interview Results

Participants evaluated the DSH keeping in mind their personal as well as organizational objectives. Responses from the interviews are analyzed through a thematic analysis and results are presented in the table below:

Table 3: Thematic Analysis of Interview Results

Themes	Description
Platform goals	Participants recognized the following goals that they can achieve through the DSH: • Research and innovation activities • Collaboration with other organizations and professionals • Encourage senior entrepreneurs to get involved • Find partners and markets for silver solutions • Attend cross-country projects
Functionalities and Services	The following functionalities and services were considered the most helpful and useful on the DSH: • Interconnected databases for financing • Feedback from different experts on innovative ideas • Possibility to search for partners and communicate with them • Collaboration tool for product development • Availability of discussion forum and chat functionality • Financial possibilities, and consultations • Information about open EU projects • Links to relevant social media channels, and events calendar

[3] https://silverhub.eu/

Diversity among platform members	Participants believed that DSH supports diversity in the following ways: • Fosters collaboration among all quadruple helix actors for mutual support • *“Members from different backgrounds and professional experiences provide feedback on different ideas”* • *“Open culture to hear the perspectives of different stakeholders”* • Possibility to view profiles of different actors for partner searching
Collaboration and Networking opportunities	Networking and collaboration opportunities are provided on the DSH but can be enhanced in the following ways: • Sharing knowledge and best practices • Facilitating business partnerships and deals • Providing access to funding and investment opportunities • Enhancing the visibility of members and their products/services • Boosting the competitiveness of the silver economy in the global market. • Clear common goals and strategy • Offering treats or benefits, using gamification • *“Including new, useful features based on user feedback”* • Information about cross-country projects and events
Support for leadership and decision-making	The majority of the participants believed that decision-making on such an open innovation platform could be challenging. They, however, suggested: • *“Platform should stay neutral and not be influenced by political actions”* • Democratic, principle of volunteering • Delegating tasks and voting can be useful • *“Different functionalities will need different ways”*
Support for a positive and supportive culture	DSH is an open platform which means that actors from various actors from different backgrounds will participate which can also lead to inappropriate conversations as well as abusive comments. Therefore, participants believed that a positive and supportive culture should be established in the DSH through the following ways: • Constructive comments for everyone • Creating a culture of communication, excluding inactive members • *“Through ease of use, understandable and straightforward interface, possibility to discuss problems and ideas together.”* • Digital coach-bot that could detect unacceptable language and report automatically to the admin.
Factors influencing attitude towards platforms	Participants shared different factors that affect their attitude positively when using different platforms and how these can be translated to their attitude towards DSH: • The added value of the platform • Supportive platform • Trust towards actors in the platform • The latest information in one place • Ease of use and variety of functions • Possibility of growing ideas into sustainable market products

Additional functionalities	Participants pointed to the following additional functionalities that they'd wish to add to the DSH: • Opportunity to subscribe to a newsletter • *"Information on new business options and e.g., public bidding competitions by using e.g., APIs."* • Project enhancement and development

Questionnaire Results

From the responses collected, it appears that the main purpose of the DSH is to share information, collaborate on projects, access resources or tools, and discuss ideas. 60% of the respondents agree that the platform supports diversity among its members in terms of their backgrounds, experiences, and perspectives. The majority of respondents also agree that the platform provides effective communication tools and features (See Figure 1).

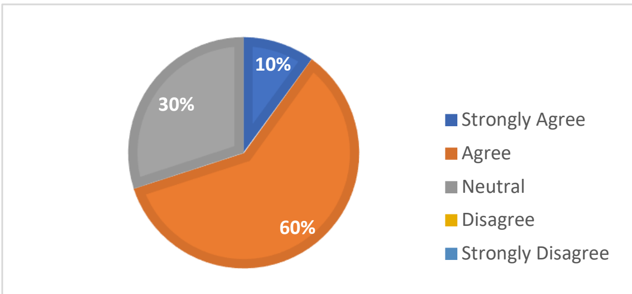

Figure 1: Does the Digital Silver Hub provide tools and features for effective communication among platform members?

In terms of the platform's decision-making structure, some respondents believe it should be democratic in nature, while others are neutral or have not formed an opinion yet. Respondents identified several reasons for participating in the platform, including gaining new knowledge or skills, connecting with others who have similar interests, contributing to a common goal, and earning money.

Regarding the platform's ability to facilitate collective intelligence, the respondents believe that the platform allows members to share their knowledge and expertise, collaborate and work together on tasks, and provides tools for brainstorming and idea generation. The overall satisfaction with the platform's performance and user experience varies among respondents, with some being very satisfied (20%) and others being neutral (40%) or somewhat satisfied (30%). The existing Silverhub collaborative platform's interface was also evaluated, with some respondents finding it easy to use and understand, while others found it somewhat easy. The interface's overall appeal was described as somewhat attractive. The majority of respondents found the platform useful in helping them achieve their goals, and many expect it to enhance the quality of their work. The user-friendliness of the platform was generally perceived positively, with the majority of respondents agreeing that they find the platform straightforward and intuitive to use and that they feel confident using it. The overall attitude towards the platform was positive, and the majority of respondents were likely to continue using the platform in the future.

DISCUSSION AND RECOMMENDATIONS

The results from the interviews identified several key themes that are imperative to the users of the DSH which include the objective and goals of the DSH, functionalities and services it offers, diversity of the platform members, provision of collaboration and networking opportunities, democratic leadership and decision making as well as a supportive and positive culture of the DSH.

Diversity and collaboration are two important factors in innovation ecosystems (Leigh, 2011) that further fuel the generation of new ideas and help decipher complex problems. The DSH gives immense importance to the collaboration factor as it enables individuals to share knowledge, expertise and resources to achieve a common goal (Chesbrough, 2010), which in this case is to come up with innovative ideas to tackle the challenges faced by the elderly in their everyday lives to help them become independent and active. This factor is further enhanced by the platform's ability to facilitate collective intelligence which enables a group of individuals and organizations to achieve goals and make decisions that surpass their individual ability and to collaborate and work together on tasks. Communication patterns also play a critical role in CI, with a higher level of communication leading to a higher level of collective intelligence (Kittur, et al., 2007). However, when there is diversity, there are conflicts also which means that this relationship has to be further explored. The DSH should strive to create a diverse and inclusive work environment that promotes harmony and understanding among its members.

Moreover, effective communication and decision-making have been highlighted where some respondents believed that the DSH should have a democratic leadership, everyone makes their own decisions but others were either neutral or have not decided yet. This leads to the importance of finding a balance between collaboration and decision-making that is both democratic and effective.

The user interface of the existing Silverhub collaborative platform had a mixed response where some respondents found it easy to use while others did not. This means that when DSH is fully established, the importance of usability in design should be considered (Barker & Rosen, 2013). According to Barker and Rosen (2013), platforms that are user-friendly and intuitive to use are more likely to be adopted and used by users (Barker & Rosen, 2013).

CONCLUSION

The DSH is a collaborative platform that supports innovation and knowledge diffusion among its users. The participants of evaluation sessions expressed that the DSH has clear goals and offers different functionalities and services that are beneficial for its users to enhance their innovative ideas and form collaborations. The DSH is also considered an ecosystem that promotes diversity among its users, providing effective communication and collaboration tools, and supporting decision-making through democratic principles. Moreover, the DSH was deemed user-friendly, provides a somewhat positive user experience, and is useful in achieving the goals and objectives of various users. Some of the areas that require improvement included enhancing collaboration and networking opportunities, maintaining a positive and supportive culture, and adding additional functionalities such as newsletter subscriptions and access to new business opportunities. In addition to this, it can also be concluded that CI is an essential component in online platforms and diversity and collaboration among platform members are crucial factors to enhance problem-solving and decision-making capabilities on the platform. Overall, the results suggest that the DSH has the potential to enhance the competitiveness of the silver economy and support its users in achieving their goals, to enhance the quality of their work. Further research is needed to understand the long-term impact of the DSH on its users and the silver economy.

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REFERENCES

Anderberg, P., 2020. Gerontechnology, digitalization, and the silver economy. *XRDS: Crossroads, the ACM Magazine for Students,* 26(3), pp. 46-49.

Arnkil, R., Järvensivu, A., Koski, P. & Piirainen, T., 2010. *Exploring quadruple helix. Outlining user-oriented innovation models. Working paper no 85,* Tampere: Work Research Center.

Atkinson, C., Draheim, D. & Geist, V., 2010. *Typed business process specifications.* Ulm, 14th IEEE International Enterprise Distributed Object Computing Conference, p. 69–78.

Auer, D., Geist, V. & Draheim, D., 2009. *Extending BPMN with Submit/Response-Style User Interaction Modeling.* Vienna, IEEE Conference on Commerce and Enterprise Computing, p. 368–374.

Barker, T. & Rosen, J., 2013. From design thinking to designing the innovation ecosystem. *Design Management Review,* 24(4), pp. 54-62.

Bodenhausen, G. V., Kramer, G. P. & Süsser, K., 1998. Pleasure principles in attitudes toward advertisements: The role of affective information processing. *Journal of Consumer Psychology,* 7(1), p. 1–36.

Bonabeau, E., 2009. Introduction. In: E. Bonabeau & G. Theraulaz , eds. *Swarm Intelligence: From Natural to Artificial Systems.* New York: Oxford University Press, p. 1–26.

Bran, F., Popescu, M. L. & Stanciu, P., 2016. Perspectives of silver economy in European Union. *Revista de Management Comparat International,* 17(2), p. 130.

Butt, S. A. & Draheim, D., 2022. Digital Silver Hub: User Dialogue Model Technical Document. *TechRxiv, Preprint*.

Butt, S. A. et al., 2021. *Designing A Digital Collaborative Platform for the Silver Economy: Inception and Conceptualization.* Quito, Eighth International Conference on eDemocracy & eGovernment (ICEDEG), pp. 47-54.

Butt, S. A. et al., 2022. A Digital Collaborative Platform for the Silver Economy: Functionalities Required by Stakeholders in a Multinational Baltic Sea Region Project. *TechRxiv. Preprint.*

Chesbrough, H., 2010. Open innovation: the new imperative for creating and profiting from technology. *Harvard Business Press.*

Dalkey, N. & Helmer, O., 1963. An experimental application of the Delphi method to the use of experts. *Management Science,* Volume 9, pp. 458-467.

Davis, F. D., Bagozzi, R. P. & Warshaw, P. R., 1989. User acceptance of computer technology: a comparison of two theoretical models. *Management Science,* 35(8), pp. 982-1003.
Draheim, D. & Weber, G., 2005. Modeling Form-Based Interfaces with Bipartite State Machines. *Journal Interacting with Computers,* 17(2), pp. 207-228.
Eatock, D., 2015. *The silver economy: Opportunities from ageing.* [Online] Available at: https://policycommons.net/artifacts/1336067/the-silver-economy/1942959/ [Accessed 27 December 2022].
Erlenheim, R. & Pappel, I., 2022. *The Role of Service Design in Increasing Regional Innovation in the Silver Economy.* Cham, Springer, pp. 11-20.
Euromonitor, 2018. *Consumers in 2018: Key Insights*. [Online] Available at: https://blog.euromonitor.com/consumers-in-2018-key-insights/ [Accessed 15 December 2022].
European Commission, 2021. *The 2021 Ageing Report. Economic & Budgetary Projections for the EU Member States (2019-2070),* Brussels: European Commission.
Festinger, L., 1954. A theory of social comparison processes. *Human Relations,* Volume 7, p. 117–140.
Friedkin, N. E. & McLain, D., 2015. A structural theory of collective action. *Annual Review of Sociology,* Volume 41, p. 375–397.
Galton, F., 1906. *Wisdom of the Crowd.* 75 ed. London: Nature.
Gordon, C., 2017. *A Silver Economy: The value of living longer,* New Zealand: SUPA-NZ.
Grundy, E. M. & Murphy, M., 2017. Population ageing in Europe. In: M. Jean-Pierre, B. L. Beattie, M. C. Finbarr & W. D. Jeremy, eds. *Oxford Textbook of Geriatric Medicine.* UK: Oxford University Press, pp. 11-18.
Janis, I. L., 1991. Victims of Groupthink. *International Society of Political Psychology,* 12(2), pp. 247-278.
Kittur, A., Chi, E. H. & Suh, B., 2007. *Crowdsourcing user studies with Mechanical Turk.* New York, Association for Computing Machinery (ACM), pp. 453-456.
Kittur, A., Chi, E. H. & Suh, B., 2007. *He Says, She Says: Conflict and Coordination in Wikipedia.* s.l., ACM, p. 61–70.
Klimczuk, A., 2016. Comparative Analysis of National and Regional Models of the Silver Economy in the European Union. *International Journal of Ageing and Later Life,* 10(2), pp. 31-59.
Krueger, R. A. & Morgan, D. L., 1997. *The focus group kit.* 2 ed. California: Sage publications.
Lazer, D., Kennedy, R., King, G. & Vespignani, A., 2014. The Parable of Google Flu: Traps in Big Data Analysis. *Science,* 343(6176).
Lazer, D. et al., 2009. Computational social science. *Science,* 323(5915), p. 721–723.
Leigh, B., 2011. The role of diversity in innovation ecosystems. *Journal of Business Venturing,* 26(3), pp. 331-343.
Malone, T. W., 1997. The dawn of the e-Lance economy. *Harvard Business Review,* 75(3), p. 144–150.
Malone, T. W. & Bernstein, M. S., 2015. Models and tools for harnessing the collective intelligence of online communities. In: J. J. Clippinger & B. J. Batya, eds. *The Biology of Business: Decoding the Natural Laws of Enterprise.* Santa Fe: Santa Fe Institute Press, p. 107–124.
Malone, T. W., Laubacher, R. & Dellarocas, C., 2010. The Collective Intelligence Genome. *MITSloan Management Review,* 51(3).
Page, S. E., 2007. *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies.* Illustrated ed. Princeton: Princeton University Press.

Pattanaik, P., Narasimhan, S. & Srinivasan, A., 2019. *Tippanee: A Web-Scale Collaborative Annotation Platform.* Shanghai, 29th ACM International Conference on Information and Knowledge Management, pp. 1-10.
Pauhofova, I. & Dovalova, G., 2015. Potential of Silver Economy in the European Union (SELECTED VIEWS). *European Scientific Journal,* 11(10).
Rouet, J. -F., Rose, F. & levonen, J., 2006. Developing a Collective Intelligence Quotient (CIQ) for Group Decision Support. *Journal of Educational Technology Development and Exchange,* Volume 1, pp. 1-15.
Segaran, T., 2007. *Programming Collective Intelligence: Building Smart Web 2.0 Applications.* 1 ed. Beijing: O'Reilly Media, Inc.
Suran, S., Pattanaik, V. & Draheim, D., 2020. Frameworks for Collective Intelligence: A Systematic Literature Review. *ACM Computing Surveys (CSUR),* Volume 53, pp. 1-36.
Surowiecki, J., 2004. *The Wisdom of Crowds.* 1 ed. New York: Anchor.
United Nations, 2020. *World Population Ageing 2020 Highlights. Department of Economic and Social Affairs.* [Online] Available at:
https://www.un.org/development/desa/pd/ [Accessed 22 December 2022].
Vaccaro, A., Dimitri, N. & Viale, G., 2016. Enabling collective intelligence: The role of social media and collaboration tools. *Technological Forecasting and Social Change,* Volume 111, p. 1–10.
Venkatesh, V. & Davis, F., 2000. A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science,* Volume 46, pp. 186-204.
Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D., 2003. User acceptance of information technology: toward a unified view. *MIS quarterly,* pp. 425-478.
Venkatesh, V., Thong, J. & Xu, X., 2012. Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly,* Volume 36, pp. 157-178.
Vergados, D. J., Lykourentzou, I. & Kapetanios, E., 2010. *A resource allocation framework for collective intelligence system engineering.* New York, Proceedings of the International Conference on Management of Emergent Digital EcoSystems.
Weninger, F., 2014. *Reddit.* [Online] Available at:
https://www.reddit.com [Accessed 22 December 2022].
Woolley, A. W. et al., 2010. Evidence for a collective intelligence factor in the performance of human groups. *Science,* 330(6004), p. 686–688.
Zuppo, C. M., 2012. Defining ICT in a boundaryless world: The development of a working hierarchy. *International journal of managing information technology,* 4(3), p. 13.
Zvidriņš, P. & Berziņš, A., 2012. Demographic development in the Baltic Sea Region. *Latvijas Zinātņu Akadēmijas Vēstis–A,* 66(5), p. 6.

Appendix X

[X]
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Lessons Learned from a Multi-National Project on Developing a Platform for the Silver Economy

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Abstract

The population is ageing rapidly worldwide, which is particularly apparent in Europe. Therefore, there is a shrinking working-age population per retiree, which has profound implications for society. In response to this challenge, the EU-funded project OSIRIS is developing a collaborative digital platform that allows the creation of new innovative solutions to tackle the ageing population's challenges and help them live independent and active life. Effective project management is crucial for the success of such a project. In this paper, we describe the project management structure of the OSIRIS project, analyze the project management plan, identify gaps and provide recommendations to improve the project management practices. The paper highlights the lessons learned from the perspective of project management methodologies, enterprise architecture management and from creating generalized customer journeys for such a platform. Our findings suggest that effective project management practices, including proper planning, risk management, communication and stakeholder engagement, are imperative for the projects' success. Overall, by sharing our experience and insights, this paper aims to provide valuable guidance for future research and development projects in the silver economy and technology field.

Keywords: Silver Economy; Project Management; Enterprise Architecture; Process Documentation

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1. Introduction

The European silver economy, representing a population of people over 55, ranks as the third-largest economy in the world, behind only the USA and China. This population segment will continue to grow as it is projected that by 2060, one in three Europeans will be over 65. This demographic change can be taken advantage of as a tremendous entrepreneurial opportunity, as it is predicted that by 2025, the silver economy will already contribute over 5.7 trillion EUR to Europe's economy [12].

Therefore, several initiatives are implemented by the public, private and academic sectors to identify solutions that help enhance the quality of life for the ageing population and enable them to contribute to the economy. One such initiative is the European Territorial Cooperation, known as Interreg, which is one of the European Union's (EU) Cohesion Policy goals that contribute to the *"harmonious economic, social and territorial development of the union as a whole."* [13] One of the Interreg Baltic Sea Region-funded projects is 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth' – OSIRIS[1]. The project was launched in January 2019 and finished in December 2021.

The project objectives are to improve innovation actors' capacity to apply smart specialization approaches for tackling the challenges of an ageing society in the region and to strengthen the ability of innovation actors to create and commercialize silver innovations in the Baltic Sea Region (BSR). It does so by developing and piloting the Smart Silver Framework as a joint innovation model and; boosting market uptake and scaling of user-driven technology innovations that demonstrate a significant impact on the quality of life of the ageing population, including age-friendly living environment, health, safety and leisure and address the needs of the silver economy market[1]. Many European countries are digitalizing, such as Estonia has developed e-government [4], along with digitalized workflows in various domains [5][6]. Thus, overcoming technological challenges in the silver economy is a logical measure to be taken.

This paper thoroughly analyzes the project management plan for the OSIRIS project and identifies areas where improvements can be made. The paper emphasizes the significance of project management methodologies and provides insights into challenges faced during the project, such as the need for sustainable outcomes and concrete project change management processes. The paper highlights valuable insights based on lessons learned throughout the project. The rest of the paper is organized as follows; in Section 2, we provide the project management structure of the OSIRIS Project. Section 3 describes lessons learned from the project management methodologies perspective. Section 4 explains lessons learned from an enterprise architecture management perspective. Scenarios and customer journeys are described in Section 5, and we finish with a conclusion in Section 6.

2. The Project Management Structure

The project management structure is organized to ensure effective and transparent governance. The project has established its Steering Committee comprising all partners' project coordinators1. The Lead Partner project manager is responsible for preparing project management guidelines which the Steering Committee must approve. As such, the Lead Partner holds the highest level of project management and is the primary contact point for communication with the Joint Secretariat and other Program authorities. Generally, the Lead Partner and the Steering Committee are responsible for strategic management, while the project coordinators are responsible for day-to-day project management and report to the Lead Partner. The project coordinators are typically responsible for tactical management.

The project was divided into the following six work packages (WP), and the Work Packages Lead's responsibilities included work package planning, executing, and monitoring at the operational level. Every work package has a dedicated team.

- WP1 – project strategic and tactical management
- WP2 – analysis of regional/national silver economy profiles, interregional learning and knowledge transfer

[1] https://www.osiris-smartsilvereconomy.eu/

- WP3 – designing Smart Silver Framework for increasing innovation actors' capacity to implement smart specialization strategies
- WP4 – piloting and Testing Smart Silver Framework
- WP5 – piloting and testing Silver Financing Mechanism

WP6 – designing and developing a virtual working environment for Digital Silver Hub (DSH).

Based on the initial plan, the risk was documented in the Risk Management Plan at the beginning of the project and approved by the Steering Committee. In case of any risks, the Lead Partner was responsible for implementing the appropriate risk mitigation actions strategy under the mutual consent of all partners. Moreover, each project coordinator was responsible for performing regular quality checks and notifying the Steering Committee and Lead Partner of any anticipated risks that could adversely affect the quality of the project.

The Lead Partner was responsible for reviewing and monitoring all project progress reports to ensure a high-quality standard of work. On the other hand, the Steering Committee will regularly perform quality checks, and in the event of any significant delays, the Lead Partner and other partners' project coordinators will decide to implement appropriate risk mitigation and elimination measures.

2.1. About the WP6

The scope of work package 6 is to document, develop and go live with the DSH (as a sustainable software tool). The DSH will integrate networked Smart Silver Labs operations, transnational accelerator functionalities and financial mechanism functionalities to facilitate the commercialization of innovative products or services developed using the Smart Silver Framework.

The created platform was planned to have five profiles; for scientists and R&D organizations; for companies; for local and national authorities; for RIS3 authorities, and; for end-users (citizens, patients, organizations). The main features that DSH was planned to support were communication functionality (forum; discussion panels; online chatting), information exchanging (newsletter, documents sharing; publishing options, resource centre (open science); partnering network), event information sharing (programs, calls, innovation contest, applications, assessment), partner search and cross-border accelerator functionalities, and investment facility functionalities (programs, applications, calls, RFP). The DSH is essential for reaching out and assuring access to any stakeholder and target group across the BSR.

Thus, the objective of work package 6 is to analyze the technical and operational functionalities to develop the DSH that must facilitate the durability, sustainability and transferability of project outputs.

3. Lessons Learned from Project Management Methodologies Perspective

The OSIRIS project is an international project with a remarkable budget indicating the need for a suitable project management methodology. While this information may have been available at the strategic level, it was never introduced to the operational level. Therefore, each work package can select its project and risk management methodology.

According to the PMBOK, all projects share similar characteristics: they are bounded, finite, and have specific deliverables that drive the project's scope [8]. Furthermore, each project must deliver a product or service; its benefits are usually realized after project closure. Typically, today's projects are cross-functional and involve teams of people with different skills working together temporarily to introduce a change that will impact others outside the team.

Project management is the planning, delegating, monitoring, and controlling of all aspects of the project and motivating those involved to achieve the project objectives within the expected performance targets for time, cost, quality, scope, benefits and risks [7]. At the beginning of the project, there was a broad consensus among the team members that the PRINCE2 (Projects in a Controlled Environment) approach would be most suitable for our project because PRINCE2 is frequently used for projects which deliver IT-related products; and because PRINCE2 is a structured project management method based on best practices.

In addition to PRINCE2, we used the Project Management Institute PMBOK (Project Management Body of Knowledge) as a standard source for continuous orientation in project management planning. We found it useful how PRINCE2 outlines the necessary tasks, assignees, and deadlines for a project, and PMBOK offered us a variety of methods for completing these tasks. For example, in PRINCE2, estimating is a critical step in creating a plan; however, PRINCE2 provides no further guidance on estimating, as several techniques can be applied depending on the project context. In contrast, the PMBOK explains and analyses the available estimating techniques so that the planner can determine the most appropriate utilization [8].

Based on PRINCE2, before implementation initiation, we developed and introduced our vision and mission statements to the project Steering Committee, Lead Partner and work package leaders to achieve a sense of direction. They were the following:

- Digital Silver Hub's vision is to support the life cycle of innovative solutions to tackle ageing challenges and enhance silver economy growth opportunities in the Baltic Sea Region.
- Digital Silver Hub's mission is to have a collaborative virtual platform where we can create, deploy and support innovative solutions to generate economic growth by using a smart specialization approach.

Since the DSH was still in the planning phase, the country representatives also introduced their vision of the basic functionality and how achieving our shared mission can be warranted. When initial requirements were collected, our team started to search for a possibility to ensure sustainability, as maintaining and developing an IT environment always incurs costs. After the end of the project, there must be some cash flow to cover the platform maintenance and further development costs. Unfortunately, the Steering Committee and Lead Partner had not considered the sustainability of the project results in the context of platform support costs. To eliminate the gap, we identified key competencies to support the platform. In addition, in the context of platform hosting, end-user support in their local language, and minimum further development to meet all countries' demands, we identified that the minimum cash flow per year is ca 400,000 EUR. This amount would cover licensing, hosting, a multilingual helpdesk, and country-based teams to satisfy potential customer expectations. We also considered unemployment insurance fees, funded pension fees, income tax and calculated income-tax-free minimums.

The project objectives were revised when the Steering Committee and the Lead Partner considered the costs of developing and maintaining the platform. The project scope was minimized, focusing on developing a web page with only the functionalities outlined in the proposal. There was a mutual agreement that the web page would be available online after the project had ended; however, concerns regarding the cost and sustainability of the platform were put on hold for now.

Thus, the first lesson learned here is that if the project aims at sustainable outcomes, the design of the business model needs to be among the project's goals.

As introduced above, IT applications with basic functionality need administration for managing various types of content, such as companies' information, financial instruments, and forum posts. The content varies between countries and languages, and as all the work packages produce new information, data accuracy may expire over time. With such large volumes of diverse data, it is not feasible for a single administrator to handle all the content in all project languages.

The second lesson learned here for the project strategic management team is: as early as possible, i.e. even before the information is collected from the several work packages in the first phase of the project, concrete and appropriate project change management processes must be developed, agreed upon, and implemented to ensure information accuracy throughout the whole project lifetime.

The project plan for work package six was created based on the PRINCE2 methodology, and software development was initiated. While the other work package leads and their teams were also performing their assigned tasks from different work packages, they lacked communication and coordination. This lack of communication hindered the overall understanding of the project objectives. As a result, the Lead Partner had to take on a more tactical and sometimes even operational role to keep the project moving forward. Due to the delays in the outcomes from other work packages, it became impossible to continue software development as planned.

Consequently, the project replanning for work package 6 was necessary, and the project management methodology had to be changed. In order to address the given challenges, we decided to engage other project partners and adopt an agile SCRUM-based approach. This methodology was chosen because it allows greater flexibility and adaptability to changing circumstances and enables the project team to respond better to unexpected changes in requirements [15].

4. Lessons Learned from an Enterprise Architecture Management Perspective

In the context of the OSIRIS project, sustainability means ensuring that the needs of the stakeholders are met in terms of information provision and consumption, software and platform administration and further development [2]. Therefore, it is important to understand the business processes in a virtual organization, such as the developed solutions, roles and responsibilities, customer journeys, number of customers, frequency and dynamics of their interactions with the solution, and the amount and structure of the data. Thus, the classical enterprise architecture management tasks must be resolved, as a virtual organization must be established to keep the solution running. When virtual enterprise architecture is not planned, there is a considerable risk that project outcomes may not be sustainable.

Enterprise architecture (EA) refers to how organizations standardize and organize IT infrastructure to align with business goals [3]. EA is the practice of analyzing, designing, planning, and implementing enterprise analysis to execute business strategies successfully [9]. EA helps businesses structure and standardize IT projects and policies to achieve desired business outcomes and stay on top of industry trends and disruptions using architecture principles and practices, also known as enterprise architectural planning. The main components of EA include business objectives and Key Performance Indicators (KPI), processes, risks and controls, Information and Communication Technology (ICT), documented knowledge and organization aspects that must be integrated into a coherent system. It can be done on paper, but there are also a lot of commercial off-the-shelf (COTS) tools in the market (e.g. QPR, Enterprise Architect, ARIS, Troux) as well as free-of-charge tools with limited functionality (Aris Express), which allows modelling of all predefined EA aspects.

The process models with related roles, capabilities, risks, objectives, KPIs, and corresponding control mechanisms act like insurance and would not let an organization sink. In addition, a role-based job description should be created to ensure clarity and accountability if roles are assigned to specific individuals or contractors from process models. The processes should be carefully designed, including analyzing roles related to software content administration and customer journeys, identifying requirements and determining the business processes prior to the system design process. Recently, unfortunately, it has been misunderstood that context diagrams, writing user stories, and identifying the functional and non-functional requirements are enough to build an IT system.

We have used a process decomposition framework [10] to describe processes (See Figure 1), which decomposes the process into phases, activities, and tasks or operations. The first level covers the enterprise process landscape and specifies how the enterprise is managed and how the company achieves objectives via processes. The second level is the logical grouping of process phases that describe managerial responsibilities to guarantee the expected process outputs. The third level is the activity level, representing the activities' sequence, value creation, desired inputs, and business rules. The fourth level is the task or operation level, which describes the responsibilities necessary to perform tasks, such as the sequence of operations, instructions, needed competencies, IT applications, risks, and business rules.

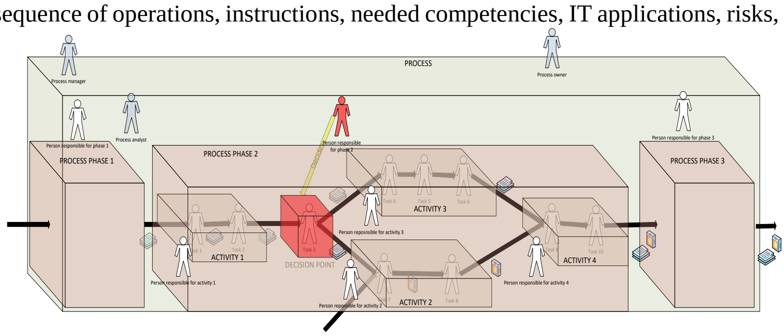

Figure 1: Process Documentation Framework Decomposition Logic [10]

For the first workshops with the Steering Committee and work package leads, we drafted the core process value chain for project specification at decomposition level 2 (Figure 2). We identified the main steps at decomposition level 3 and the actors involved (Figure 3).

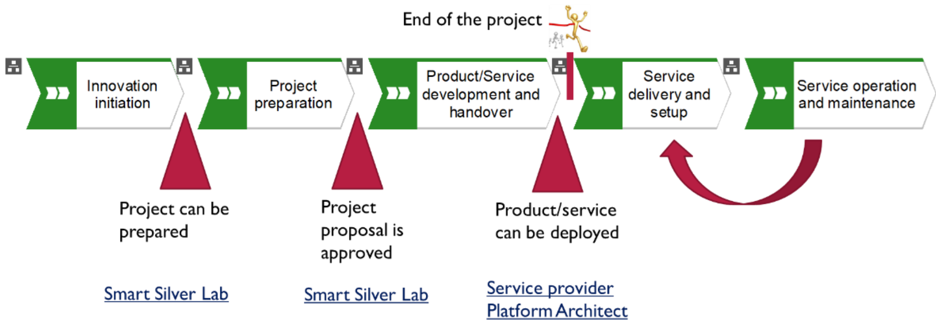

Figure 2: Initial Core Process Value Chain (Decomposition Level 2)

In Figure 2, the value chain objects are the green symbols to visually highlight the key components, while the red triangles represent process quality gates for the flow units. In addition, we also included the project timeline scope to emphasize that the process must continue running when the OSIRIS project has finished.

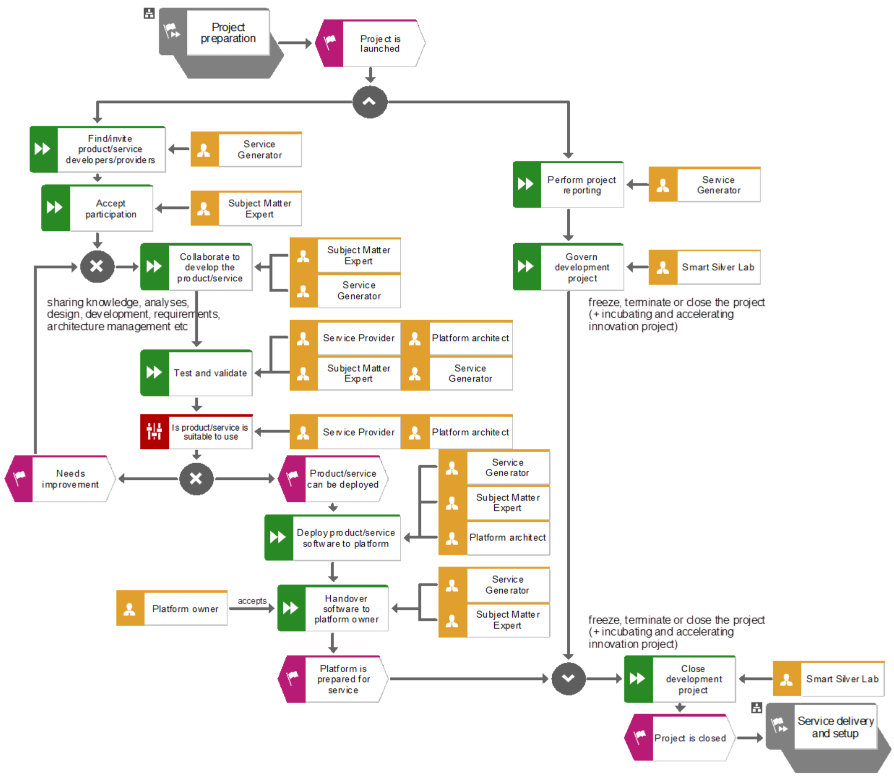

Figure 3: Sample of Product/Service Development and Handover (Decomposition Level 3)

The feedback from the meeting was encouraging, and the Steering Committee, Lead Partner and work packages Lead expressed their vision on ensuring the platform's sustainability; the process map was further developed, covering the planned value chain more precisely. After that, the work package 6 team identified the core processes, including generating and defining new product/service ideas, governing and managing product/service development programs, managing product creation, developing and managing IT services/solutions, managing IT resilience and risk, deploying IT services/solutions, creating and managing support IT services/solutions, and planning and managing customer service contacts.

All identified processes were decomposed until level 3, as shown in Figure 4. Moreover, the product creation management process, corresponding to the PRINCE2 approach, was also decomposed to level 4, representing specific tasks that process participants must do with the required inputs and outcomes. The ARIS software, hosted by TalTech, was used for this purpose, and based on the models, job descriptions were generated for each role.

However, enterprise architecture management as a discipline always demands to have its cost dimension. Therefore, a cost view was prepared to run such an organization, revealing that the Steering Committee and Lead Partner still needed to consider it further.

Thus, the third lesson learned here is that the most significant threat lies in an assumption that communication between parties is presumed to have taken place without proper documentation. It is imperative that a common understanding is documented and signed to minimize discrepancies, even when the participants are in the same physical location and sharing their opinions.

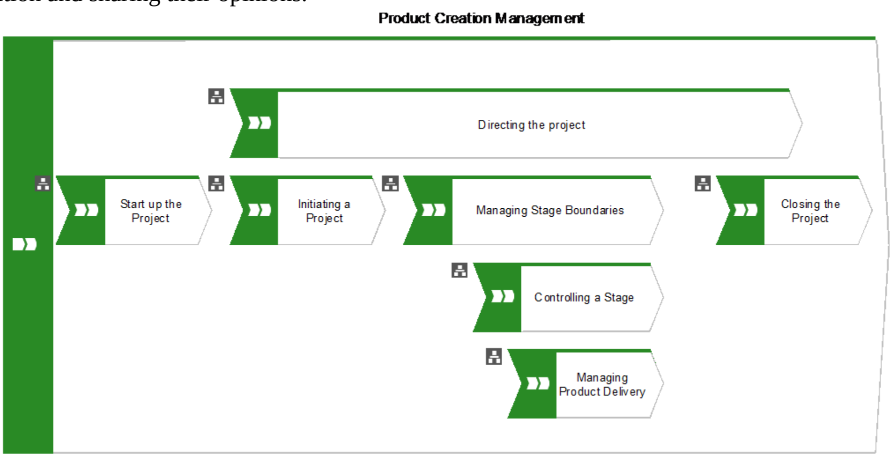

Figure 4: Sample of Process Decomposition in the Second Level

There was a lack of common understanding of the supporting organizational structure and processes required to support project outcomes from an architectural perspective. Therefore, we changed our approach and shifted our focus to customer journeys since work package 6 still needed to deliver its outcomes, which the local project coordinator controlled.

5. Scenarios and Customer Journeys

The enterprise architecture team analyses processes and often has exceptional views to analyze customer interaction with the company. Most customer-centric companies have dedicated personnel who study customer journeys to improve the customer experience. Tools such as the customer journey landscape, customer journey map and customer touchpoint map can help to analyze and prepare improvements to processes and user interfaces to enhance the digital customer experience as it is physically experienced [14].

Mostly, COTS EA tools have corresponding functionality for this purpose. Firstly, we attempted to identify the customer journey steps and then analyzed the customer touchpoints, step-related risks, weak points and assumptions, related capabilities, touchpoint owner, corresponding business process step, communication channels, and associated initiatives for improvement. This method is quite effective and widely used by telecom operators and banks.

Based on existing knowledge from project communication, the following DSH usage scenarios were identified; creating and providing innovative services for the local market; and extending service delivery to the foreign market. The existing DSH website can be accessed at silverhub.eu.

5.1. Innovative Service Creation and Provision for the Local Market

In this scenario, a research institution will conduct market analyses and identify an innovative business idea that caters to the needs of the silver economy. Potential partners and financial sources can be identified to develop the service on the DSH. An entrepreneur or non-profit organization will create a product or service that can be marketed initially on the DSH. Senior citizens can use the DSH portal to find all the necessary information about innovative solutions in the market and order the services if they decide to avail. This was planned for the minimum viable product; therefore, limited functionality is required, including making a catalogue structure, publishing structured content, and adding the tag system, search functionality and forum functionality for collecting feedback. It is a classical web-shop approach. Since the OSIRIS project covers different countries in the BSR, the DSH should have a landing page with standard information for all the countries. However, to address particular countries, each country should have its landing page in the local language.

5.2. Service Delivery Extension in the Foreign Market

In this scenario, the entrepreneur will already have the product or service and a strategy to expand the business to another country. Firstly the entrepreneur will have to understand country-based business constraints coming from legislation, financing support options and potential local partners for logistics, direct sales and customer support. When all necessary preconditions are fulfilled and risk analyses will be conducted, the entrepreneur can make its service available to the new market. Besides the fact that the service should be multilingual to cater to the language requirements of the target country, all other logic remains similar to in the local market.

5.3. Customer Journey Example

Although the OSIRIS project description outlines different user profiles, such as R&D organizations, companies, national authorities, and academic institutions, in general, their journeys in the DSH are quite similar and can be represented as follows:

i. The user enters silverhub.eu and chooses their country;
ii. Based on their chosen country, the user sees the description of available views and selects one;
iii. The user reaches the first page, which includes a welcoming (short description) text and a list of main categories;
iv. The user clicks on the category of interest and sees a list of subcategories;
v. The user selects a subcategory and sees a list of services that are filtered by the view, country, main category or subcategory;
vi. The user selects the service to learn more about;
vii. On the service page, there is a link that redirects to the actual service provider's website.

Alternatively, the user can use the search functionality to find a relevant service:

i. The user goes to the landing page and opens the search function.
ii. The user inserts a keyword that is relevant to the service that is being searched (e.g. funding)
iii. All services that match the filters of country, view, and contain the searched word in the headline are displayed on the search page.
iv. The user can then filter the results by categories.

After identifying the customer journeys, we introduced them to the potential end-users, leading us to the fourth and final lesson learned regarding presenting the generalized customer journey. We understand that end users may not frequently exhibit consistent behaviour, so creating a general customer journey that applies to all end users can be difficult. Thus, presenting the information tailored to the end user's specific situation is important, based on relevant examples covering data the end user already knows about [11].

6. Conclusion

The project has been completed, and the actual results pertaining to the developed DSH will be published by work package 6. This DSH will serve as an ecosystem to accelerate the uptake of innovative solutions and ensure long-term sustainability.

Throughout the project, valuable lessons came forward in project management that could benefit future projects. We realized the significance of having a well-defined business model to ensure sustainability. We also recognized the critical role of the change management process in guaranteeing that all stakeholders were aware of any changes in the project. Effective communication between all stakeholders should also be planned and maintained throughout the project's timeline because it is one of the critical factors to the project's success. Moreover, information which is crucial in the context of further steps must be formally approved. Lastly, we learned that presenting general information is insufficient for end-users needing personalized information to recognize their behaviour. Therefore, the information must be tailored to the particular needs of the end users to ensure that it is more relatable, reliable and understandable. These lessons can help improve project management practices and serve as guidance to ensure that future projects succeed.

References

[1] European Commission (2021) "Silver Economy Study: How to stimulate the economy by hundreds of millions of Euros per year." Available at: https://digital-strategy.ec.europa.eu/en/library/silver-economy-study-how-stimulate-economy-hundreds-millions-euros-year [Accessed 14 April 2023].

[2] Lehtinen, J., & Aaltonen, K. (2020). "Organizing external stakeholder engagement in inter-organizational projects: Opening the black box." International Journal of Project Management, 38(2), 85-98.

[3] Kotusev, S. (2019). "Enterprise architecture and enterprise architecture artifacts: Questioning the old concept in light of new findings. Journal of Information Technology", 34(2), 102-128.

[4] Pappel, I., Tsap, V., and Draheim, D. (2021) "The e-LocGov model for introducing e-governance into local governments: an Estonian case study." IEEE Transactions on Emerging Topics in Computing, 9(2): 597-611

[5] Tepandi, J., Lauk, M., Linros, J., Raspel, P., Piho, G., Pappel, I., and Draheim, D. (2017). "The data quality framework for the Estonian public sector and its evaluation." Transactions on Large-Scale Data and Knowledge-Centered Systems XXXV. Lecture Notes in Computer Science, 10680, 1-26.

[6] Pappel, I., Pappel, I., Tampere, T., and Draheim, D. (2017) "Implementation of e-invoicing principles in Estonian local governments." In Proceedings of the 17th European Conference on Digital Government (ECDG), edited by Borges, Vieira João and Rouco, José Carlos Dias. Academic Conferences and Publishing International Limited, 127−136.

[7] OGC (2009) "Managing Successful Projects with PRINCE2™." London, TSO (The Stationery Office).

[8] Project Management Institute (2017) "A Guide to the Project Management Body of Knowledge (PMBOK® Guide)." 6th Edition. Kindle Edition.

[9] White, S.K. (2018) "What is enterprise architecture? A framework for transformation." CIO.

[10] Kangilaski, T. and Ševtšenko, E. (2017) "Do we need capabilities in our management system?" Journal of Machine Engineering, 17(1): 88−100.

[11] Kangilaski, T. and Butt, S.A. (2021) "Silverhub, the tool which guides to have a brighter future – a retrospective." In Proceedings of the 14th International Conference on Theory and Practice of Electronic Governance (ICEGOV 2021), New York: ACM Press, 231−237.

[12] European Commission (2019). "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions." The 2018 Ageing Report: Economic and Budgetary Projections for the EU Member States (2016-2070). https://ec.europa.eu/info/sites/default/files/economy-finance/ip077_en.pdf

[13] Interreg Baltic Sea Region (2021) "About Interreg." Available at: https://interreg-baltic.eu/about/about-interreg/ [Accessed 14 April 2023].

[14] European Lin, D., & Lu, P. (2020) "Exploring customer journey maps and touchpoint maps to improve the digital experience." Journal of Business Research, 118: 328-337.

[15] Cohn, M. (2014) "Succeeding with Agile: Software Development Using Scrum." Addison-Wesley Professional.

Appendix XI

[XI]
Sidra A. Butt, Shweta Suran, Marina Weck, Ingrid Pappel, and Dirk Draheim. Design of a collective intelligence platform for facilitating the silver economy: An exhaustive user-centered evaluation. *IEEE TechRxiv. Preprint*, pages 1–37, 2023

Design of a Collective Intelligence Platform for Facilitating the Silver Economy: An Exhaustive User-Centered Evaluation

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Abstract

As the size of the silver generation grows, the demographic shift poses both challenges and opportunities in embracing innovation and technology. This study delves into the challenges and barriers faced by the silver generation when using digital platforms. It focuses on a collective intelligence platform, the Digital Silver Hub, and two age groups of older adults within the silver generation: adults aged 55 to 65 and those aged 65 and over. Semi-structured interviews were conducted with representatives of both age groups from the Baltic Sea Region. Thematic analysis results revealed challenges faced by each group, their expectations from the Digital Silver Hub, the importance of a user-friendly interface, concerns about data privacy and security, and the potential impacts of the platform. The research findings emphasize the importance of adopting a user-centric evaluation when designing the platform. The recommendations generated from this study can guide the development of user-friendly solutions, empowering and enriching the lives of the silver generation in our increasingly digitalized world.

Keywords: Silver generation, Information and communication technology, Collective intelligence platforms, Silver economy, Digital inclusion

1 Introduction

In the present century, demographic change has led to a higher population of the silver generation in societies all around the globe, including the European Union (EU). This change in population demographics has been explained as modifications in the age structure based on improvements in their living circumstances [1]. While this demographic change is affecting the entire global population, it is more evident in the developed areas of the world like Europe and North America [2]. Between 2019 and 2100, the number of old-age adults (those aged 80 years or above) is expected to increase from 5.8% of the population to 14.6% [3]. Gordon termed the silver economy the third-largest economy in the world after the United States and China, which holds massive opportunities for both the public and private sectors [4]. Therefore, it creates a wide scope of possibilities for policymakers and entrepreneurs to capitalize on the untapped potential of this emerging market.

As society shifts from an industrial to a digital nature, the technology landscape also evolves rapidly. Developed economies like the EU face a decreasing ratio of working-age citizens to retirees, which means the best path forward is to take advantage of the opportunities created by technology [5]. Information and Communication Technology (ICT) can be utilized to meet the needs of the aging silver generation; therefore, several digital and assistive technologies have been developed to open up new avenues for providing innovative solutions to improve the quality of life for the silver generation [6, 7]. The concept of smart aging is also gaining popularity because of its benefits, such as improved well-being and increased independence, consequently leading to lower healthcare costs [8]. Another example is City 5.0 which is a citizen-centric approach to city design, recognizing their role in shaping and providing services [9]. This approach is particularly important for the silver generation, as they often face obstacles and difficulties when trying to access services provided by the city. However, many existing solutions overlook the specific needs and preferences of different age groups within the silver generation, leading to usability issues and limited adoption [10–12]. In today's era, digital platforms have become increasingly significant for the silver generation [13]. They enable citizens to participate in different facets of life and maintain connections with their loved ones, regardless of distance. Whether it involves having video calls with family members, purchasing groceries, or even utilizing social media networks to reconnect with old acquaintances, these technological resources have expanded the horizons of the silver generation in countless ways [13]. However, these platforms are not without their challenges and limitations. While they offer potential, they also come with obstacles that require consideration and strategic solutions [14–16]. It is crucial to navigate these complexities in order to fully realize the benefits of platforms for meeting the needs of older adults [17]. Furthermore, it is essential to recognize that the silver generation includes different age groups, and they have distinct needs [18, 19]. These differences highlight the significance of tailored solutions that take into account the nuances within these age groups [20]. Acknowledging these varying needs and enhancing end-user involvement in the development process [9], along with an understanding of the challenges and possibilities at hand, becomes the first step towards paving a transformative path forward in enriching the lives of the silver generation.

The research paper aims to present a user-centric evaluation [21] to designing and developing a collective intelligence (CI) platform, Digital Silver Hub (DSH), that specifically addresses the challenges and barriers faced by the silver generation. This study focuses on two groups of older adults within the silver generation: adults aged 55-65 years old and those aged 65 and above. Therefore, the research question is: *How can the CI platform effectively address and mitigate common barriers and challenges for older adults by soliciting feedback from both age groups?*

The DSH platform, created under the EU Interreg Baltic Sea Region (BSR) OSIRIS project[1], acts as an ecosystem for innovation stakeholders, fostering the development and rapid adoption of innovative solutions addressing the challenges encountered by the older adults and facilitating their active and independent living. The DSH stakeholders represent innovation actors of the quadruple innovation helix model, Quadruple Helix (QH), which is a concept emphasizing broad collaboration in innovation between government, academia, industry, and civil society [22] represented by older adults. The DSH adopts the user-centric evaluation to drive and refine the design of the platform [21]. The user-centric evaluation ensures that such digital platforms effectively cater to the needs and preferences of the target stakeholders [23]. In this case, it is even more crucial to adopt a user-centric evaluation as the target user group represents the silver generation who have distinct characteristics and challenges. This study acknowledges the diverse expertise of the silver generation, and the designed DSH empowers them as co-creators by incorporating their valuable feedback and insights to help uncover barriers that otherwise may go unnoticed. In addition, the user-centric evaluation approach provides a perspective that also helps enhance user satisfaction and increase the technology adoption of the silver generation [21].

This study holds significant importance as it has the potential to contribute towards developing user-centered digital solutions that cater specifically to the unique needs and challenges faced by older adults. By integrating principles from ISO 9241-210 into the research process, we can ensure that the design and implementation of the CI platform adhere to recognized standards in human-centered design. This not only adds credibility to the research findings but also enhances their reliability and trustworthiness.

We proceed with the paper as follows. In Sect. 2, we conduct a literature review in regard of digital platforms for the silver generation and their user-centric evaluation. In Sect. 3, we describe the research methodology of the study. In Sect. 4, we provide a description of the Digital Silver Hub system. In Sect. 5, we report the results. In Sect. 6, we conduct a discussion on theoretical and practical implications, future work, and limitations. We finish the paper with a conclusion in Sect. 7.

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[1] https://osiris-smartsilvereconomy.eu/about-project/

2 Literature Review

2.1 Digital Platforms for the Silver Generation

According to Bran et al., the idea of industrialized economies around the globe constituting a growing population of older adults is not new [24]. However, it was not until the last decade of the 20th century that the dramatic increase in the number of aging population was truly acknowledged. Eatock claims that the concept of the silver economy gained popularity after the European Commission's paper on population aging in 2015 [25]. Grundy and Murphy define population aging as the "*process leading to the increase in the representation of older people in the total population*" [26]. Klimczuk identified population ageing as "*an increase in the length of human life*" [27]. He suggested that this has led to the interest in developing goods and services for older adult consumers and, hence, the concept of a silver economy [27]. ICT has played a vital role in helping the silver economy achieve digital inclusion as the aging population may perceive that digital technologies are valuable, makes them self-efficient and also fulfill their needs[2]. This has eventually led to more digital and ICT-based platforms and eventually revolutionized the way people socialize, search for information, and avail services [28]. Digital platforms can be considered a one-size-fits-all solution because of the flexibility and dynamicity of the platforms that they can be used for any product and service [29].

Boudreau and Hagiu elaborate on the significance of a multi-sided digital platform that allows interactions from different user groups, enabling knowledge exchange and collaboration [30]. The value created through these platforms is interdependent on the size of the group, where one group gains value when the size of the other group enlarges [31]. According to Ardolino et al., the infrastructure of such platforms should be designed in a way that allows two-way interaction as well as the transaction between the user groups; however, this is only possible when ICT is in place [32]. ICT allows online communication; therefore, devices like mobile phones, the internet, laptops, tablets, etc., are imperative for the platform to fulfill its function [33]. In order to foster user involvement, online communication tools are required to organize communication and interaction, which eventually also help in collecting data that helps streamline users' preferences and efficient use of resources [34]. For this study, we use the definition by Staub et al. as they defined the digital platform as a "*software-based system that: a) consists of a modular technological architecture, b) coordinates external actors that innovate and/or compete and c) can function as a central hub of an ecosystem, in which peripheral firms or individuals facilitate, complement and are connected via boundary resources*" [35].

There are several notable digital platforms now available that help older adults in their daily routines [36**?**, 37]. These platforms provide opportunities for older adults to build social connections [38], reduce isolation, access information, and avail of different services related to healthcare, housing, transport, leisure, and more. A list of some of the existing digital platforms with their functions is given below (Table 1).

While there are so many digital platforms and e-services available for the silver generation, there are some gaps and limitations that need to be considered [14–16, 39].

[2] https://ec.europa.eu/info/sites/default/files/1_en_act_part1_v8_0.pdf

Table 1 Existing Digital Platforms and Their Functions.

Platform	Function
AARP	A nonprofit organization that provides resources, advocacy, and community support for older adults in America.
Age UK	A charity in the United Kingdom that offers information, advice, and services to support older individuals and their caregivers.
Silver Line	A helpline in the UK that provides a 24/7 telephone service for older people seeking support, advice, or simply a friendly conversation.
Senior Planet	An organization that offers technology training and workshops to help older adults navigate the digital world and stay connected.
Elder Wisdom	An online platform where older adults provide advice, support, and wisdom to younger individuals who seek guidance.
SeniorNet	An international organization with chapters in various countries, including the Baltic Sea Region. They offer computer training, digital literacy programs, and support for older adults to enhance their digital skills and engage with technology.
AgingCare	An online community and resource platform offering information, support groups, and caregiving resources for families caring for aging loved ones.
60 and Me	A website and community created by Margaret Manning, offering inspiration, resources, and advice for women over 60.
Evermore	A platform that aims to redefine aging and offers resources, services, and communities for older adults to live purposeful lives.
Elder Orphan	A Facebook community that connects seniors who are aging without support from immediate family members.
Silvernest	A home-sharing platform that connects aging homeowners with compatible housemates, promoting inter-generational living and addressing housing challenges for older adults.
Aging Analytics	An organization that applies collective intelligence and data-driven analysis to understand the biology of aging and develop interventions for healthy aging.
Active Aging 2.0	An initiative that aims to enhance active and healthy aging by leveraging digital technologies and collective intelligence. It promotes collaboration among stakeholders in the Baltic Sea Region to develop and implement innovative solutions for older adults.
Senior Academy	An educational platform that offers learning opportunities for seniors in the Baltic Sea Region. It provides a collaborative environment where seniors can share knowledge, skills, and experiences with each other.
Gubbe	An online platform for home-care services for seniors that employs the young and encourages active aging.
VideoVisit	A software that supports remote care for seniors by incorporating digital visits into their nursing care plans.
Fiksari	A technology startup in Finland that aims to make the lives of seniors more technology-fluent.

Some digital platforms do not cater to the accessibility issues e.g. small font sizes or confusing navigations that could limit the ability of older adults to fully use the functionalities [40]. Moreover, the silver generation has diverse needs, especially among the two age groups: older adults aged 55-65 and those aged 65 and over [18]. They may have varying health conditions, cultural backgrounds, social influence, motivation to engage digitally, and technology literacy [17], which needs to be accounted for when developing solutions for this population segment and therefore lack personalized experience [41]. Most of the solutions lack offline support, which should be integrated to enhance the effectiveness of the solutions for the silver generation [42]. In addition, some platforms do not offer privacy, security, and trust, and therefore, the silver generation finds it challenging to use the platform with full confidence [43]. Digital platforms for the silver generation should be designed using the user-centric evaluation approach [44]. Digital platforms should address barriers that the aging population faces, such as age-related physical and cognitive impairments, digital literacy issues, accessibility problems, and social isolation [45]. Therefore, there is still room for improvement in terms of user-centric design, addressing barriers, and ensuring inclusion across different groups of the silver generation. These platforms should be dynamic and continuously adapt to the rapidly evolving technology; therefore, these platforms should seek user input and improve based on user feedback and changing needs [46].

2.2 Differentiating Needs of Older Adults

As the aging population grows and the technology landscape evolves, digital platforms have gained immense popularity [13]. However, for these platforms to be effective, it is imperative to understand the diverse needs and challenges of the silver generation. According to the United Nations, individuals aged 60 years or older are considered to be older persons [47]. However, different organizations have categorized the silver generation into three groups: the "young-old" (ages 60-75), the "old-old" (ages 75-85), and the "very old" (ages over 85) [48]. The research community also varies in their perspectives on defining this age group. Some consider individuals over 65 as older people [49, 50], while others regard those over 60 years as elders [51–53]. Additionally, different researchers define the elderly differently, with some defining it as individuals above the age of 55 [54–56], while others consider those aged over 50 to be elderly people [57, 58]. For the purpose of this study, we have defined two groups within the silver generation: older adults aged 55 to 65 and those aged 65 and over [18]. These two age groups have distinct characteristics, requirements, and challenges that must be addressed when designing a platform for the silver economy.

Older adults aged 55 to 65, also referred to as 'pre-retirees', are more familiar with technology and digital solutions because of growing up in the digital era [59]. They have an active lifestyle and mostly understand the importance of using technology in their everyday lives. They are socially more active and are generally proactive in maintaining their well-being. They are familiar with smartphones, laptops, tablets, and even online services [60]. However, adults aged 55 to 65 face barriers to technology adoption, especially in their careers. While the younger generation and technology replace most job positions, it becomes difficult to catch up with the changing work environment [61]. As more and more AI-assisted tools and digital platforms are introduced in the workplace, adults aged 55 to 65 may show some resistance to change [62]. Although these adults are better at using and adopting technology, not all individuals in this age group have the same level of digital literacy [63]. Therefore, adults aged 55 to 65 may also require intuitive, user-friendly designs and training when introducing new systems. Also, when adults aged 55 to 65 retire and seek opportunities, similar platforms for job searching they used earlier might not be so helpful [64]. Most job-seeking platforms focus on career development and networking opportunities; however, older adults aged 55 to 65 may need to look for opportunities for re-skilling, online learning, or freelancing jobs after retirement [65].

Older adults aged 55 to 65 are usually health conscious and focus on fitness; however, some may start facing initial signs of age-related health problems and may require specific lifestyle changes [66]. On the one hand, this age group may require platforms for fitness and nutrition, but on the other hand, they may also require services for managing chronic health issues. Moreover, older adults aged 55 to 65 are socially connected and engage in professional or recreational activities. Digital platforms also assist them in finding like-minded people and connecting to friends; therefore, platforms should be designed to address their need for community-building and networking [67]. However, stress management can still be an issue for this age group, with depression and anxiety disorders being the primary cause. It is identified that adults aged 55 to 65 can diagnose such mental health problems at an early stage and prevent them [68].

On the other hand, older adults aged 65 and over are even more diverse, with varying needs and experience with technology [69]. They face different barriers to technology adoption, such as physical challenges, acceptance barriers, technology literacy, technology usability, data management and privacy, and lack of access [70]. Many older adults aged 65 and over may have changes in skills as they age, such as changes in motor, cognitive, or sensory abilities [71]. As individuals age, their motor skills may decline, resulting in slower response times and significant variability in movement. Diseases such as arthritis may lead to swellings and further reduce the accuracy of using smart devices [71]. Declining motor skills also affect the ability to use input devices like the mouse; therefore, touchscreens are more feasible [72]. In addition, cognitive skills such as low memory capacity and less attention span and sensory skills such as vision and hearing impairments are significant challenges for this age group to adopt the technology [71]. Older adults aged 65 and over may also face mental health disorders, and it was found that detection and treatment rates amongst older adults remain low [68]. This leads to lower technology usability, and often, older adults find technology difficult to use and navigate. Small fonts, multiple buttons, and complex instructions hinder older adults from adopting the technology [70].

Compared to older adults aged 55-65, those aged 65 and over are less confident when using technology. Although older adults aged 65 and over accept the benefits of technology and are more interested in innovative solutions to help improve their quality of life, they are willing to spend on them, too [73]. Older adults aged 65 and over have a limited knowledge base and lower self-efficacy towards using technology. They constantly fear making mistakes, making them unlikely to use more than one technological solution [74]. Another concern for older adults is the social isolation that develops at their retirement age and consequently leads to health degradation [75]. Many social network services remain unusable as older adults aged 65 and over do not understand how those services can benefit them; they have problems with privacy, the interface is complex, complicated jargon is used, or they have no access to smart devices or the internet [76]. Moreover, Studies have found that lack of access to technology and infrastructure can be a significant barrier to ICT adoption for older adults aged 65 and over [77, 78]. This includes a lack of access to computers, the internet, and digital devices, as well as to training [79], support, and easy access helplines [80]. In addition, privacy and security are equally important concerns for both groups of older adults. Studies identified that if clear and transparent information about data collection and usage is not provided, it will most likely raise privacy concerns and lead to lower technology adoption [78, 81, 82]. Those services or platforms that provide feedback as a return on the value of data collected from older adults can increase their trust and understanding of technology [80].

2.3 User-Centric Evaluation in Addressing Barriers for the Silver Generation

Literature suggests that the key to effective product design for older adults is the users themselves [83]. However, designing products for older adults is a multifaceted task as it focuses on different factors such as their mental capabilities, the social and physical environment [84] and how much they are 'digitally marginalized' (i.e., "people who lack the skills or the access to developing skills for using the internet" [85]. Due to these factors, older adults aged 65 and over are frequently considered technically less ingenious than those aged 55-65 [86]. Thus, companies tend to develop products (systems or platforms) primarily for older adults aged 55-65 with complex features and options, such as newly implemented digital solutions during the COVID-19 crisis [87]; consequently, older adults aged 60 and over were not able to utilize such solutions. In order to enable all older adults to use the applications of web platforms, it is necessary to involve them in the early stage of the platform development process. Besides this, platforms for silver generation like Grandfolk[3], American Association of Retired Persons (AARP) [88], Suddenly Senior[4], ElderTreks [89], Seniors Only Club[5] and SeniorChatz[6] are quite popular but designing and development of such platforms are missing in scientific literature. Thus, it becomes crucial to investigate the underlying architecture of such platforms.

Furthermore, studies also stated that user interfaces of online platforms are not tailored according to the needs of two groups of the silver generation, thus resulting in frequent design modifications [90–93]. As a result, the silver generation is not able to utilize the platform appropriately and effectively [94] for accessing crucial services such as acquiring updated information about new policies, staying connected to friends for mental and social support, and accessing health services [93]. The main challenge in tackling such issues is to collect all relevant information from the silver generation, understand it, and effectively incorporate it into the design process. In the past few years, several approaches have been used to support the effective designing and development of crowd-oriented platforms for the silver generation, including inclusive design [95], universal design [96], user-centric design (UCD) [97], human-centered design [98], and equity-focused design [99]. Among them, user-centric design is always considered to be the most suitable as it specifically focuses on users and their requirements in every stage of the design process [100, 101]. UCD also provides different methods (like interviews, usability testing, scenario-based design, and participatory

[3] https://grandfolk.com/
[4] https://www.suddenlysenior.com/
[5] http://www.seniorsonly.club/
[6] https://www.seniorchatz.com/

design), tools (like prototypes and personas), guidelines (like universal design), and standards (like DIN 33402-2 and ISO) that enhance the requirement elicitation process [94] (see Table 2). With respect to older adults, UCD methods are considered crucial for the design of systems as they create solutions in stages where all features of the system are shaped in such a way that is easy to understand and use and evaluate the final solution with real-time users. Studies have found that poor system design choices that do not include the silver requirements are a key obstacle to performing essential activities [102–104]. Thus, it is essential to use different UCD approaches and international standards to build solutions that are easily and effectively used by our aging society.

Furthermore, ISO 9241-210 principles of the human-centered approach is the most suitable standard for user-centered design as it provides 7 principles (i.e., " suitability for the task, self-descriptiveness, conformity with user expectations, suitability for learning, controllability, error tolerance and suitability for individualization" [21]) for designing user interactive systems to make systems more serviceable by employing human factors and usability knowledge. Finally, user-centric evaluation is always considered a crucial process to find limitations, new requirements, future challenges, and the effectiveness of a system. Throughout the design process, system designers and developers take feedback on their products to gather information about how users interact with their designs, which components or features are intuitive, effective, challenging, and problematic, and what new modifications they want [21]. This feedback is used to improve the designs and ensure that the system fulfills all the needs of its users. By doing this, designers ensure that they are providing the best user experience and persistently improving their design [21].

3 Research Design

The qualitative research methodology was used for the study as the primary feature of this method is its flexibility to incorporate varying "world-views" of the actors involved [109]. Bryman associated qualitative research with "*participant observation, semi- and unstructured interviewing, focus groups, the qualitative examination of texts, and various language-based techniques like conversation and discourse analysis*" [110]. This research is part of the design science [111, 112] efforts conducted by OSIRIS - 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth'[7], an EU-funded project that responds to the changing needs of the silver generation of the BSR.

3.1 Participant Selection and Data Collection

For this research, qualitative data was collected with informed consent through interviews with 20 participants. These participants include the silver generation, divided into two groups: older adults aged 55-65 and those aged 65 and over. 10 participants were in the age group of 55-65, while the other 10 were aged 65 and above. The participants were from the six regions of the BSR: Denmark, Estonia, Finland, Latvia, Lithuania, and Russia (St. Petersburg). Purposive sampling was conducted to select

[7] https://osiris-smartsilvereconomy.eu/about-project/

Table 2 Different Types of UCD Methods.

Approach	Use-case	Some characteristics
Focus groups [105]	Requirements elicitation	•Utilize to obtain various perspectives, thoughts, or opinions on a certain topic. •It is essential to have a skilled moderator, facilitator, or researcher. •This can be done with a small sample size. •Mainly produce qualitative data.
Questionnaires and surveys [106]	Requirements elicitation & evaluation	•Use to acquire large amounts of statistical data about particular requests or challenges by asking a pre-defined set of questions. •Questions should be straightforward, real, and unbiased. •Require a large sample size. •Generate qualitative and quantitative data.
Interviews [83]	Requirements elicitation & evaluation	•Use in the early phases of the design process and provide in-depth information with respect to individual behaviour and needs. •Need a knowledgeable interviewer. •Different approaches are used to analyse answers. •Mainly produce qualitative data. •This can be done with a small sample size.
Usability testing [107]	Design & evaluation	•Primarily used to uncover digital accessibility and serviceability problems. •Allow users to interact with the prototype of the system in a live environment while the moderator, facilitator, or researcher takes notes. •Generate qualitative and quantitative data. •This can be done with a medium-small sample size.
Card sorting [108]	Design	•Mainly used to examine and design the whole architecture of a system. •The results of card sorting are used for suggesting intuitive classes and provide insights into how users feel about the system. •Mainly produce quantitative data. •This can be done with a medium-small sample size.
Participatory design [94]	Design	•Allow users to be actively involved in the creation of archetypes and decision-making processes. •Design sessions require a moderator, facilitator, or researcher with an in-depth understanding of the respective area. •Mainly produce qualitative data. •This can be done with a small sample size.

the participants to ensure that diversity in terms of gender, age, social and economic background, and technological proficiency is represented [113]. This allowed a comprehensive understanding of the needs and preferences of older adults by capturing a wide range of perspectives and experiences.

Semi-structured interviews with open-ended questions were conducted, and the individuals could expand on their responses. Interviews were, on average, 1 hour long. The interview with each participant was conducted in two parts, with the first part including a discussion about different barriers and challenges they face when adopting and using the technology. The second part involved showing the platform mockups, user dialogue models in terms of a form-oriented dialogue model [114–116] developed utilizing the Unified Modelling Language (UML), scenarios, and customer journeys [117], and web implementation of the SilverHub Platform[8] to the participants to provide a visual representation of the functionalities and features of the DSH. The participants then discussed the possible ways the DSH can help overcome some of the challenges they face, provided their feedback, gave suggestions, and provided valuable insights to the DSH.

3.2 Data Analysis

The data collected from the interviews were then transcribed, and a tool-based thematic analysis was conducted. Thematic analysis is a qualitative data analysis method that seeks to identify and categorize common or shared meanings within the given data [118]. Inductive analysis was conducted, and NVivo was used to generate codes and themes (Fig. 1). NVivo is a software tool created by QSR international for qualitative data analysis and facilitates researchers to classify, interpret, and analyze large amounts of unstructured non-numerical data [119].

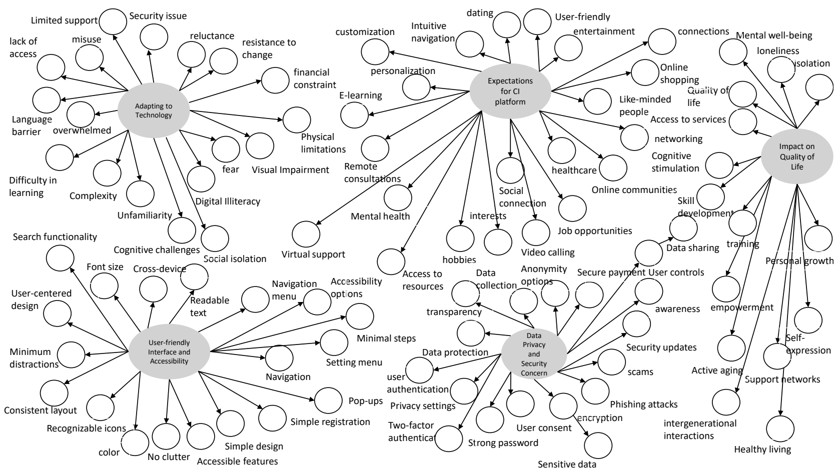

Fig. 1 Thematic map of the conducted interviews.

3.3 Integration of ISO 9241-210 Principles

The qualitative research methodology of the study seamlessly integrated the principles outlined in ISO 9241-210 [21]. These principles act as a guide for designing systems that

[8] https://silverhub.eu/

prioritize the needs of users and align with industry standards. The study incorporated the following principles into its research process:

1. Understanding Users, Tasks, and Environments: The study ensured that the platform and its functionalities were designed based on an understanding of user requirements, tasks, and the context in which they will be used. This understanding played a crucial role in participant selection and data collection.
2. Involving Users Throughout Design and Development: The study actively engaged users throughout the research process by seeking their input, collecting data from them, and integrating their feedback.
3. User-Centered Evaluation and Iteration: The study recognized the nature of design by incorporating user feedback to refine solutions and address any issues.
4. Considering the Entire User Experience: The research methodology took into account broader user experience beyond usability, including factors like support, training, and how users interacted with the system.
5. Multidisciplinary Design Team: The approach acknowledged the significance of a team with expertise and viewpoints working together to jointly create and build solutions that meet the requirements of a wide range of user groups. The team included subject matter experts, developers, UX designers, and quadruple helix actors from the six regions of the BSR.

By integrating these principles, the research approach guaranteed that the results of the study adhered to recognized standards in human-centered design for creating user-centric interactive systems, adding to the trustworthiness and reliability of the research findings.

4 System Description

The functionalities of the DSH are designed based on the components of a generic CI model [120], which include staffing, processes, goals, and motivation. The DSH platform is a collaborative space for various stakeholders and innovation actors, including private sector representatives, academicians, policymakers, and older adults. The success of the platform depends on the quadruple helix actors utilizing it effectively, with policymakers playing a crucial role in delivering public value, engaging older adults, identifying market gaps, and enhancing collaborative innovation in public administration [121]. older adults' participation is equally important as consultants on senior needs, and their contribution to developing innovative solutions on the platform is highly valued. Stakeholders can participate by sharing innovative ideas, discussing the feasibility of ideas, organizing training programs, and providing networks for collaboration. [122]

To measure the platform's success, it is crucial to have loyal users, regularly updated content, and successful collaborations. Social interaction is key, and integrated systems such as Zoom, Skype, and Teams facilitate smooth collaboration between innovation actors. Social media platforms like LinkedIn and Facebook can also be utilized to channel networking and build public relations. Chatting is preferred over video and voice calls to maintain privacy. [122]

The DSH platform is an open innovation ecosystem that enables the development, discussion, criticism, testing, and collaboration of innovative solutions. To protect ideas from being copied in the market, patent rights must be provided. Stakeholders must feel protected and trust the platform to share and work on their ideas, so incorporating patenting and copyrights is crucial. The decision-making structure is democratic, with no hierarchies, allowing everyone to make decisions for themselves and act responsibly. Contests can also be held to attract and encourage users to generate innovative ideas, with cash prizes or gift cards as rewards. [122]

External rewards play a significant role in driving the participation of stakeholders and innovation actors on the platform. For older adult participants, benefits include feeling significant and involved in creating products and services, combating social isolation and loneliness, accessing existing services conveniently, receiving tailored educational resources and training programs, and gaining access to assistive technologies and tools. The platform should be engaging, useful, and convenient to sign up for, enter, and navigate to ensure user retention. The government, incubation centers, and private sectors should be interested in financing the platform to support innovation development processes and address social challenges [122].

A smart specialization approach was employed to develop the DSH supporting the silver economy. Considering this, a Smart Silver Framework was developed, which represents a pilot cooperation model that enables collaboration between stakeholders and increases their capacity to generate economic growth through innovation. The Smart Silver Framework consists of three layers, with the first layer focusing on the quadruple helix actors. The second layer consists of infrastructure focus areas for each helix actor, and the third layer consists of classification and references. The Smart Silver Framework was evaluated and validated by each region and found to be flexible, scalable, and transferable [123]. A detailed report on the Smart Silver Framework is publicly available.[9]

The Smart Silver Lab is a multi-level governance structure that employs the Smart Silver Framework and serves as an open innovation ecosystem[10]. The Lab focuses on innovation actors and enables them to connect, coordinate, and build collaboration to develop innovative products and services for the silver economy in the BSR. The Lab uses the DSH to communicate and establish collaborations among its first layer of governance, which is the quadruple helix actors, to identify new trajectories. The Smart Silver Lab also has a repository for all innovative ideas called the Idea Lab, for all the innovative ideas that have been shared by the innovation actors, given feedback on and concluded, as well as the new and upcoming ideas as shown in the user dialogue model in Fig. 2. [123]

Innovation management becomes imperative, and innovation-supporting tools are put to use (Fig. 3). The Open Innovation Development Toolkit[11] supports the development of innovations and helps with prototyping, accelerating market uptake, and enhancing partnerships. The Silver Financing Mechanism[12] connects innovation actors

[9] https://osiris-smartsilvereconomy.eu/smart-silver-framework/
[10] https://osiris-smartsilvereconomy.eu/smart-silver-lab/
[11] https://silverhub.eu/ww/c/10054/p/1
[12] https://silverhub.eu/et/c/10064/p/1

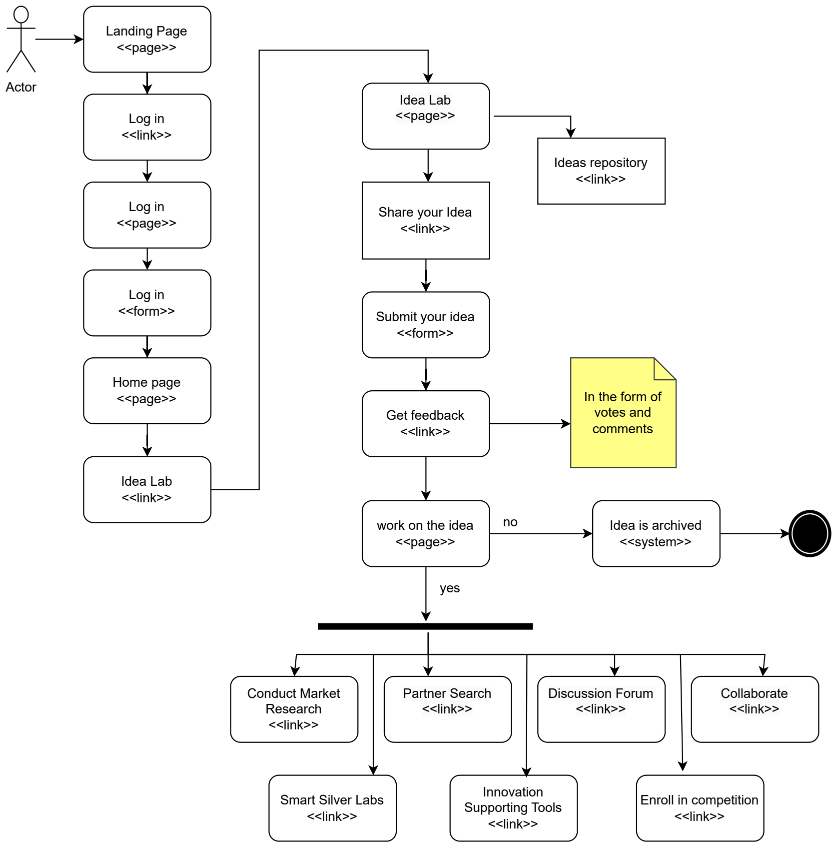

Fig. 2 User dialogue model of Idea Lab [124].

with various funding instruments, and the Knowledge Diffusion Toolkit[13] enhances the knowledge utilization, transfer, and reuse amongst the innovation actors. [123]

The DSH is a collaborative platform that emphasizes networking as an essential part of its mission. The goal is to enable quadruple helix actors to interact and exchange ideas, with the potential to partner on future projects. The platform offers discussion forums, which provide a social space for innovation actors to chat and share ideas, as well as a dedicated partner search function. The DSH also serves as an information hub for events and publications related to the silver economy. It includes a library of silver market characteristics, which can be updated and modified by users.

[13] https://silverhub.eu/et/c/10284/p/1

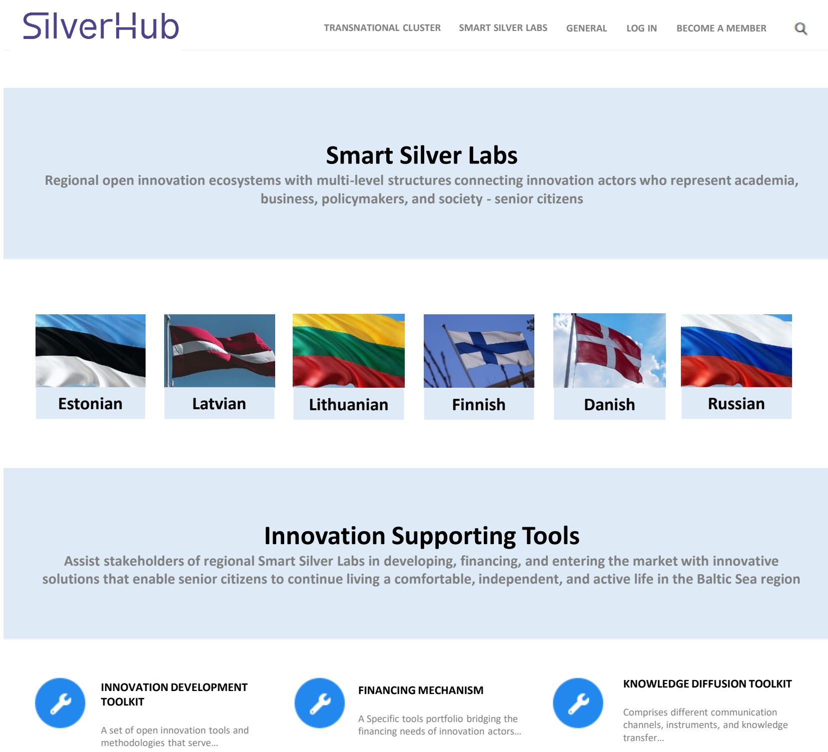

Fig. 3 Innovation supporting tools.

The most important feature of the DSH is its collaboration tools, which allow project owners and managers to invite new partners, assign tasks, create agendas and work-flows, schedule deadlines, and hold Zoom meetings. Users can also make notes, upload files, and archive projects that are no longer active as shown in the user dialogue model in Fig. 4. With these tools, innovation actors can work together efficiently and effectively. [123]

To use some of the functionalities on the DSH platform, users must sign up and log in with the correct email and password format. If entered incorrectly, users will be redirected to an error message and asked to re-enter their credentials. Once logged in, users can manage their accounts, edit their data, and change their passwords. [123]

Furthermore, users can conduct market research on the DSH through one-on-one discussions with different actors, building and sharing surveys, or organizing focus group discussions. Testers can incentivize participation in testing by offering gift cards

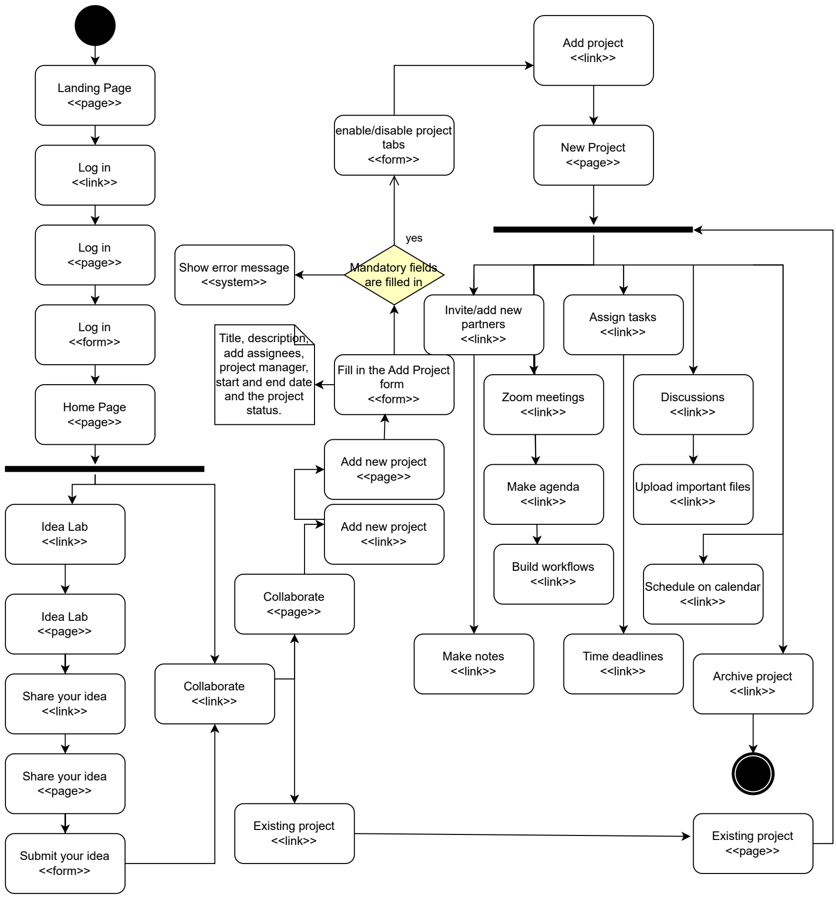

Fig. 4 User dialogue model of the collaboration tool [124].

or other rewards. Competitions are also an option for growing the DSH user base and encouraging innovative ideas. Competitions can be held on various themes related to the silver market and offer rewards like gift cards, prize money, or collaboration opportunities. [123]

The DSH also serves as an information library for all services and products for the silver generation and offers training and mentoring programs to help them learn technical skills. The platform includes an alert module that can be customized to display relevant content based on the user's country. Users can access the information library and training webpage without signing up or logging in. [123]

5 Results

An inductive thematic analysis was conducted, and the following themes were identified in Table 3.

Table 3 Themes.

Themes
Adapting to Digital Innovation and Technology
Expectations for a CI Platform
User-Friendly Interface and Accessibility
Data Privacy and Security Concerns
Potential Impact on Quality of Life

5.1 Adapting to Digital Innovation and Technology

Many people struggle to adapt to digital innovation and technology, especially seniors who struggle to keep up with rapid changes in an increasingly digitalized world. The interviews revealed several challenges faced by the silver generation.

One of the obstacles faced by older adults is their lack of familiarity with digital technology. Since many older adults grew up in an era without the use of computers and smartphones, they often struggle to navigate and utilize these devices effectively. Learning technologies can be frustrating for them, leading to feelings of inadequacy. One of the interviewees stated:

"It's becoming increasingly challenging for me to stay updated with all these gadgets. They seem complex and difficult for me to grasp."

Some older adults of both age groups shared how physical limitations hinder their ability to use devices efficiently. Visual impairment, arthritis, and other age-related health conditions can make typing on keyboards or reading text on screens challenging. One interviewee mentioned, "My vision isn't as good as it used to be, so I find it difficult to read text displayed on screens." In addition, financial constraints can also pose an obstacle for older adults when it comes to accessing and affording technologies. Devices like smartphones and computers as internet services can often be quite costly, especially for those living on fixed incomes. An 80-year-old interviewee said, "Considering my pension, purchasing a smartphone or paying for an internet connection is not something I can afford at the moment."

One common concern expressed by older adults is a fear of technology itself. This apprehension often arises from worries about making mistakes, falling victim to scams, or accidentally damaging their devices. An interviewee stated, "I've come across stories about individuals having their information stolen online. It makes me anxious about using these devices and services." However, older adults aged 55-65 were more confident and accepted technology with risks involved. Older adults aged 55-65 were using technology at their workplaces and were aware that adapting to technology was imperative to survive in the job market. Therefore, they were more well-versed with different technology intricacies and aware of cyber-hygiene. As one of the interviewees stated, "We use computers at work and are able to use them, but when a new tool is introduced, we need training, while younger employees are able to self-learn." However, when asked if older are comfortable with innovative changes at work, most of the interviewees in the age group of 55-65 were reluctant and confessed that they'd prefer rather no further changes till retirement. Therefore, another challenge encountered is resistance to change among both groups of older adults who have become accustomed to ways of doing things. This resistance extends to adopting technologies well, especially among older adults aged 65 and over. The majority of older adults aged 65 and over prefer calling a taxi by phone and going to the bank to pay bills instead of using e-services. However, if they were forced to use online services and there was no option of using conventional ways, only then were they willing to adopt. An interviewee of 65+ said, "I have been able to get by without relying on all this technology. I fail to see why I should start using it."

5.2 Expectations for a CI Platform

The interviewees were walked through different functionalities of the DSH, and their response was recorded, which leads to the second theme focusing on the expectations and desires of the silver generation regarding the DSH. Most of the interviewees perceived this platform as a solution to address some of their challenges and cater to their needs. Many seniors expressed their desire for the platform to help them connect with friends, family, and like-minded individuals. As social interactions tend to decline with age, having a platform that encourages and enables engagement becomes crucial in combating feelings of loneliness and isolation. One interviewee mentioned, "I'd be thrilled if this platform helps me communicate frequently with my grand kids!" Another interviewee stated, "It will be nice if this platform can help me find a date, as finding one at this age can be challenging." According to the interviewees, to meet this expectation, the platform must incorporate features that promote interactions such as video calling, messaging services, and online communities based on shared interests. Moreover, older adults hoped the platform would provide access to essential services such as healthcare, shopping, and entertainment. This convenience is especially valuable for seniors with mobility issues or limited access to stores and services due to factors like weather. One participant remarked "During bad weather, I wish I could order groceries and consult my doctor through the platform."

One key aspect that needs attention is creating a convenient and easy-to-use user interface. Since seniors have varying levels of digital literacy, it is essential to design an interface that's simple and intuitive. Interviewees stressed the significance of avoiding complexity or confusion. As one of the interviewees stated, "I prefer a platform that doesn't require me to read a manual. Keep it simple. I'll be more likely to use it." Interviewees mentioned that designers and developers should conduct usability testing with individuals to identify pain points and make improvements. The interface should be clean, with navigation, and prominently display essential features. Additionally, customization and personalization are highly desired by some seniors. They expressed an interest in accessing personalized content and services that align with their preferences; as one of them mentioned, "It would be great if I could see news articles tailored specifically for me, not just a bunch of random stuff." They preferred that the platform should incorporate customization options such as content filtering and preference settings. This will allow each individual user to have an experience tailored specifically for them. Personalization has the potential to enhance user engagement and satisfaction significantly.

Regarding learning and skill building, some interviewees expressed their interest in utilizing the platform to expand their knowledge and hone their abilities. They viewed it as an opportunity to delve into hobbies, acquire expertise, and keep their minds active. One interviewee even mentioned, “I’ve always had a desire to learn painting. Perhaps the platform could offer classes for that.” Therefore, the platform should provide a range of resources such as tutorials, courses, and interactive modules that facilitate learning.

5.3 User-Friendly Interface and Accessibility

During the interviews, the topic of a user interface stood out among older adults who emphasized the importance of simplicity and ease of use. Given the varying levels of literacy, seniors must have an interface that’s accessible and appealing to all users. It is essential to have an intuitive navigation system that allows older adult users to navigate through the platform effortlessly. Complex or cluttered navigation can cause confusion and frustration, and therefore, designers should prioritize an organized layout with recognizable menus and buttons. “I feel lost when there are buttons and options. I prefer something simple.” Considering that visual impairments are prevalent among individuals, ensuring readability is crucial in interface design; as one of the interviewees stated, “I strain my eyes when the text is too small or when colors are difficult to read.”

A simple and clutter-free design can benefit seniors as it reduces load and allows them to focus on the aspects of the platform. As one interviewee mentioned, a design without distractions helps them stay focused. To ensure a smoother user experience, it is important to avoid animations, pop-ups, and advertisements. The use of icons and imagery can greatly aid comprehension for seniors who may have difficulty with text-based information. As another interviewee mentioned, icons make things more apparent when they don’t understand all the words. To assist users in case they encounter difficulties, it is crucial to provide error messages and accessible help features. As an interviewee stated, having a message that explains what went wrong and what to do next is helpful.

The platform should also be responsive and adapt well to devices such as smartphones, tablets, and computers; as an interviewee said, ”I use my tablet frequently, so it’s important that the platform functions on it, too.” Ensuring compatibility across devices is crucial in making the platform accessible and allowing users to interact with it on their devices comfortably.

5.4 Data Privacy and Security Concerns

During the interviews, it became evident that data privacy and security are one of the biggest worries for the silver generation. Specifically, there were concerns about sharing information, particularly among older adults who may be more susceptible to online scams and data breaches. Therefore, building trust is crucial when addressing data privacy concerns. Interviewees emphasized the need for transparency regarding how their data will be collected, used, and protected. One interviewee expressed this sentiment by stating, “I would require assurance that my data won’t be misused or fall into the wrong hands.” The platform should clearly outline its data privacy policy and ensure that users are well-informed about how their data is handled.

Moreover, robust and reliable authentication methods can serve as a deterrent against access to user accounts and sensitive information. As one interviewee highlighted, “I worry about someone hacking into my account. Developers need to make sure it’s well protected.” Implementing measures such as two-factor authentication can significantly enhance account security but leads to complexity at the same time. However, older adults aged 55-65 were more comfortable sharing information like their name, company name, job position, and skills. However, email addresses and phone numbers should only be shared when approved to collaborate. One of the interviewees aged 55-65 stated, “I have nothing to hide, but I don’t want anyone to spam me.” Those aged 55-65 were also already aware of two-factor authentication and used it often for their bank and social media logins to secure their accounts. In addition, respecting user consent is a consideration when collecting and utilizing their data. The platform should prioritize the implementation of a consent mechanism that empowers users to make decisions about sharing their data.

Furthermore, it was highly stressed that the importance of being informed about scams and tactics employed by scammers should be discussed frequently on platforms such as the DSH. Incorporating resources into cybersecurity practices can equip users with the knowledge they need to protect themselves effectively. Addressing privacy concerns proactively, a few older adults suggested that providing options to use the DSH anonymously could enhance user comfort and encourage trial without revealing details. Therefore, the DSH should offer features that allow users to maintain anonymity while using certain platform features, as it can instill a sense of security and peace of mind among users.

5.5 Potential Impact on Quality of Life

The interviews discussed the potential impact of the DSH on older adults’ lives. Many interviewees expressed optimism regarding how this platform could enhance their quality of life, foster social connections, and provide support. Several interviewees aged 55-65 believed that using the platform could help them overcome feelings of loneliness and isolation by facilitating interactions and connections, especially after their retirement. Older adults aged 65 and over also acknowledge that the DSH can help them develop their social lives as one interviewee of 65+ stated, “Living alone sometimes makes me feel lonely. It would be wonderful to have a platform where I can talk to others.”

The ability of the platform to offer access to services was seen as a significant benefit. An interviewee stated, “Being able to access services without leaving home would be a relief, especially when I’m not feeling well.” However, having too many options in one place can be confusing, and a rating or testimonial system should exist. Such as for transport, only having different taxi services is not going to help, but if each service can be filtered in terms of wheelchair-friendly, supportive staff, pricing, and readily availability, it can help make choices more accessible and convenient.

Some of the interviewees in the age group of 55-65 mentioned that utilizing the educational resources and interactive features of the DSH could contribute to stimulation and cognitive well-being. They mentioned that after retirement, they would need something to keep them active, enrich their abilities, and enhance feelings of usefulness and significance. An interviewee said, "I want something that challenges my brain and keeps me engaged." Some of the features of the DSH, such as Idea Lab, partner searching, and collaboration tools, were appreciated by many seniors, especially the ones who plan to work on their business ideas. They emphasized that the DSH has the ability to empower individuals and promote their independence. An interviewee mentioned, "I don't want to feel reliant on others. It would be great to have a platform that supports my independence." Some seniors were also very interested in the opportunity of taking training and classes in their regions and/or online. They were primarily interested in learning different apps like SmartID and banking e-services to help them with daily routine tasks independently. By offering tools and resources that enhance autonomy, the platform can help individuals feel empowered.

6 Discussion

6.1 Theoretical Implications

The research findings have significant implications for improving our understanding of the challenges faced by the silver generation in the digital age. These challenges include unfamiliarity with technology, physical limitations, financial constraints, resistance to change, and a fear of technology [80]. Overcoming these obstacles is crucial for implementing and adopting platforms like the DSH that cater to the needs of the silver generation. Specifically, we must consider how platforms can impact their lives in terms of technology adoption, user interface design, and data privacy [80]. These implications provide valuable insights into the importance of creating platforms that cater to seniors' diverse needs and encourage their participation in the digital world [18].

The expectations of older adults from the DSH are varied and multifaceted. One key expectation is social connectedness, as many seniors express a desire to use the platform to stay in touch with family, friends, and like-minded individuals [67]. This highlights the importance of incorporating features encouraging interactions, such as video calling, messaging services, and online communities centered around shared interests [122]. Furthermore, access to services like healthcare, shopping, and entertainment is highly valued by seniors with mobility issues. The need for customization and personalization was also emphasized to ensure that content and services align with preferences [41].

Designing a user interface is crucial in order for older adults to navigate and use the platform effortlessly [93]. Simplifying the interface design using text icons, avoiding excessive clutter, and ensuring responsiveness across different devices (such as smartphones, tablets, and computers) are all important considerations in creating an accessible platform that caters to diverse user preferences [40].

Moreover, the issue of data privacy and security has become a concern for people, highlighting the need for transparent handling of data to build trust [43]. To address these concerns, it is crucial to implement authentication methods, obtain user consent, and provide cybersecurity education [78, 81, 82]. Additionally, offering options for anonymity can help users feel more comfortable and encourage them to try out services without revealing information.

The user-centric evaluation was utilized to design the DSH so that user input and feedback can be incorporated to ensure that older adults participate in co-creation and knowledge sharing on the DSH [21, 94, 97]. One very interesting outcome of the study is that the focus of the DSH should be on older adults aged 55-65 as they age and enter older age groups; they are more comfortable with technology and acknowledge that digital transformation is for their benefit [87]. They are the future of the silver economy, and if the right strategies and efforts are implemented, they can help contribute to the economy. Nonetheless, the DSH involves all age groups within the silver generation and tries to design the DSH that is impactful for the existing and upcoming silver generations.

6.2 Practical Implications

The research findings offer valuable insights and recommendations for the development, implementation, and promotion of digital platforms tailored to meet the needs of the silver generation. Collaboration among stakeholders, including governments, governmental organizations, technology companies, and educational institutions, is crucial in realizing the potential of platforms catering to the needs of the silver generation. Partnering with experts in aging, technology, and user experience will inform platform design while addressing challenges and delivering solutions. It is also important to prioritize user feedback and continually seek improvements to ensure that platforms meet seniors' evolving needs effectively. By regularly listening to input from seniors and involving them in the process of co-creation, platforms can stay relevant and have an impact [125].

The following are the summarized recommendations that have emerged as a result of the user-centric evaluation:

- It is crucial to design the DSH with a focus on user needs by considering the challenges and preferences of both age groups within the silver generation. Conducting usability testing with older adults will help identify areas for improvement and ensure an interface that is easy to use.
- Making sure the platform is accessible to users with physical and cognitive impairments is essential. Features like adjustable font sizes, easy-to-read text, and voice-activated commands can enhance usability for older adults.
- Adding personalization features that allow users to customize their experience based on their preferences can significantly enhance user engagement and satisfaction. Features like content filtering, preference settings, and personalized recommendations can cater to their needs.
- It is important for the platform to be dynamic and continuously adapt to the changing needs of the silver generation. Seeking user input, gathering feedback, and

regularly updating the platform to address evolving requirements are crucial for maintaining user engagement.
- Providing offline support options such as helplines and community centers can bridge the divide for the silver generation, who may have limited access to online services or face technological challenges.
- Building trust with users is essential, and this can be achieved through data handling practices. Clearly communicating the platform's data privacy policy and obtaining user consent for data usage are steps in establishing trust.
- Including resources on cybersecurity practices and raising awareness about scams can empower users to protect themselves while addressing concerns about data privacy.
- Collaborating with experts in aging, technology, and user experience can lead to solutions that effectively address the needs of the silver generation.
- Regularly evaluating the impact of the platform on seniors' lives through surveys and feedback can provide insights for continuous improvement and policy development.

6.3 Future Work

Although this research has provided valuable insights into the challenges and expectations of the silver generation when it comes to digital platforms like the DSH, there are still several areas that require further study. A cyclic, iterative process will be at the core of our research journey. To achieve this, we will prioritize engagement with users and continuously incorporate their perspectives and insights into the research and design process. Our iterative approach will enable us to refine our design solutions based on user feedback and the changing technological landscape. We are committed to responding to user input by adapting and enhancing the DSH platform, thereby effectively overcoming barriers faced by the silver generation while providing support for their digital interactions. Recognizing that the digital realm is dynamic and constantly evolving, our iterative approach allows us to remain flexible in tackling unforeseen challenges that may arise during the implementation of DSH. By refining design ideas, incorporating features, and adapting to evolving user requirements and technological advancements, the study will be thoroughly prepared to meet the changing landscape of user needs and technological progress.

Inclusive design is a crucial aspect that future research can explore, particularly in relation to the silver generation. This involves investigating design strategies that cater to a range of physical and cognitive abilities. Exploring the use of voice recognition, gesture-based interactions, and other emerging technologies can significantly contribute to creating platforms that are more accessible for seniors.

To maintain and improve user engagement among seniors on platforms, it is crucial to understand how to implement effective strategies. Future studies can explore techniques for ensuring that seniors continue to use these platforms in the long run. This can involve implementing gamification methods, offering personalized content recommendations, and providing incentives that align with the preferences and motivations of seniors. The progress made in technology, such as the Internet of Things

(IoT) devices and virtual reality, brings possibilities for enhancing the digital experiences of seniors. Future research can explore how these innovations can be integrated into platforms like the DSH to address challenges faced by seniors effectively.

Furthermore, it is essential to perform comparative analysis across different regions and countries to understand the unique characteristics, such as socio-cultural-economic factors, that influence ICT adoption and integration among the silver generation. By tailoring strategies and solutions for the specific needs of the silver generation in different regions, researchers can identify patterns and common characteristics. Additionally, exploring the user experience aspect of different platforms can help optimize the design and features for a more user-friendly experience. These features can be integrated into the DSH to increase its usability and accessibility to seniors in different regions.

Finally, the long-term sustainability of the DSH needs to be addressed. Factors such as funding, governance, and stakeholder engagement strategies need to be analyzed and implemented. To ensure the DSH's sustainability and maintainability, policies, daily practices, and user workflows should be made flexible and autonomous. Interoperability is also fundamental to ensure service ordering capability and secure cross-border data exchange. This helps to increase the collaborative capacity of organizations to provide innovative solutions [126]. Further research and deeper investigation are required to develop a transnational multi-stakeholder network focused on the silver economy to raise the DSH's capacity to support cross-border data exchange and innovative solutions.

6.4 Limitations

It should be noted that one limitation of this study pertains to the process of selecting participants and their characteristics. While we made efforts to ensure diversity in terms of age, gender, socio-economic background, and technological proficiency, the final group of participants may not fully represent the silver generation from different regions. Thus, the specific characteristics of the participants could impact how applicable the findings are to a range of demographics. The study was conducted in six regions within the BSR, including Denmark, Estonia, Finland, Latvia, Lithuania, and Russia (St. Petersburg). Nevertheless, it's essential to keep in mind that cultural differences and regional variations in technology adoption, usage behavior, and challenges may not be fully captured within this scope. Therefore, it's possible that these findings have limited relevance outside of these regions.

Moreover, the study engaged with participants over a relatively short period of time, which limits our understanding of how their perceptions and experiences with the DSH might evolve over the long term. To gain insights into the lasting impact of the platform on participants' digital interactions, a longer engagement period would be beneficial.

Despite using a purposive sampling approach for recruitment, there is still potential for bias. Those who volunteered for the study may have had an interest or proficiency in technology compared to others, potentially resulting in an over-representation of tech-savvy participants. This bias may impact the ability to apply the findings to seniors who are less familiar with technology. Moreover, it is worth noting that using

English as the language for data collection could unintentionally exclude a segment of the silver generation who are not proficient in English. This limitation is due to factors such as the language skills of the researchers and available resources. Therefore, the findings may not accurately reflect the experiences, difficulties, and preferences of adults who do not speak English. Different cultures and linguistic backgrounds can influence how technology is perceived in terms of digital interaction and the challenges faced. By focusing solely on English-speaking participants, valuable perspectives from individuals who primarily use other languages in their daily lives may be disregarded.

Finally, the fast pace of progress means that the digital environment is constantly changing. The features and functions of platforms designed to tackle challenges might become outdated or inadequate as new technologies emerge. Therefore, it's essential to update and adjust the platform to maintain its relevance.

7 Conclusion

Digital platforms designed for the silver economy have the potential to significantly improve the lives of the silver generation, enriching their connections, access to services, and overall well-being. However, to fully realize this potential, it is crucial to address the obstacles and challenges faced by older adults. This study explores how a digital collaborative CI platform, Digital Silver Hub, can effectively address and mitigate those barriers for the silver generation. By adopting a user-centered evaluation following the principles of ISO 9241-210, prioritizing accessibility, personalization, and transparency, and encouraging engagement, the DSH can bring about meaningful changes in the lives of the silver generation. It is also essential to consider different age groups within the silver generation, as each group has its own requirements. This research offers theoretical and practical implications for stakeholders designing digital collaborative platforms for the silver economy, emphasizing the importance of tailoring solutions to meet the specific needs of different age groups within the silver generation. As societies grapple with the challenges posed by an aging population, investing in platforms catering to the needs of the silver generation becomes beneficial and imperative in promoting active and healthy aging for future generations.

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References

[1] Linz, K., Stula, S.: Demographic change in Europe-an overview. Observatory for Sociopolitical Developments in Europe **4**(1), 2–10 (2010)

[2] Georgantzi, N.: In: Ayalon, L., Tesch-Römer, C. (eds.) The European Union's Approach towards Ageism, pp. 341–368. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-73820-8_21 . https://doi.org/10.1007/978-3-319-73820-8_21

[3] European Commission: The 2021 Ageing Report. Economic and Budgetary Projections for the EU Member States (2019-2070). Final report (2021). https://www.europarl.europa.eu/RegData/etudes/STUD/2022/729512/EPRS_STU(2022)729512_EN.pdf

[4] Gordon, C.: A Silver Economy: The Value of Living Longer. SUPA-NZ Wellington, New Zeland (2017). https://books.google.ee/books?id=rO2gzQEACAAJ

[5] Anderberg, P.: Gerontechnology, digitalization, and the silver economy. XRDS: Crossroads, the ACM Magazine for Students **26**(3), 46–49 (2020)

[6] Kim, K., Gollamudi, S., Steinhubl, S.: Digital technology to enable aging in place. Experimental Gerontology **88** (2016) https://doi.org/10.1016/j.exger.2016.11.013

[7] Barberà, R., Stack, J., Zarate, L., Pastor, C., Mathiassen, N., Knops, H., Kornsten, H.: Analysing and federating the European assistive technology ICT industry. Technical report, European Commission, Joint Research Centre (2009)

[8] Song, I.Y., Song, M., Timakum, T., Ryu, S., Lee, H.: The landscape of smart aging: Topics, applications, and agenda. Data and Knowledge Engineering **115**, 68–79 (2018)

[9] Becker, J., Chasin, F., Rosemann, M., Beverungen, D., Priefer, J., Brocke, J., Matzner, M., Rio Ortega, A., Resinas, M., Santoro, F., Song, M., Park, K., Di Ciccio, C.: City 5.0: Citizen involvement in the design of future cities. Electronic Markets **33**(1), 10 (2023) https://doi.org/10.1007/s12525-023-00621-y

[10] Hoque, R., Sorwar, G.: Understanding factors influencing the adoption of mHealth by the elderly: An extension of the UTAUT model. International Journal of Medical Informatics **101**, 75–84 (2017) https://doi.org/10.1016/j.ijmedinf.2017.02.002

[11] National Institute on Aging: The National Institute on Aging: Strategic Directions for Research, 2020-2025 (2020). https://www.nia.nih.gov/about/aging-strategic-directions-research

[12] Wang, S., Bolling, K., Mao, W., Reichstadt, J., Jeste, D., Kim, H., Nebeker, C.: Technology to Support Aging in Place: Older Adults' Perspectives. Healthcare **7**, 60 (2019) https://doi.org/10.3390/healthcare7020060

[13] Widmer-Iliescu, R.: Digital Technologies Can Help Older Persons Maintain Healthy, Productive Lives (2022). https://www.un.org/en/un-chronicle/digital-technologies-can-help-older-persons-maintain-healthy-productive-lives

[14] Cook, E.J., Randhawa, G., Sharp, C., al.: Exploring the factors that influence the decision to adopt and engage with an integrated assistive telehealth and telecare

service in cambridgeshire, uk: a nested qualitative study of patient 'users' and 'non-users'. BMC Health Services Research **16**(1), 137 (2016) https://doi.org/10.1186/s12913-016-1379-5

[15] Berridge, C., Wetle, T.F.: Why older adults and their children disagree about in-home surveillance technology, sensors, and tracking. The Gerontologist **60**(5), 926–934 (2020) https://doi.org/10.1093/geront/gnz068

[16] Peek, S.T.M., Wouters, E.J.M., Hoof, J., Luijkx, K.G., Boeije, H.R., Vrijhoef, H.J.M.: Factors influencing acceptance of technology for aging in place: A systematic review. International Journal of Medical Informatics **83**(4), 235–248 (2014) https://doi.org/10.1016/j.ijmedinf.2014.01.004

[17] Kebede, A.S., Ozolins, L., Holst, H., Galvin, K.: Digital Engagement of Older Adults: Scoping Review. Journal of Medical Internet Research **24**(12), 40192 (2022) https://doi.org/10.2196/40192

[18] Coto, M., Lizano, F., Mora, S., Fuentes, J.: Social Media and Elderly People: Research Trends, pp. 65–81 (2017). https://doi.org/10.1007/978-3-319-58562-8_6

[19] American Psychological Association: Guides for Older Adults (2023). https://www.apa.org/pi/aging/resources/guides/older

[20] Ipsos Thinks: The Perennials: the future of ageing (2019). https://www.ipsos.com/en-uk/perennials-future-ageing

[21] Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems (2010). https://richardcornish.s3.amazonaws.com/static/pdfs/iso-9241-210.pdf

[22] Arnkil, R., Järvensivu, A., Koski, P., Piirainen, T.: Exploring Quadruple Helix. Outlining user-oriented innovation models. Working Paper No 85 **85**, 130 (2010) https://doi.org/10.13140/RG.2.1.1883.2385

[23] Chammas, A., Quaresma, M., Mont'Alvão, C.: A Closer Look on the User Centred Design. Procedia Manufacturing **3**, 5397–5404 (2015) https://doi.org/10.1016/j.promfg.2015.07.656

[24] Bran, F., Popescu, M., Stanciu, P.: Perspectives of Silver Economy in European Union. Revista De Management Comparant International/Review of International Comparative Management **17**, 130–135 (2016)

[25] Eatock, D.: The silver economy: Opportunities from ageing. Technical report, EPRS: European Parliamentary Research Service (2015)

[26] Grundy, E.M., Murphy, M.: Population ageing in europe. In: Michel, J.-P.,

Beattie, B.L., Martin, F.C., Walston, J.D. (eds.) Oxford Textbook of Geriatric Medicine, 3rd edn., pp. 11–18. Oxford University Press, Oxford (2017)

[27] Klimczuk, A.: Comparative Analysis of National and Regional Models of the Silver Economy in the European Union. International Journal of Ageing and Later Life **10**, 31–59 (2016) https://doi.org/10.3384/ijal.1652-8670.15286

[28] Evans, P.C., Gawer, A.: The Rise of the Platform Enterprise: A Global Survey. The Center for Global Enterprise (2016)

[29] Hagiu, A., Yoffie, D.: What's Your Google Strategy? Harvard Business Review, April, 2009 **87**, 74–81 (2009)

[30] Boudreau, K.J., Hagiu, A.: Platform Rules: Multi-Sided Platforms as Regulators. In: Gawer, A. (ed.) Platforms, Markets and Innovation. Chapters, p. 29. Edward Elgar Publishing, United Kingdom (2009). Chap. 7

[31] Eisenmann, T., Parker, G., Van Alstyne, M.: Strategies for two-sided markets. Harvard Business Review **84**, 92–101149 (2006)

[32] Ardolino, M., Saccani, N., Adrodegari, F., Perona, M.: A Business Model Framework to Characterize Digital Multisided Platforms. Journal of Open Innovation: Technology, Market, and Complexity **6**(1), 1–23 (2020)

[33] Evans, D.S., Schmalensee, R.: Matchmakers: The New Economics of Multisided Platforms. Harvard Business Review Press, Massachusetts (2016). https://books.google.ee/books?id=pIhZCwAAQBAJ

[34] Dendere, R., Slade, C., Burton-Jones, A., Sullivan, A. C.and Staib, Janda, M.: Patient portals facilitating engagement with inpatient electronic medical records: A systematic review (Preprint). Journal of Medical Internet Research **21** (2018)

[35] Staub, N., Haki, K., Aier, S., Winter, R.: Taxonomy of Digital Platforms: A Business Model Perspective. In: Hawaii International Conference on System Sciences (HICSS 54), p. 10. IEEE Computer Society, USA (2021)

[36] Hermes, S., Riasanow, T., Clemons, E.K., B"ohm, M., Krcmar, H.: The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients. Business Research **13**(3), 1033–1069 (2020) https://doi.org/10.1007/s40685-020-00125-x

[37] Euromonitor International: Digital Seniors and the Metaverse Movement: Life for All Generations Moves Further Online (2023)

[38] Han, H., Xiong, J., Zhao, K.: Digital inclusion in social media marketing adoption: the role of product suitability in the agriculture sector. Information Systems and e-Business Management **19**(4), 1403–1426 (2021)

[39] Tomczyk, L., Mascia, M., Gierszewski, D., Walker, C.: Barriers to Digital Inclusion among Older People: a Intergenerational Reflection on the Need to Develop Digital Competences for the Group with the Highest Level of Digital Exclusion **9**, 5–26 (2023) https://doi.org/10.24310/innoeduca.2023.v9i1.16433

[40] Castilla, D., Garcia-Palacios, A., Miralles, N., Bretón-López, J., Parra, E., Rodriguez-Berges, S., Botella, C.: Effect of Web navigation style in elderly users. Computers in Human Behavior **55**, 909–920 (2016) https://doi.org/10.1016/j.chb.2015.10.034

[41] Ma, Q., Chan, A., Teh, P.: Bridging the Digital Divide for Older Adults via Observational Training: Effects of Model Identity From a Generational Perspective. Sustainability **12**, 4555 (2020) https://doi.org/10.3390/su12114555

[42] Boll, F., Brune, P.: Online Support for the Elderly? Why Service and Social Network Platforms should be Integrated. Procedia Computer Science **98**, 395–400 (2016) https://doi.org/10.1016/j.procs.2016.09.060

[43] Schomakers, E., Lidynia, C., Vervier, L., Gadeib, A., Ziefle, M.: Online privacy perceptions of older adults, pp. 181–200 (2017). https://doi.org/10.1007/978-3-319-58536-9_16

[44] Balakrishnan, S., Salim, S., Hong, J.: User Centered Design Approach for Elderly People in Using Website. In: Proceedings - 2012 International Conference on Advanced Computer Science Applications and Technologies, ACSAT 2012, pp. 382–387 (2012). https://doi.org/10.1109/ACSAT.2012.11

[45] Kumar, S., Ureel, L., Wallace, C.: Lessons from our elders: Identifying obstacles to digital literacy through direct engagement. In: ACM International Conference Proceeding Series (2013). https://doi.org/10.1145/2504335.2504357

[46] Morato, J., Sanchez-Cuadrado, S., Iglesias, A., Campillo, A., Fernández Panadero, C.: Sustainable Technologies for Older Adults. Sustainability **13**, 8465 (2021) https://doi.org/10.3390/su13158465

[47] United Nations: World Population Ageing 2020 Highlights (2020). https://www.un.org/development/desa/pd/content/world-population-ageing-2020-highlights

[48] World Health Organization: Active ageing: A policy framework (2002). https://apps.who.int/iris/bitstream/handle/10665/67215/WHO_NMH_NPH_02.8.pdf

[49] World Health Organization: World Report on Ageing and Health (2015). https://iris.who.int/bitstream/handle/10665/186463/9789240694811_eng.pdf;jsessionid=5B8E9E9CD6B2D8CFA6E34A4D7C2B3E3A?sequence=1

[50] National Institute on Aging: Global Health and Aging (2017). https://www.nia.

nih.gov/sites/default/files/2017-06/global_health_and_aging.pdf

[51] United Nations: Madrid International Plan of Action on Ageing (2002)

[52] Centers for Disease Control and Prevention: The State of Aging and Health in America 2011 (2011). https://www.cdc.gov/nchs/data/hus/hus11.pdf

[53] Rowe, J.W., Kahn, R.L.: Successful aging. The Gerontologist **37**(4), 433–440 (1997)

[54] Binstock, R.H.: Handbook of Aging and the Social Sciences. Academic Press, San Diego, CA (2010)

[55] Caro, S.A. F. G. Bass, Chen, Y.P.: The Elderly in America: A Statistical Portrait. ABC-CLIO, Santa Barbara, CA (1993)

[56] Cutler, S.J., Hodgson, L.G.: Measuring Aging. Springer, Cham, Switzerland (2001)

[57] Kinsella, K., He, W.: An Aging World: 2008. US Government Printing Office (2009)

[58] Rowe, J.W., Kahn, R.L.: Successful aging and disease prevention. Advances in Renal Replacement Therapy **5**(3), 223–232 (1998)

[59] Taipale, S., Hänninen, R.: More years, more technologies: Aging in the digital era. Human Technology **14**, 258–263 (2018) https://doi.org/10.17011/ht/urn.201811224833

[60] Rosales, A., Fernández-Ardèvol, M.: Beyond whatsapp: Older people and smartphones. Romanian Journal of Communication and Public Relations **18**, 27 (2016) https://doi.org/10.21018/rjcpr.2016.1.200

[61] Meyer, J.: Older workers and the adoption of new technologies. SSRN Electronic Journal (2008) https://doi.org/10.2139/ssrn.1010288

[62] Borghans, L., Weel, B.: Do older workers have more trouble using a computer than younger workers? Research in Labor Economics **21** (2002) https://doi.org/10.1016/S0147-9121(02)21009-2

[63] Eshet-Alkalai, Y., Chajut, E.: Changes over time in digital literacy. Cyberpsychology and behavior : the impact of the Internet, multimedia and virtual reality on behavior and society **12**, 713–5 (2009) https://doi.org/10.1089/cpb.2008.0264

[64] Karaoglu, G., Hargittai, E., Nguyen, M.H.: Inequality in online job searching in the age of social media. Information, Communication and Society **25**, 1–19 (2021) https://doi.org/10.1080/1369118X.2021.1897150

[65] Lyons, B., Wessel, J., Tai, Y., Ryan, A.: Strategies of job seekers related to age-related stereotypes. Journal of Managerial Psychology **29**, 1009–1027 (2014) https://doi.org/10.1108/JMP-03-2013-0078

[66] Watts, A., Rydell, S., Eisenberg, M., Laska, M., Neumark-Sztainer, D.: Yoga's potential for promoting healthy eating and physical activity behaviors among young adults: A mixed-methods study. International Journal of Behavioral Nutrition and Physical Activity **15** (2018) https://doi.org/10.1186/s12966-018-0674-4

[67] Wherton, J., Sugarhood, P., Procter, R., Greenhalgh, T.: Designing technologies for social connection with older people. Aging and the Digital Life Course **3**, 107–124 (2015)

[68] Wetherell, J.L., Petkus, A.J., McChesney, K., Stein, M.B., Judd, P.H., Rockwell, E., Sewell, D.D., Patterson, T.L.: Older adults are less accurate than younger adults at identifying symptoms of anxiety and depression. The Journal of nervous and mental disease **197**, 623–626 (2009) https://doi.org/10.1097/NMD.0b013e3181b0c081

[69] Fausset, C., Harley, L., Farmer, S., Fain, B.: Older adults' perceptions and use of technology: A novel approach, pp. 51–58 (2013). https://doi.org/10.1007/978-3-642-39191-0_6

[70] Gitlow, L.: Technology use by older adults and barriers to using technology. Physical and Occupational Therapy in Geriatrics **32** (2014) https://doi.org/10.3109/02703181.2014.946640

[71] Wallace, S., Graham, C., Saraceno, A.: Older Adults' Use of Technology. Perspectives on Gerontology **18**, 50–59 (2013) https://doi.org/10.1044/gero18.2.50

[72] Czaja, S., Lee, C.: Designing computer systems for older adults, 413–427 (2002)

[73] Pauhofova, I., Dovalova, G.: Potential of silver economy in the european union (selected views). European Scientific Journal, ESJ **11**(10) (2015)

[74] Caspi, A., Daniel, M., Kavé, G.: Technology makes older adults feel older. Aging and Mental Health **23**, 1–6 (2018) https://doi.org/10.1080/13607863.2018.1479834

[75] Joinson, A.: Looking at, looking up or keeping up with people?: Motives and Use of Facebook, pp. 1027–1036 (2008). https://doi.org/10.1145/1357054.1357213

[76] Coelho, J., Duarte, C.: Socially networked or isolated? Differentiating older adults and the role of tablets and television. In: 15th Human-Computer Interaction (INTERACT), pp. 129–146 (2015). https://doi.org/10.

1007/978-3-319-22701-6_10 . Springer

[77] Neves, B., Amaro, F., Fonseca, J.: Coming of (Old) Age in the Digital Age: ICT Usage and Non-Usage among Older Adults. Sociological Research Online **18** (2013) https://doi.org/10.5153/sro.2998

[78] Wang, S., Bolling, K., Mao, W., Reichstadt, J., Jeste, D., Kim, H., Nebeker, C.: Technology to support aging in place: Older adults' perspectives. Healthcare (Basel) **7**, 60 (2019) https://doi.org/10.3390/healthcare7020060

[79] Tams, S., Grover, V., Thatcher, J., Ahuja, M.: Grappling with modern technology: interruptions mediated by mobile devices impact older workers disproportionately. Information Systems and e-Business Management **19**(4), 1377–1401 (2021)

[80] Butt, S.A., Lips, S., Sharma, R., Pappel, I., Draheim, D.: Barriers to Digital Transformation of the Silver Economy: Challenges to Adopting Digital Skills by the Silver Generation. In: 14th International Conference on Applied Human Factors and Ergonomics (AHFE 2023). Springer, California, USA (2023)

[81] Bianchi, C.: Exploring how internet services can enhance elderly well-being. Journal of Services Marketing **ahead-of-print** (2021) https://doi.org/10.1108/JSM-05-2020-0177

[82] Pirhonen, J., Lolich, L., Tuominen, K., Jolanki, O., Timonen, V.: "These devices have not been made for older people's needs" – Older adults' perceptions of digital technologies in Finland and Ireland. Technology in Society **62**, 101287 (2020) https://doi.org/10.1016/j.techsoc.2020.101287

[83] Sujan Samuel Roy, J., Neumann, W.P., Fels, D.I.: User centered design methods and their application in older adult community. In: Yamamoto, S. (ed.) Human Interface and the Management of Information: Information, Design and Interaction, pp. 462–472. Springer, Cham (2016)

[84] White, P.: Designing products for older people's social and emotional needs: a case study. Anthropology & Aging **43**(2), 24–39 (2022)

[85] Eickers, G., Rath, M.: Digital change and marginalized communities: Changing attitudes towards digital media in the margins (2021)

[86] Munteanu, C., Axtell, B., Rafih, H., Liaqat, A., Aly, Y.: Designing for older adults: overcoming barriers toward a supportive, safe, and healthy retirement. Pennsylvania: University of Pennsylvania (2018)

[87] Morrison, B.A., Nicholson, J., Wood, B., Briggs, P.: Life after lockdown: The experiences of older adults in a contactless digital world. Frontiers in Psychology **13** (2023) https://doi.org/10.3389/fpsyg.2022.1100521

[88] Engelberg, M.: An identity, branding, and positioning system overview. Social Marketing Quarterly **6**(3), 119–120 (2000) https://doi.org/10.1080/15245004.2000.9961135

[89] Vigolo, V.: Strategic and Operational Marketing Tools for Older Tourists, pp. 157–176. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-47735-0_7

[90] Awan, M., Ali, S., Ali, M., Abrar, M.F., Ullah, H., Khan, D.: Usability barriers for elderly users in smartphone app usage: An analytical hierarchical process-based prioritization. Scientific Programming **2021**, 1–14 (2021) https://doi.org/10.1155/2021/2780257

[91] Bong, W.K., Maußer, F., Eck, M., Araujo, D.D., Tibosch, J., Glaum, T., Chen, W.: Designing nostalgic tangible user interface application for elderly people. In: Computers Helping People with Special Needs, pp. 471–479. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-58805-2_56

[92] Williams, D.M.: Designing an educational and intelligent human-computer interface for older adults. PhD thesis, Marquette University (2014)

[93] Machado, E., Singh, D., Cruciani, F., Chen, L., Hanke, S., Salvago, F., Kropf, J., Holzinger, A.: A conceptual framework for adaptive user interfaces for older adults. In: 2018 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), pp. 782–787 (2018). https://doi.org/10.1109/PERCOMW.2018.8480407

[94] Sankowski, O., Krause, D.: User-centered product design for older adults–comparison and applicability of methods. Design for X, Beiträge zum **29**, 25–36 (2018)

[95] Keates, S., Clarkson, P.J., Harrison, L.-A., Robinson, P.: Towards a practical inclusive design approach. In: Proceedings on the 2000 Conference on Universal Usability. CUU '00, pp. 45–52. Association for Computing Machinery, New York, NY, USA (2000). https://doi.org/10.1145/355460.355471

[96] Story, M.F.: Maximizing usability: The principles of universal design. Assistive Technology **10**(1), 4–12 (1998) https://doi.org/10.1080/10400435.1998.10131955 . PMID: 10181150

[97] Chow, A.: The usability of digital information environments: planning, design and assessment. In: Baker, D., Evans, W. (eds.) Trends, Discovery, and People in the Digital Age. Chandos Digital Information Review, pp. 13–37. Chandos Publishing, United Kingdom (2013). https://doi.org/10.1016/B978-1-84334-723-1.50002-4

[98] Schmid, F., Collis, L.M.: Human centred design principles. In: 1999 International Conference on Human Interfaces in Control Rooms, Cockpits and Command

Centres, pp. 37–43 (1999). https://doi.org/10.1049/cp:19990160

[99] Shepard, L.A., Penuel, W.R., Davidson, K.L.: Design principles for new systems of assessment. Phi Delta Kappan **98**(6), 47–52 (2017) https://doi.org/10.1177/0031721717696478

[100] Kühme, T.: A user-centered approach to adaptive interfaces. In: Proceedings of the 1st International Conference on Intelligent User Interfaces, pp. 243–245 (1993)

[101] Gulliksen, J., Göransson, B., Boivie, I., Blomkvist, S., Persson, J., Cajander: Key principles for user-centred systems design. Behaviour & Information Technology **22**(6), 397–409 (2003) https://doi.org/10.1080/01449290310001624329

[102] Quintana, Y., Fahy, D., Abdelfattah, A.M., Henao, J., Safran, C.: The design and methodology of a usability protocol for the management of medications by families for aging older adults. BMC Medical Informatics and Decision Making **19**(1) (2019) https://doi.org/10.1186/s12911-019-0907-8

[103] Newell, A., Arnott, J., Carmichael, A., Morgan, M.: Methodologies for involving older adults in the design process. In: Universal Acess in Human Computer Interaction. Coping with Diversity: 4th International Conference on Universal Access in Human-Computer Interaction, UAHCI 2007, Held as Part of HCI International 2007, Beijing, China, July 22-27, 2007, Proceedings, Part I 4, pp. 982–989 (2007). Springer

[104] Fisk, A.D., Czaja, S.J., Rogers, W.A., Charness, N., Sharit, J.: Designing for Older Adults: Principles and Creative Human Factors Approaches. CRC press, Boca Raton, Florida, United States (2020)

[105] Bruseberg, A., McDonagh-Philp, D.: User-centred design research methods: the designer's perspective. In: Integrating Design Education Beyond 2000 Conference, pp. 179–184 (2000). Citeseer

[106] Hasani, L.M., Sensuse, D.I., Kautsarina, Suryono, R.R.: User-centered design of e-learning user interfaces: A survey of the practices. In: 2020 3rd International Conference on Computer and Informatics Engineering (IC2IE), pp. 1–7 (2020). https://doi.org/10.1109/IC2IE50715.2020.9274623

[107] Abras, C., Maloney-Krichmar, D., Preece, J., *et al.*: User-centered design. Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications **37**(4), 445–456 (2004)

[108] Spencer, D., Warfel, T.: Card sorting: a definitive guide. Boxes and arrows **2**(2004), 1–23 (2004)

[109] Allan, G.: Qualitative research. In: Allan, G., Skinner, C. (eds.) Handbook

for Research Students in the Social Sciences, p. 13. Routledge, Milton Park, Abingdon-on-Thames, Oxfordshire (1991)

[110] Bryman, A.: Quantitative and qualitative research: further reflections on their integration. In: Mixing Methods: Qualitative and Quantitative Research, p. 22. Routledge, London (2017)

[111] Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Quarterly: Management Information Systems **28**(1), 75–105 (2004) https://doi.org/10.2307/25148625

[112] Peffers, K., Tuunanen, T., Rothenberger, M., Chatterjee, S.: A design science research methodology for information systems research. Journal of Management Information Systems **24**, 45–77 (2007)

[113] Patton, M.Q.: Qualitative Research and Evaluation Methods. Sage Publications, Thousand Oaks, CA (2002)

[114] Draheim, D., Weber, G.: Modeling submit/response style systems with form charts and dialogue constraints. In: On The Move to Meaningful Internet Systems 2003: OTM 2003 Workshops, pp. 267–278. Springer, Cham, Switzerland (2003)

[115] Auer, D., Draheim, D., Geist, V.: Extending BPMN with submit/response-style user interaction modeling. In: Proc. of BPMN Workshop, CEC'09 – the 11th IEEE Conference on Commerce and Enterprise Computing, pp. 368–374. IEEE, NY, USA (2009)

[116] Atkinson, C., Draheim, D., Geist, V.: Typed business process specification. In: Proc. of EDOC'2010 – the 14th IEEE International Enterprise Computing Conference, pp. 69–78. IEEE, NY, USA (2010)

[117] Butt, S.A., Kangilaski, T., D., D.: Lessons Learned from a Multi-National Project on Developing a Platform for the Silver Economy. In: Proceedings of Projman 2023 - the 7th International Conference on Project Management. Procedia Computer Science. Elsevier, Amsterdam, Netherlands (2023)

[118] Braun, V., Clarke, V.: Thematic Analysis, pp. 57–71. American Psychological Association, Washington (2012). https://doi.org/10.1037/13620-004

[119] Jackson, K., Bazeley, P.: Qualitative Data Analysis with NVivo. Sage, ??? (2019)

[120] Suran, S., Pattanaik, V., Draheim, D.: Frameworks for collective intelligence: A systematic literature review. ACM Computing Surveys (CSUR) **53**, 1–36 (2020) https://doi.org/10.1145/3368986

[121] Jukić, T., Pevcin, P., Benčina, J., Dečman, M., Vrbek, S.: Collaborative innovation in public administration: Theoretical background and research trends of co-production and co-creation. Administrative Sciences **9**(4), 90 (2019) https://doi.org/10.3390/admsci9040090

[122] Butt, S.A., Suran, S., Pappel, I., Smærup, M., Krimmer, R., Draheim, D.: A Digital Collaborative Platform for the Silver Economy: Functionalities Required by Stakeholders in a Multinational Baltic Sea Region Project. Digital Government: Research and Practice **4**(2) (2023) https://doi.org/10.1145/3592618

[123] Butt, S.A., Pappel, I., Draheim, D.: Exploring the Functionalities and Evaluation of the Digital Silver Hub: A Collective Intelligence Platform for Innovative Solutions in the Silver Economy. In: 16th International Conference on Theory and Practice of Electronic Governance (ICEGOV 2023) (2023). https://doi.org/10.1145/3614321.3614371 . ACM

[124] Butt, S.A., Draheim, D.: Digital Silver Hub: User Dialogue Model Technical Document. TechRxiv. Preprint (2022) https://doi.org/10.36227/techrxiv.19875031.v1

[125] Torfing, J., Ferlie, E., Jukić, T., Ongaro, E.: A theoretical framework for studying the co-creation of innovative solutions and public value. Policy and Politics **49**(2), 189–209 (2021)

[126] Jackson, E.B., Kivimäki, P., Pappel, I., Yahia, S.: Exploring eu e-delivery integration for enabling interregional innovation through the silverhub platform. In: Proceedings of the 24th Annual International Conference on Digital Government Research. DGO '23, pp. 172–179. Association for Computing Machinery, New York, NY, USA (2023). https://doi.org/10.1145/3598469.3598488

Appendix XII

[XII]
Taivo Kangilaski, Sidra A. Butt, Ingrid Pappel, and Erik Kangilaski. Overcoming challenges in the silver economy by connecting services in the Silver Hub: The tool to provide the basis for the innovative solutions. In *Proceedings of ICEGOV 2021 – the 14th International Conference on Theory and Practice of Electronic Governance*, pages 231––237. Association for Computing Machinery, 2021

Overcoming Challenges in the Silver Economy by Connecting Services in the Silver Hub

The tool to provide the basis for the Innovative Solutions

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ABSTRACT

Higher life expectancy and continuously low birth rates and are changing the shape of the European Union's (EU) 27 countries age pyramid. The most important change is a clear move towards a much older population structure. As a result, the share of older people in the total population will increase significantly in the coming decades. This in turn increases the burden on the working-age population to cover the social costs of an ageing population for various related services. The current article provides an overview of how the EU funded project, OSIRIS in the Baltic Sea Region (BSR) contributes to the serious challenge among the elderly by designing a communication platform in order to bring together various stakeholders within the service provision lifecycle. The paper discusses the main architectural needs for the communication platform, Silver Hub (SH) designed to be the foundation for the services among various stakeholders related to the silver economy developments. As a result, the interface is proposed considering relevant stakeholders' needs to provide an effective tool for companies and research institutions to bring new innovative and sustainable services to the silver economy market.

CCS CONCEPTS

• Silver economy; **• OSIRIS project**; **• customer journey**; **• IT architecture**;

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1 INTRODUCTION

Population ageing is a long-term trend that began in Europe several decades ago. This trend is visible in the changes in the age structure of the population and is reflected in the increase of the share of the elderly in the total population and the decrease in the share of the working-age population. Demographic change is a phenomenon that has a major impact on Baltic Sea countries. It is estimated that by 2025 the healthcare costs will double and budgetary pressure on health budgets will be huge. Dependency ratio for people over 60 years in Baltic countries will advance for ¼ to ½ by 2025 and family members will be most affected with impact over productivity, wealth, and job availability[1].

Countries are confronting with different level of challenges related to an ageing society and demographic change. In terms of innovation and RIS3 (Research and Innovation Strategies for Smart Specialisation) implementation is confronting with a bigger pressure related to the ageing phenomenon and thus new resources and solutions must be identified to respond better to societal needs based on a cost-efficient approach.

Starting from 2019, the EU funded 'Supporting the Smart Specialization Approach in the Silver Economy to Increase Regional Innovation Capacity and Sustainable Growth' – OSIRIS Interreg (BSR) project[2] was launched. It was planned to run until the end of 2020, but due to COVID-19 restrictions, the project was extended for one year. OSIRIS BSR project consortium consists of Latvia, Lithuania, Estonia, Denmark, Russia and Finland. It aims to increase innovation actors' capacity for applying smart specialization approaches to regional development by exploring new entrepreneurial opportunities, promoting the development of new products and service innovations, strengthening and scaling up the existing "hot spots" of innovation to meet specific needs and tackle the challenges of the ageing society of the BSR region. Estonia is known as a digital

[1] https://ec.europa.eu/eurostat/databrowser/view/demo_pjanind/default/table?lang=en
[2] https://www.osiris-smartsilvereconomy.eu/

leader[3] in the governance domain both in the public and private sector by providing various innovative tools as well models for digital services and data exchange both at state and local level [10][12][13][14].

The current article is provided by the project's Work Package (WP) 6 team (altogether project has 6 work packages), whose task is to prepare the web-based portal where all project outcomes can be easily consumed by the main identified stakeholders – academia, businesses, senior citizens, local authorities and web portal content managers. Literature review regarding silver economy and need for a unified platform have already been analysed in our previous research [11][12] thus in this paper we focus mainly on the research question which aims to investigate the design path and collaboration of the development team within Silver Hub (SH) development framework. Therefore, the need to collect the requirements for the User Interface, application architecture and customer journeys and content administration is the focus of this research paper.

For the current article the qualitative research methods along with the software development approaches were used. In the course of qualitative data gathering were employed semi-structured interviews in order to get feedback from respective stakeholders and experts in the relevant countries. The collected data was coded and used to create the initial guidelines for a framework. Once that was completed, the experts and stakeholders were asked to participate in interviews and workshops to help validate the framework and design requirements for the environment.

1.1 Software Development Methodologies

As it is well known, each software development project needs to go through seven phases which are planning, requirements gathering, software designing and prototyping, software development, testing, deployment and operations & maintenance [1].

The classical method of software development is the waterfall [2]. When each phase is completed the project moves into the next step. The advantage of this model is that each phase can be evaluated for continuity and for feasibility to move on. The quite popular today is an agile approach [3] which focuses on user experience and input. In the iterative software development model [4], developers swiftly create an initial basic version of the software. Then they review and improve on the solution in small iterations. Moreover, the DevOps [5] is a rising trend where operations team also incorporates. Like agile, this approach seeks to improve the usability and relevance of IT solutions. From the project proposal, it was identified that in order to analyse the expected results, the waterfall approach was needed.

1.2 WP6 Initiation

OSIRIS BSR project[4] has several WPs whose outcomes must be published via Silverhub.eu, which is the web portal. At the beginning of the WP6 start, the team declared its vision and mission statement and introduced them to the other project participants to have a common understanding of what we plan to implement.

[3]https://www.un.org/development/desa/publications/publication/2020-united-nations-e-government-survey
[4]https://silverhub.eu

Silverhub.eu vision is to support the life cycle of innovative solutions to tackle ageing challenges and to enhance Silver economy growth opportunities in the Baltic Sea Region. **Silverhub.eu mission** is to have a collaborative virtual hub that supports the creation, deployment and publishing of innovative solutions to generate economic growth by using a smart specialization approach. Thus, the WP6 team understood that there is a need for a sustainable platform to support collaboration, service initiation, development and implementation as well. To warrant sustainability, there is a need to understand how the financing model will look like when the project will be finished.
WP6 team used questionnaires, interviews and workshops to collect the requirements [6] for the Web portal. Based on those results, processes and customer journeys were developed, which were the starting point for architecture development. At the beginning of the WP6 activities, the services development processes based on the PRINCE2 approach [8] was described accordingly. Fortunately, it soon turned out that the project management team was simply looking for an environment for publishing results and communication, and it is not recommended to run the services on the platform. Thus, instead of a platform, a completely different task had to be solved architecturally, and the work so far had to be written under the acquisition of experience. Thus, the new customer journeys were built up, and several weeks were lost. As known from M. Goldratt project management approach [7], the project plan must have buffers that warrant a critical chain. Thus the WP6 was under continuous time pressure until the information was announced that the project delivery date had postponed. The second challenge was related to the other WPs deliveries which were delaying. – every outcome introduces the new requirements. Thus, our team decided to use the SCRUM approach instead of the waterfall approach to develop the software.

1.3 Supported Processes

From the collected requirements, the main processes were identified which must be supported on the SH. The first focus was related to the country based local market-related information identification and collaboration and the second when some companies want to extend their grip and sell service to the foreign market as well.

1.3.1 Process for local country. The main process which is focused on the local market must support collaboration between academics, businesses, non-profit organizations, policymakers and senior citizens. Businesses, non-profit organizations as well as academics need financing mechanisms to develop the new services, they need to find suitable competencies available on the market and as well as a tool to use to collaborate or develop the service. Policymakers want to express their priorities for services via projects or funding mechanism. In addition to this, their need to have an overview of which services are provided in their region to identify the bottlenecks. Senior citizens need to have a single point of truth from where to find the service they need. As the internet is wide, for seniors could be sometimes challenging to find needed service or information for them. Also, they need to express their expectations and even collaborate in the development of new services (Figure 1).

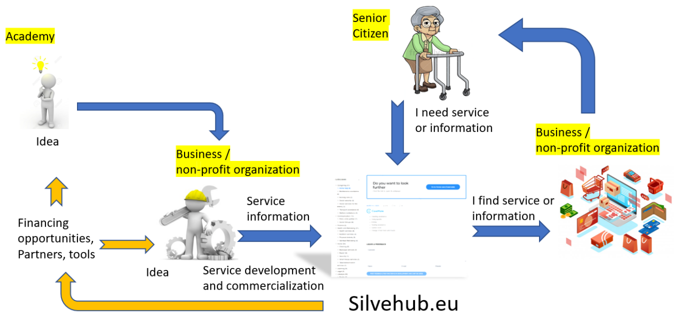


Figure 1: Process for local country

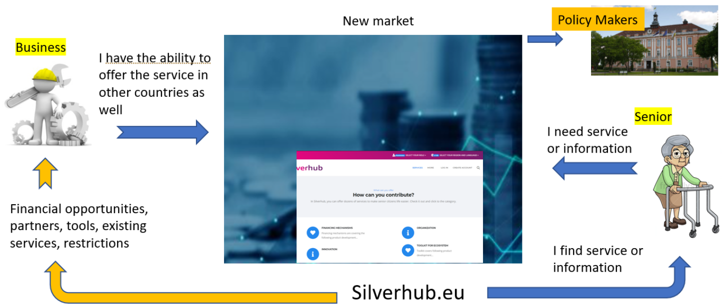


Figure 2: Process for entering new market

Table 1: Customer Journey, Option 1

Step	Description
1	Customer enters to Silverhub.eu
2	Chooses country
3	Based on the country, (s)he sees a description of views. And needs to select the role view.
4	Now user reaches the first page and sees welcoming (short description) text and a list of main categories.
5	User clicks on category (s)he is interested in and sees the list of subcategories.
6	User selects subcategory and sees the list of services that are filtered by: Role view, Country, Main category, Sub-category
7	User selects the service (s)he wants to read more about.
8	On the service page, there is a link to the service provider website.

1.3.2 Process for entering new market. Businesses, which have already well-working services or ready-made products could need to have a wider market. For that, they need to know the circumstances and requirements in the target country; the business opportunities, potential partners etc. When they ready to enter the market, they can use Silverhub.eu as one source of marketing and publish their service information to make it available to the target country senior citizens. Local authorities can also monitor if there are new service providers (Figure 2).

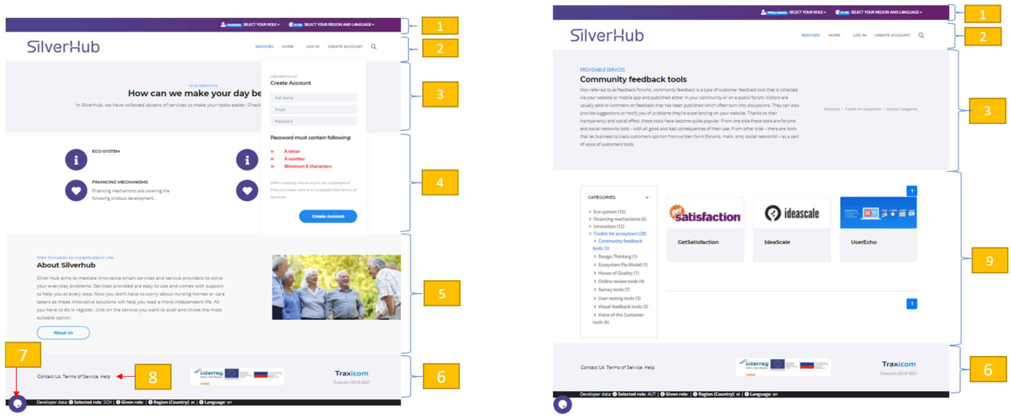
1.4 Customer Journey

Analysing the predefined processes content, the following generalized customer journey was identified (Table 1)(Table 2):

Thus, if the information from different WPs is uploaded, the main functionality is the search functionality. As the major stakeholders use mobile devices, the focus must be on developing a web page that is mobile friendly. Moreover, to support communication between main stakeholders, the forum, news, chat, event management and availability to provide feedback functionality must be implemented. The main design principles are presented in Figure 3.

Table 2: Customer Journey, Option 2

Step	Description
1	After reaching on the first page, (s)he opens search and inserts word that is relevant to the service that is searched (e.g. funding)
2	On the search page, all services that match the following filters are displayed: Country, Role view, The headline of content contains searched word
3	Customer can filter results by categories.



1 - View, language and country selection
2 - Main functional menu items, search
3 - Content description area
4- Categories and sub-categories with a short description
5 - Text area, e.g. for custom pages
6 - Logos, Terms
7 - Online Chat with portal administrators
8- Terms, help - references to custom pages
9- Content view, search results, navigation

Figure 3: Current design principles

Figure 4: ArchiMate objects in use

2 ARCHITECTURE COMPONENTS

From an architecture documentation point of view, the ArchiMate notation [9] was agreed to use for documentation. Based on the information above, the following architecture components presented in Figure 4 were implemented. Those are User Management, Menu / Category Management, Country and Role Management, Information Content Management, Custom Page management, Forum Management, Search Engine, Tawk Component (for Chat) with Admin chat UI, Chat component for the participant with Chat UI, Information publishing and dashboard, Alert module, Silverhub Mobile UI and Wiki UI with MediWiki Component (Figure 5). There will be a user interface for content managers, computer-based web users and mobile device users. For information exchange between the presentation layer and the data layer, mostly the JSON queries are used.

2.1 User Management

Siverhub.eu must support the availability to publish information from users from the world wide web. Thus, to minimize the unwanted information to be published, the user, who wants to publish content, must be identified and authorized. For single-user minimal information will be collected to correspond to GDPR requirements. Every authorized user can request additional right (e.g. for publishing events, adding services, adding information into the forums, etc).

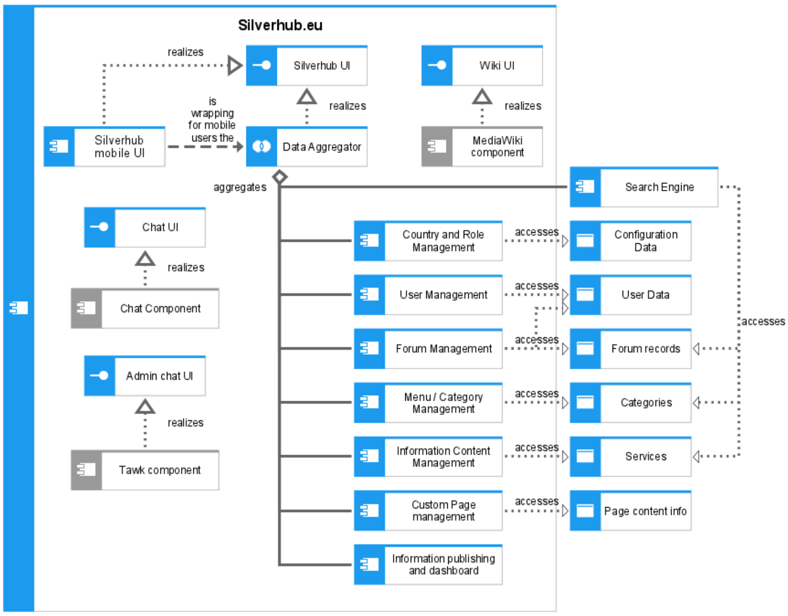


Figure 5: Silverhub.eu initial architecture

Table 3: Supported language based on country

Language:Country	Estonian	English	Lithuanian	Latvian	Finnish	Danish	Russian
Estonia	x	x					x
Latvia		x		x			x
Lithuania		x	x				x
Finland		x			x		
Russia		x					x
Denmark		x				x	

2.2 Country and Role Management

According to the project description, there will be four main interest groups, having their information view and narrowed context, varying based on countries. Each country has a policymaker, senior citizen, academic and business roles, and from Silverhub.eu perspective also the content manager role. The content manager is needed because the content of the forum will vary in 7 languages, thus every country must administrate their forums and content based on role views as well. In addition, each country has defined those roles a bit differently thus the role descriptions must be administrated.

2.3 Menu / Category Management

The content of Silverhub.eu is structured to the categories and subcategories. The subcategory tree can be endless, but we want to keep unwritten principles that main information must be accessible not more than three "clicks" and find within 5 seconds. This leads to the navigation tree depth not more than three levels. Thus, we will have a hierarchy after selecting the country and language view:
Main category - > Subcategory -> Service/content
Categories and menu items vary from country to country and may have different descriptions and are presented in different languages (Table 3).

2.4 Forum Management

There will be regional forums and international forum. Regional forums will use the local language and international forum will be in English. As every forum, it will have its categories and topics. Each forum record can be marked as inappropriate and the forum administrator has the right to decide if a certain comment should be deleted.

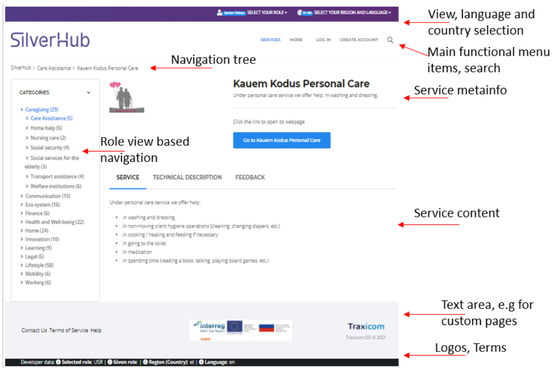


Figure 6: Sample service description view

2.5 Chat Module

An additional possibility to communicate is online chat. For that purpose, Silverhub.eu has integrated a standalone chat engine. Country-based rooms and international room for online chat is prepared. Chat functionality is allowed only for logged in users.

2.6 Custom Page Management

Custom page management is needed to provide unstructured content and can be used e.g. for news, roles descriptions and event management etc. Each custom page has its name, content and the possibility to describe a sidebar. When the page is created it will have its own URL and there could be a background image for content and header information as well.

2.7 Information Content Management

Mainly the Silverhub.eu publishes URL-s to the services and/or documents and their content description. Each URL will have its unique ID and name. In addition to this, it may have its description, technical description, feedback part and logo if needed. Services could be created, updated, and removed (Figure 6). Also, there is a possibility to use tags to combine different services for the search engine.

2.8 Alert Module

Alert module is needed to emphasize some content. There can be a possibility to elect role, and country where the alert is displayed - e.g, if there will be an OSIRIS event in Estonia, then when a user starts to use Estonia's content, the title bar will be displayed with corresponding content and with URL to the custom page to the academia and business roles.

2.9 Information Publishing and Dashboard

Dashboards are important tools for content administrators. They alert if there is a new user who wants to have additional access rights, if there reported inappropriate content in forums or if there are additional services that must be published. It also helps to publish information into the front-end etc.

2.10 Silverhub Mobile UI

As Siverhub.eu main concept for architecture is "mobile-first". Development and design results are firstly aligned with mobile devices UI-s and only then for the computers. Mobile UI uses the same components as computer-based UI but run on top of mobile browsers.

2.11 Wiki Module

Silverhub.eu guides are accessible via MediaWiki module. Roles background, development methodology, architectural principles, functional and non-functional requirements, and functional help is provided for the front end as well for back-end users. Wiki module has its own login functionality because a stand-alone component is used for it.

3 CONCLUSION AND FURTHER STEPS

The project is ongoing till the end of 2021, thus, to ensure a logic that meets the interests of the end-user, the communication between different WPs needs to be improved in the project. It is important that the different work packages also reflect more on the holistic approach to information presentation, and their analysts do not only analyse WP results in isolation. It is the broader information handling that will enable the data collected at the end of the project to be turned into an effective tool for companies and research institutions to bring new innovative and sustainable services to the market, which would contribute to providing solutions to the problems of the ageing population to help them live a more independent and comfortable life. The SH will connect various stakeholders and boost the economy with services that are efficiently accessible within the digital environment. In addition, SH provides an opportunity for collaboration among the private and public sector and involves academia to investigate technologies that support digital transformation, innovation and implementation among Silver Economy development. However, in addition to the SH development activities an important aspect is related to the application and implementation of the SH among relevant parties in order to engage all stakeholders in such a way that they would provide and use services on that collaborative platform. Thus, in further steps a huge attention must be paid to the proper implementation methodology including awareness raise, trainings and promotional activities to make sure SH will be used efficiently enough as it was the main target.

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REFERENCES

[1] Richard Murch. 2012. The Software Development Lifecycle - A Complete Guide, Kindle Edition, 114.
[2] Ade Shokoya, 2012. Waterfall to Agile: A Practical Guide to Agile Transition, Kindle Edition, 129.
[3] Alal S. Koch , 2005, Agile Software Development. Evaluating the Methods for Your Organization, Artech House, 280.

[4] Michelle Allan, 2019 What Is Iterative Development – An Easy Guide For Beginners https://www.goodcore.co.uk/blog/iterative-development/

[5] Gene Kim, Patrick Debois, John Willis, Jez Humble, 2016. DevOps Handbook: How to Create World-Class Agility, Reliability, and Security in Technology Organizations, IT Revolution Press, 480.

[6] S. A. Butt, I. Pappel, E. Õunapuu, 2021. Potential for increasing the ICT adaption and identifying technology readiness in the silver economy: case of Estonia. In: Proceedings of Electronic Governance and Open Society: Challenges in Eurasia (EGOSE).

[7] Eliyahu M. Goldratt, 1997. Critical Chain, North River Press, 246.

[8] AXELOS, 2017. Managing Successful Projects with PRINCE2, TSO, 6th ed., 400.

[9] The Open Group, ArchiMate®3.1 Specification, https://pubs.opengroup.org/architecture/archimate3-doc/

[10] I Pappel, I Pappel, T Tampere, D Draheim, 2017. Implementation of e-invoicing principles in Estonian local governments. In: Proceedings of the 17th European Conference on Digital Government.

[11] S.A. Butt, K. Rava, T. Kangilaski, I. Pappel, D. Draheim, 2021. Designing A Digital Collaborative Platform for the Silver Economy: Inception and Conceptualization. In: Proceedings of the Eighth International Conference on eDemocracy & eGovernment (ICEDEG).

[12] R Saputro, I Pappel, H Vainsalu, S Lips, D Draheim, 2020. Prerequisites for the adoption of the X-Road interoperability and data exchange framework: a comparative study, Seventh International Conference on eDemocracy & eGovernment (ICEDEG), 216-222

[13] I. Pappel, V. Tsap, D. Draheim, 2019. The e-LocGov model for introducing e-governance into local governments: an Estonian case study, IEEE Transactions on Emerging Topics in Computing, 597-611

[14] J Tepandi, M Lauk, J Linros, P Raspel, G Piho, I Pappel, D Draheim, 2017. The data quality framework for the Estonian public sector and its evaluation, Transactions on Large-Scale Data-and Knowledge-Centered Systems XXXV, 1-26

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1. Sidra A. Butt, Ingrid Pappel, and Enn Õunapuu. Potential for increasing the ICT adaption and identifying technology readiness in the silver economy: Case of Estonia. In *Proceedings of EGOSE 2020 – the 7th International Conference on Electronic Governance and Open Society: Challenges in Eurasia*, pages 139–155. Springer International Publishing, 2020
2. Sidra A. Butt, Emna A. Elhadjamor, Ingrid Pappel, Enn Õunapuu, and Dirk Draheim. A knowledge map for ICT integration in the silver economy. In *Proceedings of CENTERIS 2020 – the 8th International Conference on Enterprise Information Systems*, volume 181 of *Procedia Computer Science*, pages 693–701. Elsevier, 2020
3. Sidra A. Butt and Dirk Draheim. Ethical challenges of ICT for the silver economy. In *Proceeding of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 152–155. IEEE, 2021
4. Sidra A. Butt, Karin Rava, Taivo Kangilaski, Ingrid Pappel, and Dirk Draheim. Designing a digital collaborative platform for the silver economy: Inception and conceptualization. In *Proceedings of ICEDEG 2021 – the 8th International Conference on eDemocracy & eGovernment*, pages 47–54. IEEE, 2021
5. Sidra A. Butt, Ingrid Pappel, and Dirk Draheim. Digital Silver Hub: User dialogue model technical document. *IEEE TechRxiv. Preprint*, pages 1–49, 2022
6. Sidra A. Butt, Shweta Suran, Ingrid Pappel, Michael Smærup, Robert Krimmer, and Dirk Draheim. A digital collaborative platform for the silver economy: Functionalities required by stakeholders in a multinational Baltic Sea Region project. *Digital Government: Research and Practice*, 4(2):1–20, 2023
7. Sidra A. Butt, Ingrid Pappel, and Dirk Draheim. Exploring the functionalities and evaluation of the Digital Silver Hub: A collaborative platform for innovative solutions in the silver economy. In *Proceedings of ICEGOV 2023 - the 16th International Conference on Theory and Practice of Electronic Governance*. Association for Computing Machinery, 2023
8. Sidra A. Butt, Silvia Lips, Rahul Sharma, Ingrid Pappel, and Dirk Draheim. Barriers to digital transformation of the silver economy: Challenges to adopting digital skills by the silver generation. In *Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics*, volume 97, pages 151–163. Springer, 2023

[46]Estonian Research Information System (ETIS) fields of research

9. Sidra A. Butt, Marina Weck, Ingrid Pappel, and Dirk Draheim. Multifaceted evaluation of the Digital Silver Hub to validate the platform requirements. In *Proceedings of AHFE 2023 - the 14th International Conference on Applied Human Factors and Ergonomics*, pages 164–177. Springer, 2023

10. Sidra A. Butt, Taivo Kangilaski, and Dirk Draheim. Lessons learned from a multinational project on developing a platform for the silver economy. In *Proceedings of Projman 2023 - the 7th International Conference on Project Management*, Procedia Computer Science. Elsevier, 2023

11. Sidra A. Butt, Shweta Suran, Marina Weck, Ingrid Pappel, and Dirk Draheim. Design of a collective intelligence platform for facilitating the silver economy: An exhaustive user-centered evaluation. *IEEE TechRxiv. Preprint*, pages 1–37, 2023

12. Taivo Kangilaski, Sidra A. Butt, Ingrid Pappel, and Erik Kangilaski. Overcoming challenges in the silver economy by connecting services in the Silver Hub: The tool to provide the basis for the innovative solutions. In *Proceedings of ICEGOV 2021 – the 14th International Conference on Theory and Practice of Electronic Governance*, pages 231––237. Association for Computing Machinery, 2021

13. Markko Liutkevicius, Karl I. Pappel, Sidra A. Butt, and Ingrid Pappel. Automatization of cross-border customs declaration: Potential and challenges: A case study of the Estonian Customs Authority. In *Proceesings of EGOV 2020 – the 19th International Conference on Electronic Government*, volume 12219 of *Lecture Notes in Computer Science*, pages 96–109. Springer, 2020

14. Ingrid Pappel, Sidra A. Butt, Ingmar Pappel, and Dirk Draheim. On the specific role of Electronic Document and Record Management Systems in enterprise integration. In *Proceedings of ICICT 2021 – the 5th International Congress on Information and Communication Technology*, pages 37–51. Springer Singapore, 2021

15. Sidra A. Butt, Ingrid Pappel, and Karin Oolu. Implementation of Electronic Records Management Systems: Potential and challenges a case study of the Water and Power Development Authority (WAPDA) in Pakistan. In *Proceedings of ICT4SD2021 – the 6th International Conference on ICT Analysis and Applications*, pages 629–639. Springer Singapore, 2021

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