RIGA TECHNICAL UNIVERSITY

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METHODOLOGICAL FRAMEWORK FOR SPANNING KNOWLEDGE TRANSFER BOUNDARIES IN CROSS-DISCIPLINARY INNOVATION PROCESS

Summary of the Doctoral Thesis

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DOCTORAL THESIS PROPOSED TO RIGA TECHNICAL UNIVERSITY FOR THE PROMOTION TO THE SCIENTIFIC DEGREE OF DOCTOR OF SCIENCE

To be granted the scientific degree of Doctor of Science (Ph. D.), the present Doctoral Thesis has been submitted for defence at the open meeting of RTU Promotion Council "RTU P-09" on 19 December 2023 at 12:30 p. m. at the Faculty of Engineering Economics and Management of Riga Technical University.

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DECLARATION OF ACADEMIC INTEGRITY

I hereby declare that the Doctoral Thesis submitted for review to Riga Technical University for promotion to the scientific degree of Doctor of Science (Ph. D.) is my own. I confirm that this Doctoral Thesis has not been submitted to any other university for promotion to a scientific degree.

Inese Suija- Markova ……(signature)
Date: 24.07.2023.

The Doctoral Thesis has been written in English. It consists of an Introduction, 3 chapters, Conclusions and Recommendations, 34 figures, 27 tables, and 10 appendices; the total number of pages is 155, not including appendices. The Bibliography contains 263 titles.

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GENERAL CHARACTERISTICS OF THE THESIS

Cross-disciplinary innovation refers to the process of combining knowledge and expertise from different fields, organizations, and sectors to create new ideas, products, or solutions. The importance of the cross-disciplinary innovation process continues to increase for several reasons. First, many of the challenges facing society today, for example, population aging, food security, renewable energy, climate change and environmental protection, and citizen security, are multifaceted and require solutions that are beyond the scope of any one discipline and the capacity of one organization or one sector. The great physicist Albert Einstein once said that it is impossible to solve the problem on the same level at which it originated. You need to rise above this problem, to the next level, to see it from another perspective. The cross-disciplinary innovation process is an instrument for reconciling diverse viewpoints and identifying new perspectives. Second, with the rapid pace of technological advancement, cross-disciplinary innovation allows for the creation and uptake of innovative technologies that draw upon multiple areas of expertise. Third, as the world becomes increasingly interconnected, cross-disciplinary innovation allows for a more holistic approach to problem-solving that considers cultural, social, and economic factors that may be unique to different regions of the world. Finally, combining knowledge and expertise from different fields can lead to the development of new products, services, or solutions that would not have been possible otherwise.

Knowledge-intensive business services (KIBS) is a sub-sector of the service industry which plays a crucial role in innovation development. KIBS imply firms, regardless of ownership structure, that rely heavily on their employees' professional knowledge and whose main business is the provision of primarily non-routine knowledge-intensive services to other organizations operating in various sectors and industries (Miles et al., 1995; Muller & Doloreux, 2009). KIBS provide expertise, knowledge and skills to other businesses or organizations that are unavailable in-house, such as design, research and development, information technology services, and business management consulting. The importance of KIBS lies in the fact that they help businesses improve their competitiveness, productivity, and innovation. By providing expert advice, KIBS help companies improve their decision-making processes, develop new strategies, and identify new market opportunities (Bettiol et al., 2015). Furthermore, KIBS also play a significant role in promoting knowledge sharing and innovation within the economy. They often serve as intermediaries between research institutions and businesses, translating academic research into practical solutions that can be applied to real work. This collaboration between KIBS and other industries fosters innovation, ultimately leading to economic growth and development (Doloreux & Shearmur, 2010). In the future, the importance of KIBS is expected to grow. The repercussions of the COVID-19 epidemic are still being felt by our economies, along with the heightened geopolitical instability, the climate, and other major ecological and existential crises. KIBS have the potential to generate, disseminate, and implement crucial

knowledge for the transition to more sustainable production and consumption practices (Miles, 2020).

The research conducted as a part of Doctoral Thesis shows that KIBS innovate for various customers outside their organization. Most innovations are created and developed in multi-disciplinary, multi-sectoral, and multi-organizational teams, necessitating collaboration with different experts and companies, requiring knowledge from various disciplines and specialities. Innovation development in a cross-disciplinary environment requires knowledge sharing and transfer across varying levels of expertise, disciplines, specialities, and organizational experiences. As a result, the innovation process becomes more complex as multiple boundaries emerge and must be identified and addressed throughout the stages of the innovation process. The more complex the problem to be solved and the higher the level of innovation to be achieved, the more likely it is that various knowledge transfer boundaries will appear. Collaborative communication barriers, language difficulties, insufficient domain expertise, fear, differences in culture and values, resource allocation, power dynamics, and conflicting agendas are some of the challenges that KIBS need to overcome to ensure successful collaboration.

Many practices, including methods, tools, strategies, and approaches, have been invented and applied to span diverse boundaries in the cross-disciplinary innovation process. For example, design thinking is a human-centred innovation approach involving empathy, ideation, prototyping, and testing. It encourages collaboration between different disciplines and helps teams understand each other's perspectives. Open innovation involves collaborating with external partners to access their knowledge and expertise. This can include universities, start-ups, and other organizations that have specialized knowledge. Knowledge mapping involves creating a visual representation of the different knowledge types needed for an innovation project. This can help to identify knowledge gaps and areas where expertise from different disciplines is required. Co-creation workshops bring together stakeholders from different disciplines to generate ideas and develop solutions collaboratively. Storytelling is a powerful tool for communicating complex ideas and building empathy between team members from different disciplines. Last but not least, a great number of boundary objects (e.g., maps, prototypes, glossaries, data visualisations, etc.) have been invented to make knowledge meaningful to people from different disciplines and to help to facilitate communication and understanding (Rau, Moslein, Neyer, 2016). These are just some examples of approaches that have become popular and are widely used for spanning boundaries in the cross-disciplinary innovation process.

Despite the plethora of innovation practices, research and the author's professional experience reveal that companies still struggle to manage knowledge creation and transfer within cross-disciplinary teams. There are several reasons for that. First, managers of innovation projects and processes are often not aware of or trained to recognize the various potential obstacles to knowledge transfer that might arise from interactions between disciplines and organizations. Second, they tend to use one or more innovation practices to encourage cross-disciplinary invention without analysing whether or not these practices are aimed at overcoming the same barrier. Third, there is a lack of a comprehensive and

integrated picture of the many stages of the innovation process, the various emerging barriers, and the appropriate strategies to overcome them.

Therefore, the **research goal** of the Doctoral Thesis is to develop a methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process.

To achieve the goal, the following **research objectives** are defined:

1. Characterise the KIBS sub-sector, roles, activities, and performance.
2. Explore the concept of knowledge transfer and how it takes place in the innovation process.
3. Learn how KIBS innovate and transfer knowledge in the innovation process and what barriers they face.
4. Identify practices, tools, and approaches KIBS utilizes to span knowledge transfer boundaries in the innovation process.
5. Elaborate the methodological framework for spanning knowledge transfer boundaries in the innovation process.
6. Test and evaluate the methodological framework for spanning knowledge transfer boundaries in the innovation process.

The research object is the innovation process of knowledge-intensive business services.

The research subject is knowledge transfer boundaries and spanning mechanisms in the cross-disciplinary innovation process of knowledge intensive business services.

The Doctoral Thesis is grounded in the **theoretical perspectives** that underpin the concept of KIBS in knowledge transfer. It includes scientific works investigating the firm's knowledge-based view (KBV), which argues that knowledge is a critical strategic resource that drives competitive advantage. KBV highlights the importance of knowledge creation, acquisition, and application in KIBS as a key driver of innovation and competitiveness (Polanyia, 1962; Nelson & Winter, 1982; Kogut & Zander, 1992). The innovation system's perspective emphasises KIBS's role in innovation processes (Hipp, 1999; Tuominen & Toivonen; 2011; Dolorex & Shearmur, 2010). It also addresses the knowledge codification and transfer theory which focuses on the codification and documentation of knowledge to facilitate its transfer (Polanyi, 1962; Nonaka & Takeuchi, 1996), knowledge classification (Blacker, 1995; Carlile, 2002), and absorptive capacity theory that highlights the organisation's ability to absorb, assimilate, and apply external knowledge (Cohen & Levinthal, 1990). This theory emphasises the importance of organizational learning, flexibility, and adaptability in facilitating knowledge transfer.

The study employed a variety of quantitative and qualitative **research methods:**

1. Narrative literature review based on the analysis of foreign scientific literature, articles, papers, economic magazines and books, conference materials, and internet database resources.

2. Statistical data analysis of KIBS sub-sector performance on the global, EU and national levels based on the data derived from the World Bank National Accounts data, OECD National Accounts data files, databases of WTO, ECB, Eurostat, CIS, and the Central Statistical Bureau of Latvia.
3. Online survey of enterprises based on the combination of non-probability sampling techniques – voluntary response sampling, snowball sampling, and purposive sampling.
4. Pilot testing and evaluation of the methodological framework in the experimental innovation co-creation laboratory (ICL) with the participation of businesses, scientists, and representatives of governmental authority – regional development management organization.

The collected data were analysed using a variety of **tools and methods**:

1. Publish or Perish, a software that extracts and analyses academic citations from Google Scholar searches.
2. CiteSpace, an open-access Java computer program for systematic literature reviews using scientometrics methods based on WoSCC citation data and data visualization.
3. R version 4.1.2 and MS Excel software for quantitative data analysis.
4. Conceptual content analysis of qualitative (textual) data using NVivo software.
5. Focus group discussion and semi-structured interviews with innovation co-creation laboratory participants for a structural evaluation of the author's developed methodological framework

The empirical **study was conducted** in the period **from 2016 to 2022 in five stages**:

1. Scientific literature review and statistical data analysis of the KIBS sub-sector and its performance during the innovation process.
2. Survey how KIBS innovate and transfer knowledge during the innovation process.
3. Development of the methodological framework for spanning knowledge transfer boundaries in the process of cross-disciplinary innovation.
4. Pilot testing and evaluation of the methodological framework in the experimental innovation co-creation laboratory.
5. Drawing of conclusions and recommendations.

The limitation of the dissertation is that the proposed methodological framework was tested in a single experimental study, in one country and in an online environment. More experiments are required to demonstrate its usefulness concerning the purpose for which it was created. Additionally, the KIBS online survey results must be generalised with caution due to the number of respondents.

The main scientific contributions and novelty of the Doctoral Thesis are as follows:

1. KIBS characteristics, classifications, roles, and activities are identified.
2. Knowledge transfer boundaries faced by KIBS in the innovation process are discovered.
3. Mechanisms and practices for knowledge transfer in the cross-disciplinary innovation process are identified.
4. Key elements of the methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process are identified.
5. The methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process is developed and tested.

The following theses are brought forward for the defence:

Thesis 1. KIBS is a sub-sector of the service industry which plays a crucial role in innovation development and whose significance is expected to grow in the 21st century.

Thesis 2. As innovations are developed in cross-disciplinary teams necessitating collaboration with experts from various disciplines and specialities, knowledge transfer is challenging in the innovation process.

Thesis 3. Although various practices, such as methods, tools, and strategies, have been invented to facilitate knowledge transfer in the cross-disciplinary innovation process, KIBS face a vast array of knowledge transfer boundaries in the innovation process.

Thesis 4. A holistic methodological framework may help span various knowledge transfer boundaries in the cross-disciplinary innovation process.

Approbation and practical application of research findings. The research study findings have been presented at the following scientific conferences.

1. Contemporary Challenges in Management and Economics: 22nd International Scientific Conference "Economics and Management, ICEM", Riga, Latvia, May 10–12, 2017. Papers presented: **Suija-Markova, I.** (2017). Characterization of R&D Performing Enterprises. **Suija–Markova, I.** (2017) Transdisciplinary Working for Environmental Research: Case of an R&D Performing Organisation from Latvia.
2. WMSCI 2018 – the 22nd World Multi-Conference on Systemics, Cybernetics and Informatics, Orlando, USA, July 8–11, 2018 (online presentation). Paper presented: Locovs, J., Gaile-Sarkane, E., **Suija-Markova, I.**, Rostoka, Z., Rubina, L. (2018). Enterprise Agility – Modern Term or Future Trend for Successful Company Development?
3. 6th ABI – CEE Chapter Annual Conference on International Business in the Dynamic Environment: Changes in Digitalisation, Innovation and Entrepreneurship, Kaunas, Lithuania, September 25–27, 2019. Paper presented: **Suija-Markova, I.**, Briede, L., Gaile-Sarkane, E., Ozoliņa-Ozola, I. (2019). Multitasking and Its Effects on Individual and Organizational Performance in KIBS.

4. INTED 2020, 14th Annual International Technology, Education and Development Conference, March 2–3, 2020, Valencia, Spain (online presentation). Paper presented: **Suija-Markova, I.**, Briede, L., Gaile-Sarkane, E., Ozoliņa-Ozola, I. (2019). Multitasking and Its Effects on Individual and Organizational Performance in KIBS.
5. Joint Mathematics Meeting 2021, USA, January 6–9, 2021 (virtual, online presentation). Paper presented: **Suija-Markova, I.**, Gaile-Sarkane, E. (2021). Multitasking and its effects on an individual in study process.
6. Society of Open Innovation: Technology, Market, and Complexity (SOI) & Riga Technical University 2021, Daegu, Korea, July 12–15, 2021 (online presentation). Paper presented: **Suija-Markova, I.**, Gaile-Sarkane, E. (2021). Knowledge Transfer: Innovative Trends in Management Science.
7. WMSCI 2022 – the 26th World Multi-Conference on Systemics, Cybernetics and Informatics, July 12–15, 2022 (virtual, online presentation). Paper presented: **Suija-Markova, I.**, Mežaka, I., Gaile-Sarkane, E. (2022). Barriers to Innovation in the Knowledge Intensive Business Services.
8. Riga Technical University 63rd International Scientific Conference "Scientific Conference on Economics and Entrepreneurship, SCEE'2022, Riga, Latvia, October 13, 2022. Paper presented: **Suija-Markova, I.** (2022). A methodological framework for co-creation of government–research–industry innovation.

The author applied the findings and results of the research study during guest lectures in entrepreneurship-related study programs organized by the Faculty of Engineering Economics and Management of Riga Technical University in various faculties.

The author's developed methodological framework for spanning knowledge transfer boundaries in a cross-disciplinary innovation process was tested and validated in the experiment named Innovation Co-creation Laboratory. Based on that, the author, in collaboration with Vidzeme Planning Region, has written and published "Guidelines for Organizing an Innovation Co-Creation Laboratory Online for Public Sector Organizations with Engagement of Researchers and Entrepreneurs". The guidelines were published in 2020, ISBN 978-9934-8940-4-6 and are available online.

Thesis structure and volume. The Doctoral Thesis consists of an introduction, three chapters, conclusions and recommendations, a list of references and five appendices.

Chapter 1 is devoted to KIBS analysis. It provides a general overview of KIBS definitions, features, and existing classifications. In addition, statistical data analysis is performed to characterize the KIBS subsector, its performance, and its prognosis on a global and EU scale. The KIBS competitiveness dimensions, indicators, and measures are reviewed. Given the importance of KIBS to the innovation system and the purpose of this study, Chapter 1 provides a comprehensive analysis of the KIBS innovation process and the barriers faced during the innovation development. Chapter 1 presents part of the results of the online survey of KIBS companies conducted by the author.

Chapter 2 examines the concept of knowledge transfer within the context of the inter-disciplinary innovation process. First, the term "knowledge" is analysed, followed by an overview of the numerous types of knowledge. The concept of knowledge transfer is deconstructed based on a systematic review of knowledge transfer-related research conducted through bibliometric analysis and visualization of Web of Science Core Collection (WoSCC) using the CiteSpace software. Next, Chapter 2 provides an overview of the concept of innovation, innovation classifications, and the various collaborative approaches and teams utilized to develop innovation. Chapter 2 concludes with a comprehensive analysis of the mechanisms and practices used to overcome various knowledge transfer boundaries in the process of inter-disciplinary innovation as derived from the literature review and the online survey of KIBS.

Chapter 3 is devoted to the methodological framework for overcoming the knowledge transfer boundaries in the process of inter-disciplinary innovation. It describes the underlying principles, essential elements, and the methodological framework matrix. In addition, the validation and pilot testing of the methodological framework are described.

The Doctoral Thesis comprises 157 pages, excluding appendices. The content of the Thesis is illustrated by 34 figures, 27 tables, and ten appendices. The bibliography contains 236 sources of reference.

Author's publications

1. **Suija-Markova, I.** (2017). Characterization of R&D Performing Enterprises. In: Contemporary Challenges in Management and Economics: 22nd International Scientific Conference "Economics and Management, ICEM", Riga, Latvia, 10–12 May 2017, ISBN: 978-9934-10-937-9
2. **Suija-Markova, I.** (2017) Transdisciplinary Working for Environmental Research: Case of an R&D Performing Organisation from Latvia. In: Contemporary Challenges in Management and Economics: 22nd International Scientific Conference "Economics and Management, ICEM", Riga, Latvia, 10–12 May, 2017, ISBN: 978-9934-10-93
3. Locovs, J., Gaile-Sarkane, E., **Suija-Markova, I.**, Rostoka, Z., Rubina, L. (2018). Enterprise Agility – Modern Term or Future Trend for Successful Company Development? In: WMSCI 2018 – 22nd World Multi-Conference Syst. Cybern. Informatics, Proc, Vol. 3, pp. 13–18. ISBN: 9781510897045
4. **Suija-Markova, I.**, Briede, L., Gaile-Sarkane, E., & Ozoliņa-Ozola, I. (2020). Multitasking in knowledge intensive business services. Emerging Science Journal, 4(4), pp. 305–318, DOI: 10.28991/esj-2020-01233
5. **Suija-Markova, I.** (2020). Guidelines for Organising an Innovation Co-Creation Laboratory Online for Public Sector Organisations with Engagement of Researchers and Entrepreneurs. Vidzeme Planning Region: Cesis. ISBN: 978-9934-8940-4-6
6. **Suija-Markova, I.**, Mežaka, I., Gaile-Sarkane, E. (2022). Barriers to Innovation in the Knowledge Intensive Business Services. In: N. Callaos, E. Gaile-Sarkane, S. Hashimoto, B. Sánchez (Eds.), Proceedings of the 26th World Multi-Conference on Systemics,

Cybernetics and Informatics: WMSCI 2022, Vol. II, pp. 148–153. International Institute of Informatics and Cybernetics, DOI: 10.54808/WMSCI2022.02.148

7. **Suija-Markova, I.** (2022). A methodological framework for co-creation of government-research-industry innovation. In: Proceedings of the Riga Technical University 63rd International Scientific Conference "Scientific Conference on Economics and Entrepreneurship" (SCEE'2022), pp. 100–109. DOI: 10.7250/scee.2022.010

Keywords: knowledge-intensive business services, cross-disciplinary, innovation knowledge transfer, boundary spanning, methodological framework.

1. KNOWLEDGE INTENSIVE BUSINESS SERVICES

Chapter 1 of the Doctoral Thesis explores the evolution of KIBS, the main characteristics and classifications of KIBS, and the quantitative data describing KIBS performance on the global and EU levels. It also analyses the KIBS innovation activities and identifies various boundaries faced by KIBS in the innovation development process. Chapter 1 of the Doctoral Thesis is 43 pages long; it contains 17 figures and 8 tables.

KIBS features and classifications

Miles et al. (1995, p. 28) coined the term "knowledge intensive business services" (KIBS) to describe industries which "1) rely heavily on professional knowledge; 2) either are themselves primary sources of information and knowledge; or 3) or use knowledge to produce intermediary services to their clients' production processes; 4) are of competitive importance and supplied primarily to businesses". The KIBS subject has received much attention since the Mile's trigger publication. Although the term is now commonly used to study various industries, there is no universally accepted definition of KIBS. Furthermore, the term is used to describe a set of firm's characteristics (KIBS features), a type of firm (KIBS firms), and a sector of firms (KIBS sector). Because KIBS is more of a research and policy concept than an empirically used one, most KIBS firms are unaware of their status and do not consider themselves such (Nählinder, 2005). In this research, the working definition of KIBS implies firms, regardless of ownership structure, that rely heavily on their employees' professional knowledge and whose primary business is providing primarily non-routine knowledge-intensive services to other organizations operating in various sectors and industries.

The significance of KIBS is expected to grow in the twenty-first century. We are currently living in the aftermath of the Fourth Industrial Revolution, which has been fuelled by more sophisticated and integrated technologies, artificial intelligence, human-machine interconnections, and big-data analytics. Emerging technologies such as collaborative Web 2.0 and Web 3.0 technologies, the Internet of Things, and other technologies such as biotechnology and nanotechnology allow enterprises and final consumers to access new services and business models (Schwalb, 2016). Furthermore, they may contribute significantly to economic growth and deal with major societal challenges such as population aging, food security, renewable energy, climate change and environmental protection, and citizen security. Competitive pressures from market globalisation and public sector regulations also alter company relationships, increasing the need for modernisation and collaboration with partners and competitors. In this context, KIBS will play an increasingly important role in converting the potential of new technology into business results and improved welfare, as well as assisting enterprises, particularly small and medium-sized enterprises, in competently adopting and integrating new technological and organizational systems and processes (Gallouj, Weber, Stare, & Rubalcaba, 2015).

Because no standard definition of KIBS has emerged, a large body of literature investigates the characteristics of KIBS. The review of scientific and professional literature allows us to conclude:

1. Employees, with their specialized skills and competencies, are the most valuable and important asset and resource of KIBS enterprises.
2. Knowledge is the primary production factor and output of KIBS, and it is embedded in the services and artifacts they provide to their customers.
3. Because the provision of KIBS necessitates close interaction with the customer, mutual learning and knowledge co-creation are common in KIBS production activities.
4. Because KIBS conduct consulting in the form of problem-solving, the ability to adapt their knowledge and expertise to the specific needs and requirements of the individual customer is critical.
5. KIBS play several roles in the innovation process. When intervening in the launch and development of customers' innovation activities, KIBS act as a source of innovation; as a facilitator of innovation when assisting organizations at various stages of the innovation process; and as a vector of innovation when contributing to knowledge transfer between and within organizations, industries, innovation networks, clusters, and regions.
6. KIBS are perceived as innovative firms capable of continuously acquiring, processing, capitalizing, and delivering new knowledge while combining various professional expertise to produce the result.
7. Networking with a variety of actors is critical for KIBS enterprises to manage service production successfully.

KIBS categorization along industry lines and economic vocabularies is one of the most frequently used approaches. Another well-known KIBS categorization is based on the types of knowledge and technology used in the KIBS production process, which differentiates between technology-based or technical KIBS (T-KIBS), professional KIBS (P-KIBS), and creative KIBS (C-KIBS). Although widely used, these categorization approaches have been criticized for failing to provide the specific characteristics, structural differences and distinct behavioural patterns that distinguish an individual KIBS company. As a result, many features-based classifications of KIBS have been developed. KIBS have been classified according to the knowledge types, inputs to innovation, tie strength with the client, knowledge base, level of skills and knowledge-intensity, cognitive features and knowledge management practices, knowledge strategies and networking strategies, and business development activities. Overall, the literature review on KIBS classification shows that narrow categorizing of KIBS along industry lines distorts understanding of KIBS, emphasizing the need for more studies focusing on the significant and often subtle differences in KIBS specificities, structural differences, and behavioural patterns.

KIBS innovation process and challenges faced

Theoretical and empirical studies on KIBS have been conducted over the last decade to better understand how this service sub-sector innovates. Studies have focused on roles of KIBS in innovation systems and processes (Doloreux & Shearmur, 2010), the types of innovative behaviour of KIBS (Tuominen & Toivonen, 2011), mechanisms of knowledge transfer and innovativeness improvement through the provision of KIBS (Doroshenko, Miles, & Vinogradov, 2013), and determinants of innovation in KIBS (Doloreux & Frigon, 2019).

According to Doloreux and Shearmur (2010), KIBS play two significant roles in the innovation process:

1. Innovation enablers, or sources, carriers, and facilitators of innovation for their customers. As KIBS cannot develop and integrate all the information and knowledge necessary for innovation by themselves, KIBS enterprises act as intermediaries and innovation vectors by collecting information and transferring knowledge through collaborative work with their customers.
2. Innovators in their own right. KIBS develop innovations by combining old and new knowledge, and their main inputs and outputs contain a high degree of intangible and implicit knowledge. As such, KIBS are seen as doing both supporting innovation in their customer industries and carrying out internal innovation activities of scientific, technological, organizational, financial, and commercial character.

Several studies have explored how innovation activities and processes are carried out in KIBS. According to Hipp (1999), KIBS sources of knowledge for innovation include marketing, consultants, suppliers, competitors, and enterprises. They also use market research more often than non-KIBS. Meanwhile, KIBS conducts internal R&D to generate new knowledge for innovation, and it does so more frequently and continuously than non-KIBS. Furthermore, KIBS obtains information from outside sources such as conferences, journals, and computer-based networks. Because KIBS produce more non-technological innovation, there is usually no structural separation between R&D and manufacturing crews in KIBS, and employees implement innovation activities in addition to their regular service provision operations (Tuominen & Toivonen, 2011). It implies that innovation activities can be dispersed throughout the organization and that there may not be a separate development function coordinating these activities (Heusinkveld & Benders, 2002). Furthermore, in some cases, the innovation process necessitates forming a temporary, cross-border team comprised of individuals with diverse knowledge from various domains and organizations.

While KIBS produce more non-technological innovation, they do have technology-based innovation processes such as software, hardware, multimedia, material technologies, biotechnologies, environmental technologies, and others. This is yet another indication that KIBS serve as a link between the scientific base that generates new technological

knowledge and the economy that applies this knowledge to its own products and processes (Hipp, 1999).

KIBS innovation activities can be informal and iterative, with a large proportion of employee-driven innovation occurring outside of formal development project settings. This means that KIBS can purposefully launch incomplete solutions to market early and iteratively carry out development concurrently with actual service delivery (Toivonen, Tuominen, & Brax, 2007). According to Tuominen and Toivonen (2011), KIBS use five main innovation activities – opportunity exploration, generativity, championing, formative investigation and application. Although the innovation process conducted by KIBS proceeds linerary through the generic phases of new product development, those being idea generation, development and launch, each phase comprises a different combination of the afore-listed innovative behaviours.

All in all, KIBS firm's innovation competence relies on the capability:

1) to exchange and combine pieces of internal and external knowledge owned by various parties (Miles, 2008, as cited by Landry, Amara, & Doloreux, 2012);
2) "… to combine, in a new unique body of knowledge, codified scientific and technical knowledge with tacit knowledge based on extensive experience to help other organizations deal with problems" (Amara, D'Este, Landry, & Doloreux, 2016, p. 4066); and
3) to transfer knowledge, skills and a service output to client organizations (Leiponen, 2007, p. 444).

In other words, innovation can occur only in the presence of knowledge creation, integration, and transfer. Knowledge transfer in the KIBS' innovation process is challenging because the information and knowledge required for innovation comes from different sources, cooperation partners and network relations. First, knowledge embodied in a person and a specific context is harder to share with customers than codified knowledge. Second, when organizations form groups of individuals with diverse knowledge from various industries and organizations to develop a new product or service or solve a complex problem, the challenges of knowledge transfer become especially intense because of their heterogeneous backgrounds, values, and interests. In such cases, successful knowledge transfer requires spanning a variety of boundaries, the most common of which are knowledge boundaries – syntactic, semantic, and pragmatic boundaries (Edmondson & Harvey, 2018), cognitive boundaries (Smith, 2016), organizational boundaries (Wilhelm & Dolfsma, 2018; Smith, 2016), interest boundary (Smith, 2016), a power boundary (Filstad, Simeonova & Visser, 2018), and professional identity and ingroup/outgroup boundaries (Smith, 2016). Third, the success of innovation can be hampered by a lack of absorptive capacity on the part of both the firm developing and providing KIBS and the customer organization. Fourth, knowledge hiding is an obstacle to knowledge creation, transfer, and innovation in KIBS (Labafi, 2017).

To identify knowledge creation and transfer boundaries that KIBS face during the innovation processes, the author conducted an online survey of enterprises at the beginning of 2022. An invitation to participate in the survey was sent to 346 employees of various organizations from various industries via the authors' e-mail and social media accounts (Facebook and LinkedIn), with a hyperlinked address to the questionnaire website. The survey was anonymous, which helped to maintain confidentiality. A total of 103 surveys were returned out of 346 surveys sent out, representing a 30 % response rate. 24 respondents worked in the primary and secondary sectors of the economy, while 79 worked in KIBS (according to NACE Rev. 2).

The online survey revealed that the majority of KIBS companies innovate for various customers outside their organization. Most innovations are generated in collaboration with experts and companies, requiring knowledge from various disciplines and specialities. The survey results confirm that KIBS employ multi-disciplinary and multi-organizational teams to develop innovative solutions.

The survey results confirm that KIBS face a vast array of knowledge transfer boundaries in the innovation process, ranging from individual boundaries (e.g., collaborative communication, domain expertise, individual differences, fear, language barriers), (inter)organizational boundaries (e.g., hierarchy of authority, leadership, deficient processes, conflicting agendas, regulatory barriers, multi-tasking, culture), scarce resources (e.g., financial barriers, temporal barriers), external environment (e.g., legislative barriers, fast-changing circumstances), and specific working conditions (e.g., geographic boundaries, different time zones, multi-language environment). However, as stated previously, innovation is only possible through knowledge transfer and the spanning of various boundaries. The author addresses this issue in Chapter 2 of the Thesis.

2. KNOWLEDGE TRANSFER IN THE CROSS-DISCIPLINARY INNOVATION PROCESS

Chapter 2 of the Doctoral Thesis explores the concept of knowledge transfer in the context of the innovation development process. It examines the numerous classifications of innovation, the categories of knowledge necessary for their development, and different mechanisms and practices of knowledge transfer employed in the cross-disciplinary innovation process. It is 44 pages long and contains 8 figures and 16 tables.

The concept of knowledge transfer

The topic of knowledge transfer has been deeply analysed by researchers in management science since the beginning of the 1990s. The research topics have changed from the exploration of core elements of the knowledge transfer process, barriers and enablers of knowledge transfer, and social capital affecting knowledge transfer to various organizational forms (alliances, partnerships, clusters, networks) in which knowledge transfer occurs and the role and implication of knowledge transfer in the firm's innovation performance.

Although many studies have been conducted to examine the concept of knowledge transfer, many authors and researchers have failed to establish a clear definition for it. On occasions, it has been discussed in conjunction with terms such as "knowledge exchange", "knowledge sharing", "knowledge reproduction", and "knowledge translation".

Based on the literature review, seven themes emerged to represent the units of knowledge transfer analysis. The knowledge component represents the knowledge dimensions, categories and elements studied. Of these, the tacit and explicit characteristics of knowledge have been central to the analysis of knowledge transfer. The content and message component refers to the information to be transferred and its attributes (Prihodova et al., 2019). The stakeholders or actors' component entails the people involved in the knowledge transfer process. There is a common agreement shared by scientists that the knowledge transfer process has two main actors – the source or sender that transfers the knowledge and the receiver who acquires the knowledge (Liyanage, Elhag, Ballal, Li, 2009). The stakeholders can be individuals or the organizations (Albino, Garavelli, Schiuma, 1998). Prihodova et al. (2019) highlight the third group of actors, namely, knowledge beneficiaries, meaning wider groups of society who benefit from the knowledge implementation.

Having carried out the content analysis of twenty-three definitions, the author concludes that knowledge transfer has been defined, first and foremost, as a process by which the knowledge embodied in one unit is successfully transferred to another unit. The knowledge transfer process is characterized as dynamic (Gilbert, Cordey-Hayes, 1996), fluid, complex and iterative, involving many different actors (Bramwell, Wolfe, 2008). It is a part of the continuous learning process (Argote, Miron-Spektor, 2011) and communication involving

information processing activities (Albino, Garavelli, Schiuma, 1998; Ko, Kirsch, King, 2005).

The knowledge transfer process covers several stages (Minbaeva, 2007), the number of which varies from model to model. For example, Szulanski (1996) has proposed a knowledge transfer model consisting of four stages: initiation, implementation, ramp-up, and integration. According to Liyanage, Elhag, Ballal, and Li (2009), knowledge transfer involves six main steps: awareness, acquisition, transformation, association, application, and knowledge externalisation/feedback. In the view of Wang et al. (2004), knowledge transfer is a systematically organized process, and the organization can establish various internal policies, structures, and processes to facilitate learning.

Knowledge transfer is a process of dyadic knowledge exchanges between the source or sender who shares knowledge and the recipient unit who acquires the knowledge (Szulanski, 1996). It happens at multiple levels – between individuals, firm's units, organizations, disciplines, domains and contexts, and has to cross a variety of boundaries, e.g., knowledge, firms', professional, social, political, geographic, technological, and others (Carlile, Rebentisch, 2003; Minbaeva et al., 2003; Argote & Fahrenkopf, 2016; Herfeld & Lisciandra, 2019).

Most of the reviewed definitions emphasise that knowledge transfer requires identifying accessible knowledge that already exists (Liyanage, Elhag, Ballal, Li, 2009), acquiring it and subsequently absorbing this knowledge to make things (products, services, processes) more efficient and effective (Maurer, Bartsch, Ebers, 2011). In other words, the key element in the knowledge transfer process is not the knowledge of the source but rather the extent to which the recipient acquires and applies this knowledge. Therefore, the absorptive capacity of the receiving unit is regarded as one of the most significant determinants of the success of knowledge transfer (Minbaeva et al., 2003).

As mentioned above, the term "knowledge transfer" is often used interchangeably with the term "knowledge sharing". Having performed an extensive review of scholarly literature, Tangaraja, Mohd Rasdi, Abu Samah, and Ismail (2016) conclude that "knowledge sharing" and "knowledge transfer" are two different while interconnected concepts. The processes involved in each of these concepts vary depending on the perspective of knowledge sharing and the strategy used to transfer knowledge. The authors conclude that knowledge transfer can be achieved using two strategies –personalisation and codification. The knowledge transfer codification strategy is defined as explicit knowledge that is transferred from codified materials (e.g., books, documents, technical reports) to a recipient. In the personalisation strategy, the source's sharing is a critical process for enabling knowledge transfer. As a result, one of the primary findings of this study is that "knowledge sharing" is a subset of the knowledge transfer personalisation strategy, whereas in the codification strategy, knowledge sharing is not one of the immediate processes involved in the actual knowledge transfer because the actual codification process occurred earlier (Tangaraja et al., 2016).

Knowledge transfer in the context of innovation development

Scholars have reached three major conclusions about the phenomenon of innovation in the last decade. To begin, there is agreement that innovation is multidimensional and dependent on new development or significant improvement. Second, innovation, in whatever form it takes, results from interaction between a firm with organizational capacity and resources and a network of multiple stakeholders with whom the firm is exchanging new knowledge, implying that innovation occurs in an interactive knowledge exchange system. Third, creating innovative solutions and approaches to fixing complex issues calls for the transferring knowledge from various fields and cross-disciplinary collaboration.

The scholars have developed a vast number of innovation classifications. For example, Garcia and Calantone (2002) have classified innovations along the dimensions of innovative characteristics or degree of innovativeness of innovations. Klarin (2019) has proposed a classification of product and service innovations from a firm's perspective. According to the findings of Klarin's study, the most widely discussed types of innovation are radical vs. incremental innovation, imitative innovation, disruptive vs sustaining innovation, frugal innovation, value innovation, reverse innovation and jugaad innovation. The author concludes that the degree of novelty of the invented solution is a critical variable classifying innovations, and the reviewed typologies focus on the novelty of solutions themselves. However, none of these classifications addresses the question of what type of knowledge is required to create an innovative solution of one level or another or what level of creativity is required to solve one type of problem or another.

It has been widely recognized that the level of collaboration, communication, and coherence within a team correlates with the team's propensity to generate innovative and appropriate solutions (Stokols, Misra, Moser, Hall, & Taylor, 2008); therefore, different types of collaborative approaches and teams have been invented and applied in the innovation process.

- **Intra-disciplinary**. All team members have the same field of competence and the same speciality; initial cohesion is great, and they share a common language from the start (Sanchez-Segura, Hadzikadic, Dugarte-Peña, & Medina-Dominguez, 2018).
- **Multidisciplinary**. Team members have diverse areas of experience and specialization, minimal initial cohesion, and they do not share a common language at the onset. During the team creation session, multidisciplinary teams devote more time than intra-disciplinary teams. However, duration is not dependent on team size but rather on the absence of a shared language and initial cohesion (Sanchez-Segura et al., 2018). Multidisciplinary collaborations use knowledge from one or more fields to solve a problem, or work on a project together. Knowledge transfer is mostly one-way, and the collaborators add their knowledge to the project (Boger et al., 2016). The lack of a common language and low cohesion compelled members of a diverse team to be more conscious of their teammates. Consequently, creating new ideas is more effective than in interdisciplinary and intra-disciplinary teams (Sanchez-Segura et al., 2018).

- **Interdisciplinary**. All team members have the same field of expertise but various specializations, initial cohesion is moderate, and they do not have a similar language at the outset. Interdisciplinary team members collaborate to integrate disciplinary perspectives and address a similar issue without spilling over into other disciplines (Sanchez-Segura et al., 2018). Interdisciplinary collaborations are more interactive and characterized by two-way knowledge transfer, in which team members not only give knowledge to the project but also receive new views through the team's collaborative efforts (Boger et al., 2016).
- **Transdisciplinary**. There are several interpretations of transdisciplinarity. According to Norris, O'Rourke, Mayer, and Halvorsen (2016), members of transdisciplinary teams work together to create a shared conceptual framework that synthesizes and extends discipline-specific knowledge, producing new models and terminology to solve a common problem. This interpretation is consistent with Boger et al. (2016), who assert that transdisciplinary work is the cooperative creation of a consensus rather than a search for "fact" or "truth", and it aims to integrate and amalgamate knowledge from different backgrounds by synthesizing, fusing, and extending concepts, methods, and theories across traditional boundaries. A different interpretation is proposed by Brown (2010), as cited by Sanchez-Segura et al. (2018), which states that trans-disciplinarity entails teams that need to include "non-traditional research partners", seeing it as a way for people from different fields and parts of society to work together to produce knowledge that benefits from multiple sources of knowledge and ways of knowing. This can be thought of as an attempt to access the "collective mind" of a team comprised of many perspectives to tackle real-world challenges, sometimes known as "wicked problems", by implementing innovative, transformative change (Boger et al., 2016).

In summary, the higher the novelty level of an innovative solution, the more revolutionary and far-reaching the idea is, and the greater its impact. When multiple types of knowledge are combined in novel ways, these higher levels are more easily attained. Collaboration in which experts from numerous relevant fields work together is more likely to lead to a more complete understanding of the problem space. This is because it gives access to different perspectives and new ways of thinking that a single-discipline group would not know about or consider. However, it is also true that the more complex the problem to be solved, the greater the difficulties in knowledge transfer and the higher the chance for the emergence of knowledge transfer boundaries.

While cross-disciplinary (e.g., interdisciplinary, multidisciplinary, and transdisciplinary) innovation development is a powerful concept in theory, guidance on how to put it into practice is still required.

Mechanisms and practices for knowledge transfer in cross-disciplinary innovation process

In the last two decades, scholars from a variety of disciplines, such as management, information systems, engineering, environmental sciences, and design, have focused on the identification, classification, and evaluation of diverse practices used for knowledge transfer across different knowledge boundaries that emerge during the innovation process. Practices such as using boundary objects, knowledge management systems (Carlile, 2002; 2004; Bechky, 2003), dialogue-based approaches (Majchrzak, More, & Faraj, 2012), collaborative prototyping (Schrage, 2008), and acting out scenarios (Muller, 2003) are a few examples.

Rau, Neyer, and Möslein (2012) have conducted one of the most complete literature reviews on innovation practices and mechanisms for crossing semantic and pragmatic boundaries, as defined by Carlile (2002). Analysis reveals that innovation practices include four mechanisms for crossing the semantic boundary, including "rely on a joint structure", "engage a translator", "learn and adapt the counterparts' language", and "develop a mutually understood language". Three mechanisms for crossing the pragmatic boundaries encompass "anticipate interests", "reframe interests", and "negotiate interests".

At the beginning of 2022, the author conducted an online survey of enterprises. As a part of the online survey of enterprises, the author requested that the respondent shared information on the innovation practices (methods, tools, strategies, approaches) that his or her organization used to overcome different knowledge boundaries and ensure effective knowledge sharing during the innovation process. The provided answers were studied using the conceptual content analysis, which identifies the presence and frequency of concepts in a text.

The respondents shared many practices the firms employ for crossing syntactic, semantic, and pragmatic knowledge transfer boundaries. Additionally, the respondents were asked to name tools and approaches their organizations use to secure effective knowledge transfer. It is worth reminding that the effectiveness component of the knowledge transfer concept refers to both the knowledge transfer outputs and their effects on individual organizations. Table 1 summarizes the knowledge transfer practices of KIBS, which respondents regard as effective.

Overall, most respondents provided multiple responses, therefore it is possible to assume that the KIBS companies surveyed use a combination of knowledge transfer practices. It is also reasonable to assume that some of these practices are used concurrently, such as documenting during a co-working event while employing a suitable approach such as design thinking, depending on the need and the challenge addressed in the innovation process.

Chapter 2 of the Thesis leads us to the following conclusions:

1. The majority of KIBS companies polled by the author innovate for various customers outside their organization. Most innovations are generated in multi-disciplinary and

multi-organizational teams, necessitating collaboration with different experts and companies, requiring knowledge from various disciplines and specialities.

Table 1

Tools and Approaches for Effective Knowledge Transfer in KIBS [Created by the author]

Knowledge transfer tools and approaches	**Description**	**Examples**	**Frequency**
Digital tools	Software, programs, applications, platforms, and (online or offline) resources for use with computers, mobile devices, or other digital devices that include text, audio, and visual stimuli	Miro, Stack Overflow, Git, Howspace, Microsoft 365, Zoom, Jira, Google Docs, MsTeams, Dropbox, Notion.io, Slack, Notion, Figma, Mural, Zoho, Asana, Confluence, Enterprise Architect, BPMN2, Notion Board	44
Meetings	Events in which people gather to discuss one or more topics, most often in a formal or business setting	Project team meetings (face to face much better than over some communication tool), face-to-face meetings, quick check-in meetings, progress reporting meetings, face-to-face and online meetings to exchange tacit information and experiences, different kinds of meetings, daily meetings, recurrent meetings	32
Approaches	Ways of dealing with situations and problems faced in the innovation process	Design thinking, technology road map, concept map, co-working, prototyping and piloting, culture map, lean management, co-creation, technological readiness levels, PDCA cycle, agile rituals, design sprints	31
Documentation	Written materials which provide proof or evidence of something or are a record of something	Working reports, documenting processes, internal documentation, reports, guidelines, continuously updated project documentation, written protocols	22
Events	Moderated events in which people gather to spark group creativity, co-create and co-work	Event storming, hackathons, failure Fridays, workshops (Gopp, Learning Café), co-working workshops, team-building events, workshops	20

Table 1 (continued)

Knowledge transfer tools and approaches	Description	Examples	Frequency
Creative thinking techniques	Approaches that take a novel look at a problem while still applying rigorous analysis and careful planning	Brainstorming, idea board, analogy cards, 5-Whys, round Robin, seeking alternatives, lateral thinking techniques	16
Supportive environment	Activities aimed at building an environment characterized by relationships of trust, mutual respect, and openness	Creating an environment which is open about differences, environment that motivates people to share their knowledge, building culture and motivation to understand the mutual benefit of free and open knowledge sharing, environment which encourages sharing of knowledge.	15
Defined team structure	A structure of the team which determines the distribution of different roles, responsibilities, and hierarchy of authority within the team	A moderator who only moderates. A team of assistants helping to fix information on paper and do digital transfer. A leader who makes others lead as the power of performance are knowledge, skills and competencies of each individual. An agile coach who understands and lives agile as a learning experience. An engineer who knows about validating the construction. A creative person who makes the vision and perspectives tangible, setting up a product development committee, establishing clear roles and responsibilities in the innovation team.	9

2. The information and knowledge required for innovation come from different sources, cooperation partners and network relations, therefore knowledge transfer in the KIBS' innovation process is challenging. The research results confirm that KIBS face a vast array of knowledge transfer boundaries in the innovation process, ranging from knowledge boundaries such as syntactic, semantic, and pragmatic boundaries to various contextual boundaries.
3. The more complex the problem to be solved and the higher levels of innovation to be achieved in the innovation project, the wider the range of knowledge and cross-disciplinary (interdisciplinary, multi-disciplinary, and transdisciplinary) collaboration is required. That, in turn, increases the likelihood of various knowledge transfer boundaries appearing.

4. In the innovation process, an extensive array of practices (methods, tools, strategies, and approaches) has been applied by KIBS to cross diverse knowledge transfer barriers and implement cross-disciplinary collaboration.

Despite this, the survey results indicate that firms continue to struggle to span numerous knowledge transfer boundaries within multidisciplinary teams. To address this challenge, the author of the Doctoral Thesis is proposing a practice-based methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process. The author of the Thesis used professional experience and empirical research to lay the groundwork for the methodological framework for spanning knowledge transfer boundaries in the process of cross-disciplinary innovation. From 2008 to 2022, the author was the Chief Executive Officer (CEO) of the Institute for Environmental Solutions, a research, development, and innovation organization (IES). Founded in 2008, IES has grown into a multidisciplinary, international team of scientists, researchers, and practitioners who develop innovative solutions for sustainable natural resource management. The team comprises highly educated specialists with backgrounds in physics, chemistry, agronomy, biology, forest management, computer programming, public administration, entrepreneurship, and innovation management. As CEO, the author oversaw cross-disciplinary research and innovation projects, used a multi-stakeholder approach in innovation development, and introduced and regularly used various innovation development practices such as rapid prototyping; innovation co-creation; science, art, and technology fusion; and design sprints.

3. A METHODOLOGICAL FRAMEWORK FOR SPANNING KNOWLEDGE TRANSFER BOUNDARIES IN A CROSS-DISCIPLINARY INNOVATION PROCESS

Chapter 3 of the Doctoral Thesis introduces the process of the development of the methodological framework for spanning knowledge transfer boundaries during the cross-disciplinary innovation creation (the methodological framework), the key elements and the matrix of the methodological framework, and the results of the pilot testing. The chapter is 24 pages long and contains 9 figures and 3 tables.

Structure of the methodological framework

In this study, it has been confirmed that KIBS companies generate innovative solutions for themselves or customers outside their organizations by forming cross-disciplinary teams. Innovation development in a cross-disciplinary environment requires knowledge transfer across different levels of expertise, disciplines, specialities, and organizational experiences. As a result, the innovation process becomes more complex as multiple boundaries emerge and must be identified and addressed throughout the stages of the innovation process. The more complex the problem to be solved and the higher the level of innovation to be achieved, the more likely it is that various knowledge transfer boundaries will appear. Even though a vast array of practices – methods, tools, strategies, and approaches – has been invented and applied to cross diverse barriers, research and the author's professional experience show that companies still struggle to manage knowledge transfer within cross-disciplinary teams regularly. There are several reasons for that. First, managers of innovation projects and processes often are not aware of and trained to recognize the potential obstacles to knowledge transfer that might arise from interactions between disciplines. Second, they tend to use one or more innovation practices to encourage cross-disciplinary invention without analysing whether these practices aim to overcome the same barrier. Third, there is a lack of a comprehensive and integrated picture of the many stages of the innovation process, the various emerging barriers, and the appropriate strategies to overcome them.

To address this challenge, the author has elaborated on the methodological framework for spanning knowledge transfer boundaries in the process of cross-disciplinary innovation. The structure of the methodological framework is shown in Fig. 1.

The proposed methodological framework is grounded in four principles.

1. Holistic approach. The methodological framework comprises six interconnected elements that provide a comprehensive view of knowledge transfer during the cross-disciplinary innovation development process.
2. Causal reasoning. The methodological framework incorporates cause-and-effect logic, which states that actions and activities in one stage and process impact another stage and process.
3. Iterative. The methodological framework aims to take adopt an innovation development approach, in which practices and solutions are revisited, adapted, and refined through a series of feedback loops to fit the reality in their context.
4. Useful concerning the purpose. The methodological framework shall be useful to cross-disciplinary innovation development managers in navigating the various knowledge transfer boundaries that may arise during the course of action.

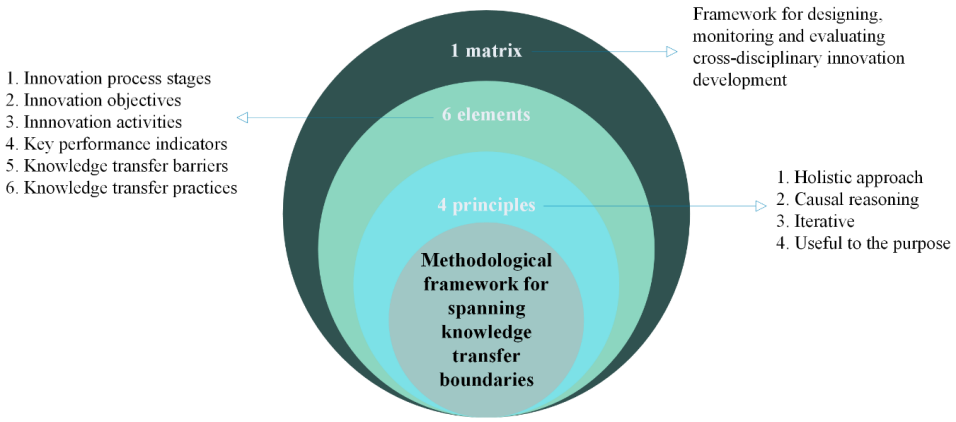

Fig. 1. Structure of the methodological framework [Created by the author].

The key elements of the methodological framework (Fig. 2) are derived from the exploratory research and the online survey of KIBS enterprises.

1. Innovation process stages. The innovation process typically involves several stages, varying depending on the specific approach or model used. In the author's proposed methodological framework, the innovation process consists of four generic phases: 1) internal and external innovation opportunity exploration; 2) strategy selection; 3) idea generation and solution development; and 4) evaluation and full-scale implementation.
2. Innovation objectives. Defining objectives at each stage of the innovation process is essential for several reasons. Initially, explicit objectives provide the creative process with direction and concentration. Without defined goals, teams may not know what they are striving for, which can result in low morale, time, and resource waste. Second, objectives aid in defining what success looks like at each step of the innovation process

and provide a framework for monitoring progress and outcomes. This allows teams to monitor their progress, modify their strategy as necessary, and celebrate their achievements. Third, objectives guarantee that all participants in the innovation process are aligned and working toward the same purpose. This is especially relevant in larger businesses because various teams may have varying priorities. Fourth, establishing responsibility for each step of the innovation process and ensuring that resources are allocated in a manner that supports the overall innovation project aim are facilitated by distinct objectives. This can be especially crucial in circumstances with limited resources.

3. Innovation activities. Various innovation activities can help achieve innovation goals. Defining objectives regarding particular actions clarifies what must be done and how it must be accomplished. In addition, it facilitates the prioritization of activities based on their relevance and urgency and the monitoring of progress. Monitoring progress against certain activities makes it simpler to spot potential bottlenecks or problems and take remedial action. Lastly, dividing objectives into actions increases the innovation process's adaptability. As new information becomes available or circumstances change, it becomes simpler to adapt actions to suit these modifications without compromising the overarching purpose.
4. Key performance indicators. The methodological framework includes a set of key performance indicators that may be used to evaluate the innovation team's success at each innovation stage and activity. It is essential to remember that the precise key performance indicators that are most pertinent will vary based on the organization and the type of innovation opportunity being investigated.
5. Knowledge transfer barriers. The list of probable knowledge transfer barriers that teams may encounter during cross-disciplinary innovation is one of the innovations of the suggested methodological framework. It is essential to remember that the more complicated the problem to be solved and the greater the level of creativity to be attained, the more probable it is that diverse knowledge transfer barriers will emerge. The methodological framework focuses on five knowledge transfer-related boundaries: 1) individual boundaries; 2) (inter)organizational boundaries; 3) boundaries related to scarce resources; 4) boundaries deriving from the external environment; and 5) boundaries related to specific working conditions. One of the most important responsibilities of innovation project or process managers is to be aware of the existence of various boundaries, to learn to recognize them by observing and analysing the behaviour of relevant involved actors and to be able to choose and apply the most suitable practice (tool, method, approach) to traverse different boundaries.
6. Knowledge transfer practices. There are many methods, tools, strategies, and approaches invented to facilitate innovation development and knowledge transfer in the cross-disciplinary and cross-organisational teams. The methodological framework elaborated by the author gives a comprehensive list of practices that may be implemented in each innovation process phase to achieve the set innovation objectives and carry out innovative activities. It is important to note that the utilization of certain knowledge

transfer practices will depend on the organization and innovation potential being investigated.

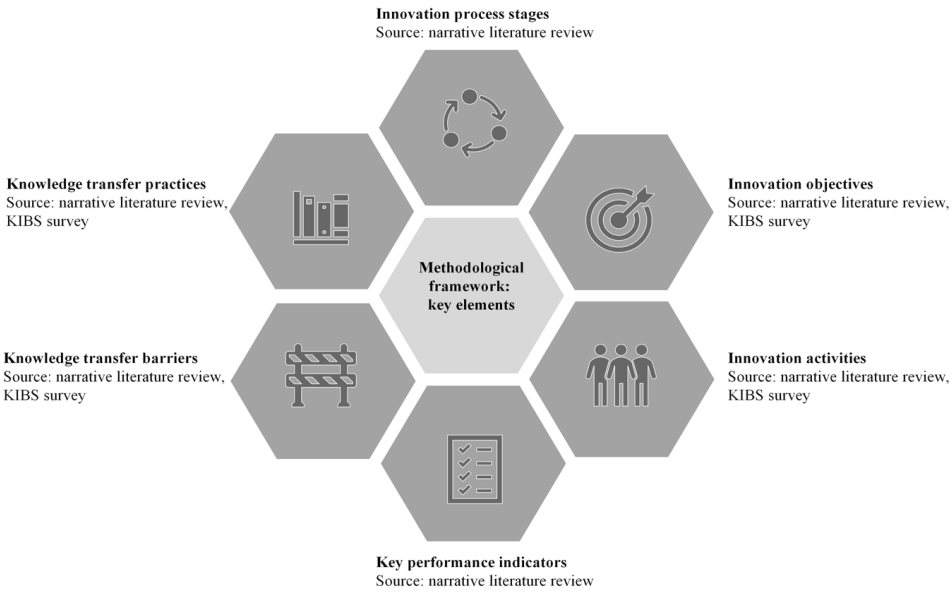

Fig. 2. Key elements of the methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process [Created by the author].

All six of the aforementioned components are interwoven and included in the matrix. Both vertical and horizontal logic exist inside the matrix. The vertical logic shows step-by-step guidance for cross-disciplinary innovation development implementation. The horizontal logic specifies how each innovation process step is implemented and monitored and the diversity of approaches utilized to accomplish it. Tracing clues for knowledge transfer boundaries, evaluating progress, and iterating on the applicability of applied knowledge transfer procedures pervade the methodological framework.

Key actors involved in the implementation of the process of knowledge transfer boundaries spanning are:

1. Customer. Internal or external body (e.g., department, company, group of people) who pays for the innovation development service and may be practically engaged in creating an innovative solution.
2. Innovation project manager/facilitator. A person who leads and manages an innovation process throughout its life cycle and is accountable for delivering results through teamwork and collaboration.
3. Innovation team. A cross-disciplinary team with the goal of developing a novel solution to the problem at hand.
4. Stakeholders. Anyone interested in or affected by the outcomes of the innovation process.
5. Support partners. Specialists in tools, methods, or topics pertinent to the problem being addressed.
6. End users/target audience. A person or other entity that consumes or makes use of goods or services created as a result of the innovation process.

Pilot-testing of the methodological framework

The methodological framework was tested in the experiment named "Innovation Co-creation Laboratory". Figure 3 illustrates an overview of the pilot-testing.

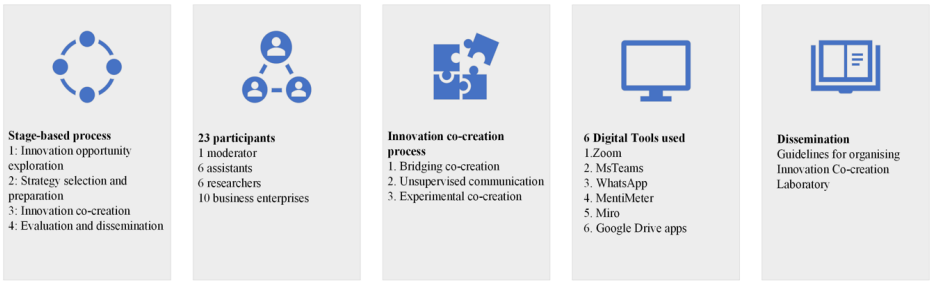

Fig. 3. Overview of the pilot-test "Innovation Co-creation Laboratory" [Created by the author].

The pilot-test was designed as a four-stage process: 1) innovation opportunity exploration; 2) strategy selection and preparation; 3) innovation co-creation; and 4) evaluation and dissemination. The pilot-test included 23 participants representing government, research, and business entities (Fig. 4). The innovation co-creation process itself consisted of three parts: 1) bridging co-creation; 2) unsupervised communication; and 3) experimental co-creation. Testing was fully tailored to the online environment because it was carried out in compliance with the COVID-19 social distancing rules. As a result, 6

digital tools were used during the pilot-test. Finally, the author of the Doctoral Thesis wrote practically applicable guidelines for organizing the innovation co-creation laboratory online. The guidelines have been published in the Latvian and English languages and are available online.

Fig. 4. Participants of the pilot-test "Innovation Co-creation Laboratory" [Created by the author].

Figure 5 depicts how the methodological framework developed by the author was used to plan and implement the Innovation Co-creation Laboratory. The pilot-test was conducted in the frame of the Interreg Baltic Sea Region project "Strengthening Smart Specialisation by Fostering Transnational Collaboration (GoSmart BSR), co-financed by the European Regional Development Fund. It was commissioned by Vidzeme Planning Region (VPR), a public administration body in Latvia, with the purpose to encourage small and medium-sized enterprises operating in a smart specialisation area to open innovations and collaborate with researchers. The pilot-test was designed and moderated by the Thesis author and a team of assistants.

In accordance with the methodological framework, one of the responsibilities of the innovation process manager or the moderator is to trace hints for the emergence of different knowledge boundaries, to learn to recognize them by observing and analysing the behaviour of relevant involved actors, and to be able to select and apply the most appropriate practice (tool, method, approach) to traverse different boundaries.

During the pilot-test, the moderators utilized a self-assessment questionnaire to monitor the participants' knowledge-transfer boundaries. The self-assessment is an effective method, as it helps innovation process managers, facilitators, or moderators to become more aware of various boundaries that may arise during the cross-disciplinary innovation process and to improve cross-disciplinary innovation process management skills through self-reflection and learning.

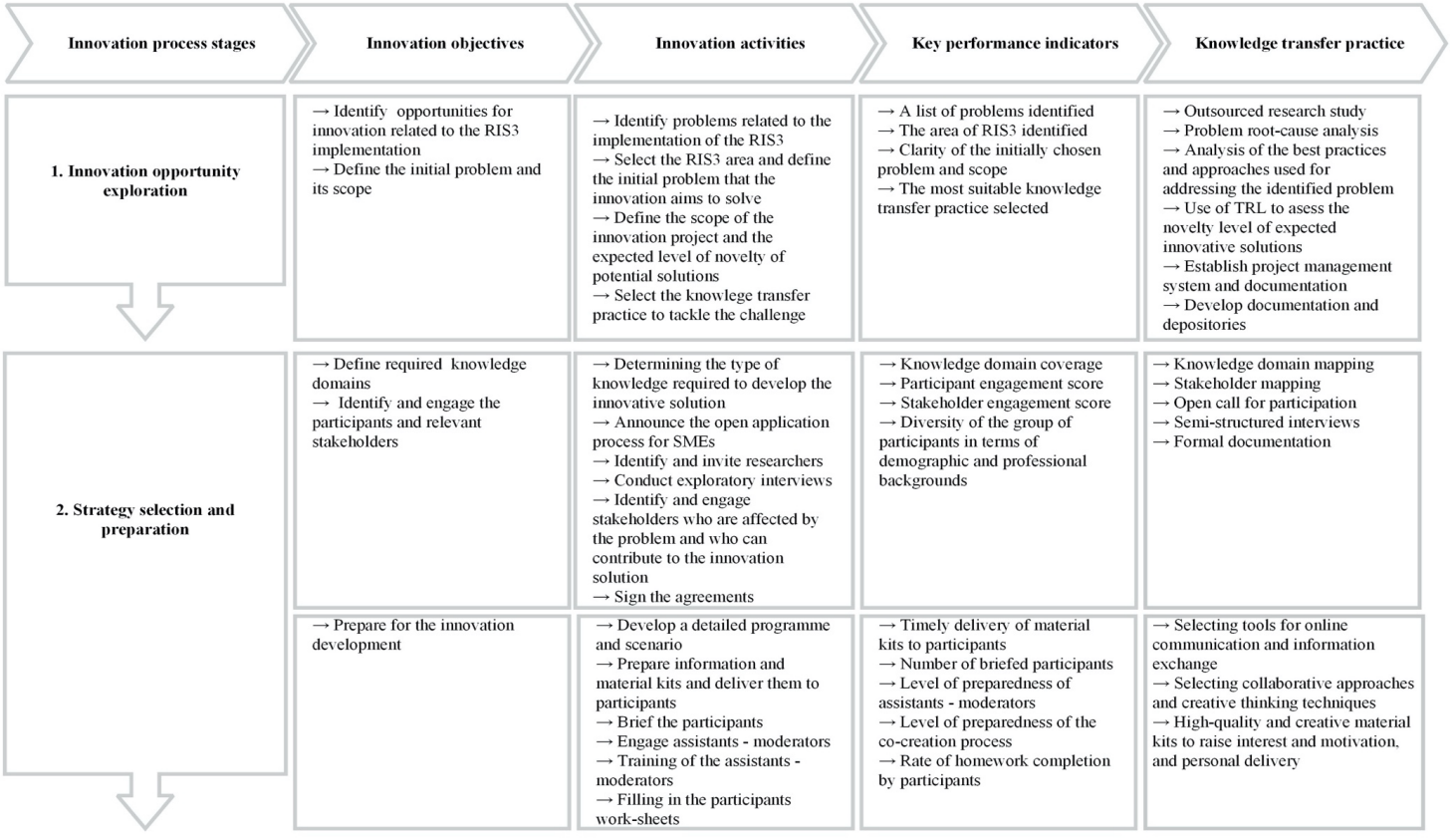

Fig. 5. Pilot-testing of the methodological framework in the experiment “Innovation Co-creation Laboratory” [Created by the author].

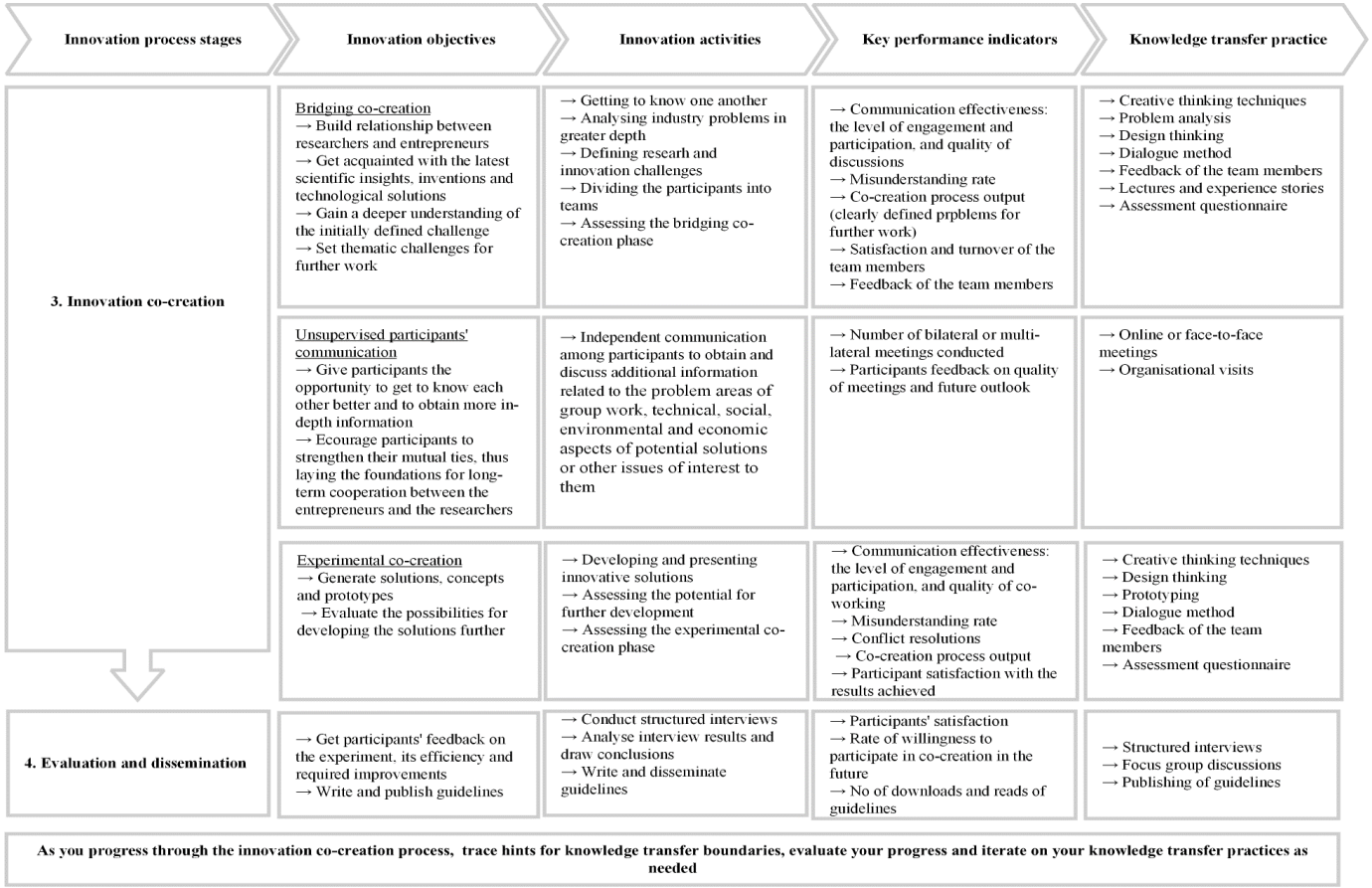

Fig. 5. Pilot-testing of the methodological framework in the experiment “Innovation Co-creation Laboratory” (continued) [Created by the author].

Table 2 provides a summary of the encountered boundaries and corrective actions taken. It is important to note that self-assessment does not guarantee the complete dissolution of various boundaries; rather, it is a practice that enables innovation process managers to become more aware of participant behaviour, to actively respond to and influence the process, and to become more skilled process moderators by analysing their own experience.

Table 2

Knowledge Transfer Boundaries Encountered During the Pilot-testing and Corrective Actions Applied [Created by the author]

Knowledge transfer boundary encountered	**Observed behaviour**	**Action applied**
Individual boundaries		
Use of professional terminology	Use of scientific terms unfamiliar to entrepreneurs	Asking researchers to clarify the term and to give examples
Avoidance of clarification	Participants are aware that they lack understanding of specific terms but avoid clarification	Active listening; moderators encourage entrepreneurs to ask questions and ask clarifying questions themselves
Struggle to explain the idea	Participants struggle to explain their ideas so that others can understand	Encouraging to give clarifying examples explaining the idea
Collaborative communication boundary	The entrepreneur admitted that he did not know how and where to find relevant knowledge, and the researcher suggested to read scientific articles	Moderators explain that it is not a common practice for entrepreneurs to read scientific articles and ask for alternative suggestions
Lack of group moderation skills	During the experimental co-creation, some groups got stuck in idea generation exercises and could not identify new perspectives, and some assistants passively observed the group work	Analysis of encountered difficulties after the event
Lack of skills in using digital tools	Some moderators struggled to use Miro during the group work in the experimental co-creation phase	Analysis of encountered difficulties after the event
Organizational boundaries		
Conflicting agendas	Some individuals (both entrepreneurs and scientists) engaged alone in the innovation project and hoped that by doing so, they would convince others of their ideas	Reminding about the purpose of the innovation co-creation laboratory and encouraging all parties to brainstorm alternative solutions that consider each other's interests and concerns
Competition	Some individuals did not want to share their knowledge during the co-creation process because of business competition	Practicing open dialogue and transparent communication

Table 2 (continued)

Knowledge transfer boundary encountered	Observed behaviour	Action applied
Boundaries related to scarce resources		
Temporal boundary	The time allocated for completion of individual tasks was insufficient	Giving a little bit of extra time for completion of some tasks. Due to the limited timeframe of the whole experiment, this boundary was difficult to remove
Boundaries deriving from the external environment		
Legislative boundary	During the problem identification and idea generation, participants cited various legislative acts that prohibit the development of certain solutions, thus inhibiting the creative thinking process	Encouraging participants to discover new facets and perspectives by posing queries to maintain their curiosity and energy
Boundaries related to specific working conditions		
Online environment	Limited time for discussions, lack of informal interactions, limited possibilities to prototype real-world solutions	Planning the programme of innovation co-creation as interactive and dynamic as possible

Evaluation and dissemination

The logic underlying the evaluation of the author's proposed methodological framework was derived from the validation approach established by Pedersen et al. (2000). The purpose of the evaluation stage was to validate whether the methodological framework is useful to innovation development managers in navigating the various types of knowledge transfer boundaries that may arise during the cross-disciplinary innovation process. The usefulness of the methodological framework was determined by evaluating two primary factors: its effectiveness and its efficiency.

To be regarded as effective, the methodological framework has to meet three criteria:

1. The individual elements constituting the methodological framework must be accepted.
2. Internal consistency of how those individual elements have been put together in the methodological framework has to be accepted.
3. The appropriateness of the problems used to verify the performance of the methodological framework has to be accepted.

To be regarded as efficient, the methodological framework has to meet three criteria:

1. The outcome of the methodological framework must be accepted as useful concerning the chosen problem's initial purpose.
2. The achieved usefulness must be accepted to be linked to applying the methodological framework.

3. The usefulness of the methodological framework must go beyond one case study.

Three main inputs were used to develop the methodological framework: 1) exploratory research; 2) the online survey of KIBS enterprises; and 3) the author's own professional experience. The purpose of the methodological framework is to help innovation process managers, facilitators, and moderators to span various knowledge transfer boundaries appearing in the cross-disciplinary innovation process and to develop innovative solutions. The framework was pilot-tested during the experiment named Innovation Co-creation Laboratory. It brought together a multi-disciplinary group of researchers, entrepreneurs, and government representatives with the purpose to test the potential of industry-research co-creation for the development of innovative solutions in the areas of smart specialisation, in this case, food and beverage production.

To evaluate the validity of the methodological framework, the following methods were applied:

1. A focus group discussion which took place two days after the end of the Innovation Co-creation Laboratory. The focus group discussion brought together seven persons and was moderated by the author of the Doctoral Thesis. The focus group comprised four Vidzeme Planning Region specialists, including the Head of the Development and Projects Department, the Manager of International Projects, the International Innovation Broker, the Director of the Vidzeme Entrepreneurship Centre, and the Communication Specialist. Two additional participants in the focus group represented the Design Factory of Riga Technical University and participated in implementing the Innovation Co-creation Laboratory as trainers and moderators.
2. To assess the methodological framework from the perspective of businesses and scientists, one week after the conclusion of the experimental co-creation phase at the Innovation Co-creation Laboratory, the author conducted in-depth interviews with the researchers and entrepreneurs who participated in the experiment. To structure the conversation, the interview questions were sent to the participants in advance. As social distancing requirements remained in effect, the interviews were conducted online via the Zoom platform, and the average interview lasted 45 minutes. A total of 13 interviews were conducted, including seven with SMEs and six with researchers. The answers of researchers and entrepreneurs were analysed with the help of content analysis.

Effectiveness of the methodological framework

In the opinion of the focus group, the developed methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process meets all the three defined criteria for measuring its effectiveness.

First, the individual elements constituting the methodological framework were derived from the exploratory research, the online survey of KIBS companies, and the author's professional experience in managing cross-disciplinary innovation development processes.

Second, as depicted in Fig. 6, the planning and implementation of the Innovation Co-creation Laboratory was carried out according to the methodological framework's vertical and horizontal logic. By exploring the matrix vertically, one can follow the stage-based innovation process implementation instructions. By reading the matrix horizontally, it is possible to determine how each innovation stage was implemented, what key performance indicators were monitored, and which knowledge transfer practices were utilized. Throughout the pilot-test, the appearance of various knowledge transfer boundaries was tracked. The focus group participants concluded that the methodological framework's elements are assembled logically and consistently.

Third, the methodological framework was applied to plan and implement the Innovation Co-creation Laboratory, a targeted intervention of Vidzeme Planning Region, a public administration body, in order to encourage small and medium-sized enterprises (SMEs) operating in a smart specialization area to open innovations and to collaborate with researchers. Implementing the Innovation Co-creation Laboratory experiment proved that the methodological framework serves as an effective tool for the management of cross-disciplinary innovation development projects (Table 3).

Table 3

Effectiveness of the Methodological Framework [Created by the author]

Effectiveness indicators	**Yes/No**
The individual elements of the methodological framework are acceptable	Yes
The internal consistency of how the elements of the methodological framework are put together is acceptable	Yes
The appropriateness of the problem used to verify the performance of the methodological framework is acceptable	Yes

Efficiency of the methodological framework

The use of the methodological framework allowed for exhaustive and detailed planning of the Innovation Co-creation Laboratory, as well as the accomplishment of results that would not have been feasible if only a single innovation development method had been utilized. In addition, the methodological framework prepared the moderators of the Innovation Co-creation Laboratory for the various barriers to knowledge transfer that typically arise during the work with cross-disciplinary innovation teams, thus helping moderators to navigate the process and to test the Innovation Co-Creation Laboratory as a practice for industry-research innovation development. The usefulness of the Innovation Co-Creation Laboratory as the main outcome of the pilot-test was highly evaluated by the experiment participants (Table 4). The third criterion for measuring the effectiveness of the proposed methodological framework was not met because it has been tested only in one instance and in one country. More empirical tests are needed to prove its usefulness.

Table 4

Efficiency of the Methodological Framework [Created by the author]

Efficiency indicators	**Yes / No**
The outcome of the methodological framework is useful concerning the initial purpose of the chosen problem	Yes
The achieved usefulness of the outcome is linked to applying the methodological framework	Yes
The usefulness of the methodological framework is beyond one case study	To be researched

Summarizing the results of the Doctoral Thesis, the author concludes that the development of innovation necessitates collaboration and knowledge creation of experts from various disciplines and specialities. As a result, it is a challenging process in which multiple barriers impeding successful knowledge transfer appear. It is possible to enhance the effectiveness of the cross-disciplinary innovation process by employing a comprehensive methodological framework for knowledge transfer that helps span multiple boundaries.

CONCLUSIONS AND RECOMMENDATIONS

The **conclusions** of this PhD research are organized according to the four theses proposed by the author.

Thesis 1. KIBS is a sub-sector of the service industry which plays a crucial role in innovation development and whose significance is expected to grow in the 21st century.

1.1. The exploratory research confirms that employees, with their specialised skills and competencies, are the most valuable and important asset and resource in KIBS enterprises. As a result, knowledge is the primary production factor and output of KIBS, which is embedded in the services and artifacts that they provide to their customers.

1.2. The review of scientific and professional literature reveals that KIBS are perceived as innovative firms capable of continuously acquiring, processing, capitalizing, and delivering new knowledge while combining various professional expertise to produce the result. Networking with various actors is critical for KIBS enterprises to manage service production succesfully.

1.3. The research confirms that KIBS play several roles in the innovation process. When intervening in the launch and development of customers' innovation activities, KIBS act as a source of innovation, as a facilitator of innovation when assisting organizations at various stages of the innovation process; and as a vector of innovation when contributing to knowledge transfer between and within organizations, industries, innovation networks, clusters, and regions. This allows to conclude that KIBS are regarded both as innovation enablers and innovators in their own right.

1.4. As emerging technologies and global competitive pressures continue to transform the business landscape, the research and professional communities assume that KIBS industries, especially those with specialized skills and high qualifications such as scientific and technical services, will continue to grow and play an important role in the 21st century. KIBS will be crucial in helping companies adopt and integrate new technological and organization systems and processes, as well as in converting the potential of new technology into business results and improved welfare. KIBS will also play a vital role in addressing major societal challenges such as population aging, food security, renewable energy, climate change, and environmental protection.

Thesis 2. As innovations are developed in cross-disciplinary teams necessitating collaboration with experts from various disciplines and specialities, knowledge transfer is challenging in the innovation process.

2.1. The scholars have agreed that innovation development is a complex and multidimensional process that involves significant improvements or new

advancements. It requires interaction between a firm with organizational capacity and resources and a network of multiple stakeholders exchanging new knowledge, emphasizing the interactive knowledge exchange as a vital element for innovation. Cross-disciplinary collaboration and knowledge transfer from various fields are essential in creating innovative solutions and approaches.

2.2. Based on the literature analysis, the author concludes that knowledge transfer is a dynamic, complex, and iterative process of exchanging knowledge between units, involving many different actors and covering several stages. Knowledge transfer can be achieved through personalization or codification strategies. The success of knowledge transfer depends on the absorptive capacity of both the source and the receiving unit.

2.3. The results of the online survey of KIBS enterprises confirmed that most KIBS companies innovate for a variety of customers outside their organization. Most innovations are generated in collaboration with different experts and companies, requiring knowledge from various disciplines and specialities, meaning that KIBS employ cross-disciplinary teams to develop innovative solutions.

2.4. The review of scientific and professional literature allows to conclude that knowledge transfer is challenging in the cross-disciplinary innovation process for several reasons. The knowledge embodied in a person and a specific context is more challenging to share with others than codified knowledge. Various types of boundaries appear when people of heterogeneous backgrounds, values, and interests constitute the innovation development group. It can also be hampered by a lack of absorptive capacity on the part of both the firm developing and providing the innovation service and the customer organization, and knowledge hiding.

Thesis 3. Although various practices, such as methods, tools, and strategies, have been invented to facilitate knowledge transfer in the cross-disciplinary innovation process, KIBS face a vast array of knowledge transfer boundaries in the innovation process.

3.1. In the innovation process, a large array of practices (methods, tools, strategies, and approaches) has been applied by KIBS to cross diverse knowledge transfer barriers and implement cross-disciplinary collaboration. Despite this, the survey results indicate that firms continue to struggle to span numerous knowledge transfer boundaries within cross-disciplinary teams, ranging from knowledge boundaries such as syntactic, semantic, and pragmatic boundaries to various contextual boundaries.

3.2. The more complex the problem to be solved and the higher levels of innovation to be achieved in the innovation project, the wider the range of knowledge and cross-disciplinary (interdisciplinary, multi-disciplinary, and transdisciplinary) collaboration is required. That, in turn, increases the likelihood of various knowledge transfer boundaries appearing.

3.3. The theoretical and practical research confirm that managers of innovation projects and processes are often unaware of or not trained to recognize the potential obstacles to knowledge transfer that might arise from interactions between disciplines and organizations. They tend to use one or more innovation practices to encourage cross-disciplinary invention without analysing whether or not these practices are aimed at overcoming the same barrier. There is a lack of comprehensive and integrated picture of the many stages of the innovation process, the various emerging barriers, and the appropriate strategies to overcome them.

Thesis 4. A holistic methodological framework may help spanning various knowledge transfer boundaries in the cross-disciplinary innovation process.

4.1. Based on the exploratory research, the online survey of KIBS, and the author's professional experience, the methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process has been developed. It meets four basic principles. It is holistic; it incorporates cause-and-effect logic, it is iterative and useful to the purpose it was created.

4.2. The methodological framework comprises six interrelated elements – innovation process stages, innovation objectives, innovation activities, key performance indicators, knowledge transfer barriers, and knowledge transfer practices. All the elements are integrated into a matrix. A self-assessment questionnaire for identifying knowledge transfer boundaries in the cross-disciplinary innovation process has been elaborated as an additional tool.

4.3. The developed methodological framework was pilot-tested in the Innovation Co-creation Laboratory experiment. The experiment was a targeted intervention of a public administration body in order to encourage small and medium-sized enterprises operating in a smart specialization area to open innovations and collaborate with researchers. The methodological framework was used as the base for planning and implementation of the Innovation Co-creation Laboratory.

4.4. According to the evaluation results, the methodological framework is useful – effective and efficient – concerning the purpose it was designed. However, further testing shall be continued in different innovation projects and initiatives, organizations, countries and regions, and conditions.

Based on the conclusions presented, the goal of the dissertation – to develop a methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process – has been attained. The theses put forward for defence have been confirmed.

Recommendations

With the rise of new technologies and competitive pressures on a global scale, it is believed by both the research and professional communities that knowledge intensive business services will continue to grow and hold a significant position in the service sector and the business landscape of the 21st century. KIBS will be essential in assisting companies and governments in developing innovative solutions for new products and services and improved organizational systems, processes, and technologies. Furthermore, KIBS will play a critical role in creating innovations to address major societal challenges. To facilitate the growth and long-term operation of the KIBS sub-sector, it is critical to continue research and development of solutions for more effective and sustainable KIBS management and production of innovative knowledge-intensive services.

Based on the research results of the Thesis, the following recommendations are made for various groups of stakeholders.

For academics and researchers

1. Continue action-based research and evaluate the usability of the methodological framework developed by the author in various innovation projects and cross-disciplinary initiatives. This can increase the usefulness of the methodological framework as an instrument for spanning various knowledge transfer boundaries in the process of inter-disciplinary innovation development.
2. Continue conducting theoretical and applied research on the various boundaries that may arise during the process of cross-disciplinary innovation. One of the focal areas could be the knowledge network analysis, which could enhance comprehension of the structure of knowledge transfer networks and identify key actors and interactions that facilitate or impede knowledge transfer in the innovation process.

For KIBS enterprises

3. Continue testing the author's devised methodological framework in various innovation projects and initiatives of cross-disciplinary characters. To continuously learn about and apply various tools, methods, and approaches to facilitate knowledge transfer and cross different boundaries in the cross-disciplinary innovation process.
4. Encourage employee development by providing training and professional growth opportunities that promote cross-disciplinary skills and knowledge. This can enhance their ability to lead and work in cross-disciplinary teams and develop innovative solutions based on knowledge transfer across different fields.
5. Foster a culture of innovation that encourages experimentation, risk-taking, and creativity. This can help create an environment that seeks and supports cross-disciplinary collaboration and innovation.

For policymakers

6. Promote cross-disciplinary innovation development by creating funding opportunities, innovation ecosystems, and educational programs that facilitate collaboration and knowledge transfer across disciplines, organizations, sectors, and countries. This can help break down silos and encourage genuine knowledge sharing between researchers and practitioners in different fields.
7. Support industry–academic collaborations to enhance knowledge transfer and cross-disciplinary innovation. This can involve providing targeted funding, creating partnerships between enterprises, research centres and universities, and supporting joint research initiatives.
8. Introduce cross-disciplinary innovation development as a good practice in the public sector institutions (e.g., ministries, agencies, regional and local authorities, state enterprises), thus helping the sector to become effective, efficient, customer-oriented, and capable of tackling various societal challenges. Continue testing the author's devised methodological framework in multiple innovation projects and initiatives of cross-disciplinary character.

For educational institutions at different levels of education

9. Promote cross-disciplinary education by creating programs and courses encouraging students to work across different fields. This will help them develop cross-disciplinary communication and collaboration skills and knowledge that essential for innovation development.
10. Use problem-based and project-based learning to facilitate cross-disciplinary innovation development skills. Pay particular attention to developing innovation management, process moderation and facilitation skills.
11. Use technology to facilitate knowledge transfer and cross-disciplinary innovation development. This can involve creating and using online platforms for sharing knowledge and resources and virtual and augmented reality technologies to simulate cross-disciplinary environments.

The author continues her work on the Doctoral Thesis topic by giving courses, workshops, and seminars to the top and middle-level managers of public and private sector organizations about knowledge transfer and cross-disciplinary innovation management, supervising master thesis of the students of the Faculty of Engineering Economics and Management of Riga Technical University and leading various development projects and initiatives in her capacity as Deputy Mayor of Cēsis municipality.

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Inese Suija–Markova
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