RIGA TECHNICAL UNIVERSITY

Inese Suija-Markova

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

Doctoral Thesis

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RIGA TECHNICAL UNIVERSITY
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To be granted the scientific degree of Doctor of Science (Ph. D.), the present Doctoral Thesis has been submitted for the 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 the review to Riga Technical University for the promotion to the scientific degree of Doctor of Science (Ph. D.) is my own. I confirm that this Doctoral Thesis had not been submitted to any other university for the promotion to a scientific degree.

Inese Suija – Markova (signature)
Date: 21.11.2023.

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

ANNOTATION

Suija-Markova I. Methodological Framework for Spanning Knowledge Transfer Boundaries in Cross-Disciplinary Innovation Process. Doctoral Thesis. – Riga: RTU Press, 2023. - 155 p.

The aim of the doctoral thesis is to develop a methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process. It is written in the English languages, and consists of an introduction, three chapters, conclusions and recommendations, a list of references and five appendixes.

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. Also reviewed are the KIBS competitiveness dimensions, indicators, and measures. Given the importance of KIBS to the innovation system and the purpose of this research study, chapter 1 provides a comprehensive analysis of the KIBS innovation process, and the barriers faced during the innovation development. Chapter 1 presents a portion 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. The second chapter 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 spanning knowledge transfer boundaries in the process of inter-disciplinary innovation. It describes the research design and methods used, as well as the underlying principles, essential elements, and 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 10 appendices. The bibliography contains 236 sources of reference.

Key words: knowledge intensive business services, cross-disciplinary, innovation knowledge transfer, boundary spanning, methodological framework

LIST OF ACRONYMS

CIS	Community Innovation Survey
C-KIBS	Creativity intensive knowledge intensive business services
ECB	European Central Bank
EU	European Union
ICL	Innovation Co-creation Laboratory
KBV	Knowledge-based view of the firm
KIBS	Knowledge intensive business services
KPI	Key performance indicator
OECD	Organisation for Economic Co-operation and Development
P-KIBS	Professional knowledge intensive business services
RBV	Resource-based view of the firm
R&D	Research and development
SMEs	Small and medium-size enterprises
T-KIBS	Technology-based knowledge intensive business services
VPR	Vidzeme Planning Region
WoSCC	Web of Science Core Collection
WoS	Web of Science
WTO	World Trade Organization

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INTRODUCTION

Cross-disciplinary innovation refers to the process of combining knowledge and expertise from different fields, sectors, and organisations to create new ideas, products, or solutions. The importance of 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 capacity of one organisation and one sector. The cross-disciplinary innovation process is one such 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 more and more 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 have not been possible otherwise.

Knowledge intensive business services (KIBS) is a sub-sector of service industry which plays a crucial role in the 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 no available 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 to improve their competitiveness, productivity, and innovation. By providing expert advice, KIBS help companies to improve their decision-making processes, develop new strategies, and identify new market opportunities (Bettiol et al., 2015). Furthermore, KIBS also play 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 the real work. This collaboration between KIBS and other industries fosters innovation, which ultimately leads 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 has 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 a variety of customers outside their organization. Most innovations are created and developed in multi-disciplinary, multi-sectoral, and multi-organizational teams which necessitates collaboration with different experts and companies, requiring knowledge from various disciplines and specialities. Innovation development in cross-disciplinary environment requires knowledge sharing and transfer across different levels of expertise, disciplines, specialities, and organizational experiences. As a result, the innovation process becomes more difficult 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.

A vast array of practices, including methods, tools, strategies, and approaches has been invented and applied to span diverse boundaries in cross-disciplinary innovation process. For example, design thinking is a human-centred approach to innovation that involves empathy, ideation, prototyping, and testing. It encourages collaboration between different disciplines and helps teams to 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 types of knowledge that are needed for an innovation project. This can help to identify knowledge gaps and areas where expertise from different disciplines is needed. Co-creation workshops bring together stakeholders from different disciplines to collaboratively generate ideas and develop solutions. 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 own 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 often are not aware of or trained to recognize the various potential obstacles to knowledge transfer that might arise from interactions between disciplines and organisations. 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 barriers that emerge, 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 utilized by KIBS 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.

Research object is innovation process of knowledge intensive business services.

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 into the **theoretical perspectives** that underpin the concept of KIBS un knowledge transfer. It includes scientific works that investigate the knowledge-based view (KBV) of the firm, 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 and Winter, 1982; Kogut & Zander, 1992). The innovation systems perspective which emphasis the role of KIBS 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 and 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 and 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**, including:

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 in the global, EU, and national level 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, snow-ball sampling, and purposive sampling.
4. Pilot testing and evaluation of the methodological framework in the experimental innovation co-creation laboratory (ICL) with participation of businesses, scientists, and representatives of governmental authority – regional development management organisation.

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

1. Publish or Perish, a piece of 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 structural evaluation of the author's developed methodological framework

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

1. Scientific literature review and statistical data analysis of KIBS sub-sector and its performance during the innovation process.
2. Survey on 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.

Figure 1 illustrates the overall logics of the research and how it is incorporated in the various sections of the doctoral thesis.

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

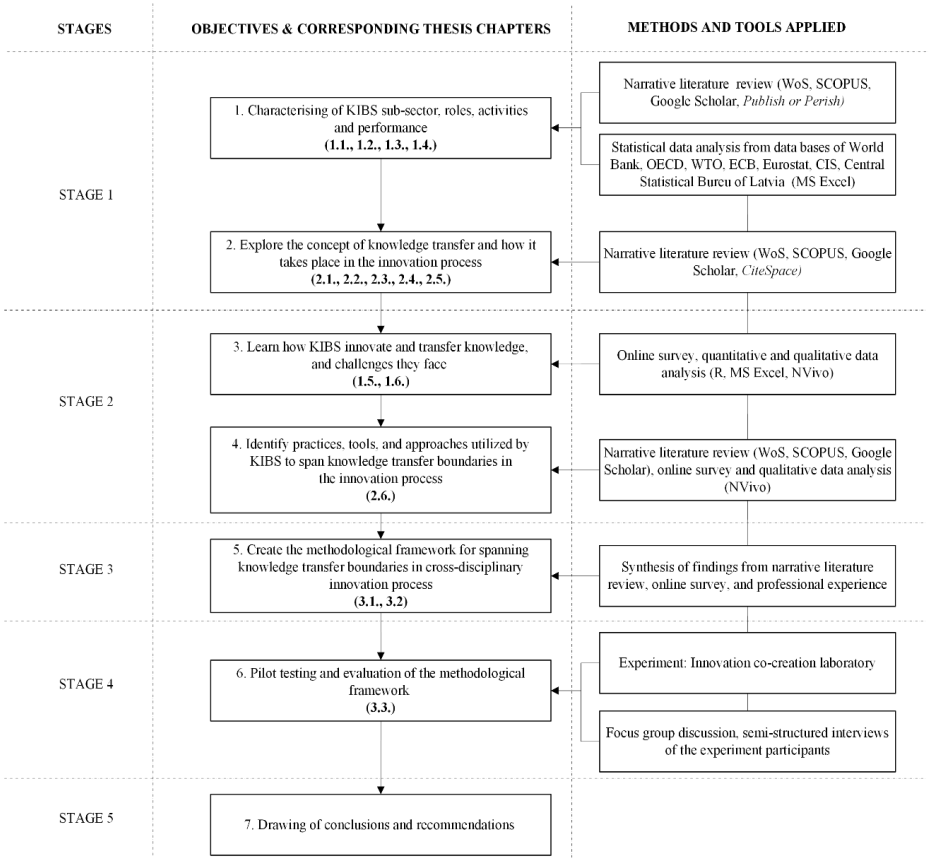


Fig. 1. The overall logics of the research and the methods and tools applied [Created by the author].

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 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 service industry which plays a crucial role in the 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 a variety of 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 spanning various knowledge transfer boundaries in cross-disciplinary innovation process.

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

The author's developed methodological framework for spanning knowledge transfer boundaries in 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 Organising an Innovation Co-Creation Laboratory Online for Public Sector Organisations 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 dissertation consists of an introduction, three chapters, conclusions and recommendations, a list of references and five appendixes.

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. Also reviewed are the KIBS competitiveness dimensions, indicators, and measures. Given the importance of KIBS to the innovation system and the purpose of this research study, chapter 1 provides a comprehensive analysis of the KIBS innovation process, and the barriers faced during the innovation development. Chapter 2 presents a portion 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. The second chapter 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.

The third chapter is devoted to the methodological framework for crossing 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 158 pages, excluding appendices. The content of the thesis is illustrated by 34 figures, 27 tables, and 10 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

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

1. KNOWLEDGE INTENSIVE BUSINESS SERVICES

1.1. KIBS definition and evolution

In the early 1990s, knowledge intensive business services (KIBS) emerged as a distinct research topic. Until then, KIBS were referred to as "consultancy firms," "professional services," "business services", or "advanced business services" (Muller & Doloreux, 2009).

Miles et al. (1995, p.28) coined the term "knowledge intensive business services" to describe industries which "1. rely heavily on professional knowledge; 2. either are themselves primary sources of information and knowledge; 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 a lot of attention since the Mile's trigger publication.

The figure 1.1. depicts data demonstrating trends in the use of the term "knowledge intensive business services," either in the article tile or as a keyword in the text, in comparison to the term "professional services" (PS), which has been the focus of research for a longer time. The data are retrieved from the tool Publish or Perish (PoP) (Harzing, 2007), a software programme which extracts and analyses academic citations from Google Scholar searches. Despite some limitations (for example, some articles are counted twice because they are cited twice, and the software only uses Google Scholar), PoP counts publications of all types, including scientific articles in highly regarded journals, books and book chapters, theses, policy papers, and reports.

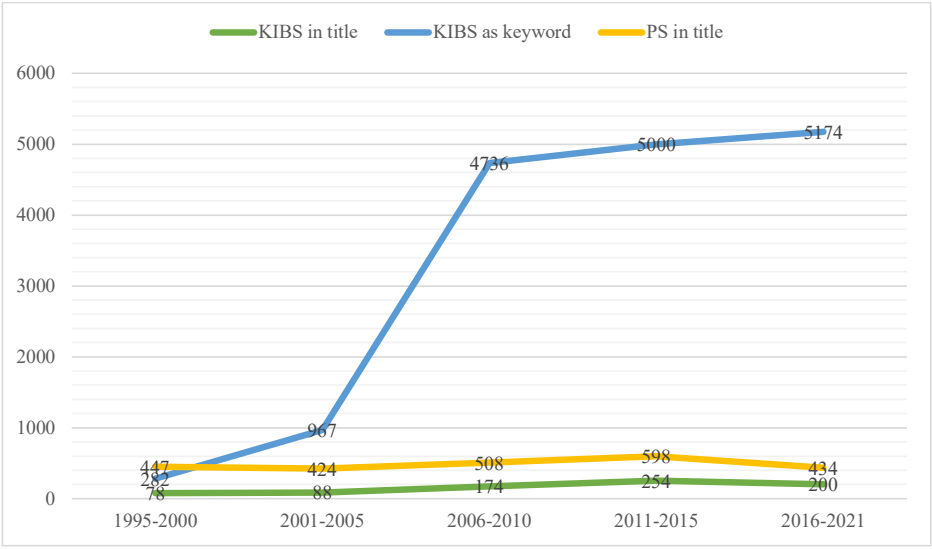


Fig. 1.1. Publications with "Professional services" and "Knowledge intensive business services" in their titles and text [Created by the author using Publish or Perish].

The use of the term KIBS in the title of a publication generally implies that KIBS are the focus of the study, whereas when the term appears in the text, it could mean that either a specific KIBS sector or case is investigated, or that KIBS as a whole is mentioned alongside other terms or contrasted with another category (Miles et al., 2018). The data derived using PoP show that there has been significant and ongoing interest in the KIBS topic for more than twenty-five years, and it is safe to assume that this trend will continue in the future as broader socioeconomic changes drive the need for KIBS.

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 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 concept, most KIBS firms are unaware of their status and do not consider themselves to be such (Nählinder, 2005).

Most researchers agree that KIBS are a subset of services that share three main elements, based primarily on the definition of Miles et al. (1995, p.28).

1. KIBS are “knowledge intensive”. It implies that KIBS firms rely heavily on specialized knowledge, as opposed to capital equipment or functional labour. A large proportion of the KIBS workforce is made up of professionals with extensive qualifications or training in relevant fields, implying that human capital is the most important factor in KIBS' operations. At the same time, the term "knowledge-intensive" can refer to the nature of the work performed by KIBS, implying that KIBS are involved in complex and intellectually challenging activities (Miles, Belousova, & Chichkanov, 2018).
2. KIBS customers are other businesses. KIBS clients are mainly other organisations operating in various sectors - public, private, charitable, and they provide inputs to business processes rather than final consumption activities of individuals or households. As a result, "knowledge-intensive" organizations that provide services to individual consumers, such as higher education and health care, are not generally classified as KIBS.
3. KIBS products are mainly “services”. The term "services" is used in the KIBS context to refer to activities or industries that specialize in the development of intangible solutions that effect some kind of transformation in the world other than the production of a tangible product. It is worth noting that the term "services" refers to both service firms and industries, as well as the activities or outputs of such firms and industries.

Appendix 1 of the thesis summarizes the most often cited definitions of KIBS. In this research, the working definition of KIBS will imply firms, regardless of ownership structure, that rely heavily on their employees' professional knowledge and whose primary business is the provision of primarily non-routine knowledge-intensive services to other organizations operating in various sectors and industries.

Although many KIBS professions date back hundreds of years, there is no comprehensive historical survey of KIBS evolution. Figure 1.2 depicts the birth and early

stages of development of the most frequently cited KIBS professions and industries, including advertising, accounting and legal services, management consulting, engineering, research and development, and information technology-related services.

Because of changing competitiveness conditions, the growth of KIBS reflects an increasing demand for knowledge. The KIBS sector includes firms that have emerged with the goal of assisting other organizations in addressing challenges that necessitate the use of external sources of knowledge (Miles, 2005). Advertising, for example, is one of the oldest business service industries. In the nineteenth century, the first advertising agencies, which acted as brokers for space in newspapers, were established in the United States, facilitating the growth of the advertising industry. Agencies were producing advertising messages, copy, and artwork by the early twentieth century, and by the 1920s, agencies planned and executed complete advertising campaigns, from initial research to copy preparation to placement in various media (Encyclopædia Britannica, 2017).

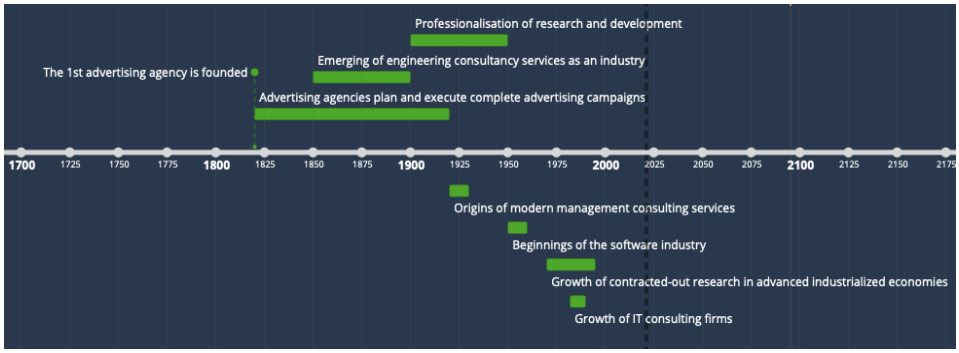


Fig. 1.2. A timeline of KIBS evolution based on literature review [Created by the author].

The Industrial Revolution gave an impetus not only to the development of non-technology KIBS such as advertising, accounting, and business management consulting, but also the technology based KIBS. The first significant phenomenon to demonstrate this was the professionalization of research and development (R&D) (Toivonen, 2004). The German companies Siemens, Krupp, and others were the first to establish laboratories to exploit the opportunities of scientific discoveries, and, as early as 1900, employed several hundred people on scientific research. “Germany was more advanced than the US in terms of not only the formation of industrially-based research, but also in relation to the development of industry–academic links” (Howells, 1999, p. 19).

At the micro level, the rapid growth of KIBS such as computer software and information processing services, R&D and technical services, marketing, business organization services, and human resource development services is linked to the increasing competitiveness pressures on firms in almost all sectors, as product lifecycles shorten and customer expectations rise (Huggins, 2011). According to OECD (2000), many factors have contributed to the growth of KIBS, including the outsourcing of many former activities by

established firms, the growth of smaller production units and firms that use external services to supplement their internal resources, the need for greater flexibility within firms, the rise of knowledge-based economies that rely on expertise and specialized service inputs, and specialized and increased division of labour in many areas. Technological advancement and the internet are also important factors that have created new production opportunities and modes of supply (European Union, 2015).

At the macro level, regional and national competitiveness is maintained by fostering innovation within respective business communities. KIBS have grown in regions and countries where many of the most high-value-added firms are clustered within specific areas of economic activity, according to multiple studies. These companies tend to concentrate on their core competencies while also making extensive use of external knowledge for innovation (Huggins, 2011).

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 (Schwalb, 2016). 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 are allowing enterprises and final consumers to access new services and business models. Furthermore, they may contribute significantly to economic growth and dealing 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 are also altering 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).

1.2. KIBS features and classification

Because no standard definition of KIBS has emerged, a large body of literature investigates the characteristics of KIBS. It is important to note that these are general characteristics of KIBS firms, which does not necessarily imply that they apply to all KIBS firms in all countries. The majority of what is written about KIBS is derived from the definition, based on case studies, or studies focusing on one or more aspects of KIBS. The table 1.1 lists the most frequently cited KIBS features.

The primary value-added activities of KIBS are knowledge accumulation, creation, and dissemination in order to develop customized service or production solutions to meet the needs of the customer (Bettencourt et al., 2002, Bettiol et al., 2015, Exposito-Langa, et al.,

2015, Belso-Martínez, et al., 2011, Doloreux & Shearmur, 2010, Bolisani, Donò, & Scarso, 2016). "KIBS customers are organisations that have a problem to solve, a difficult task to perform or an innovation project to develop but do not have all the skills and knowledge needed. These organisations turn to providers of knowledge-based services for assistance" (Bettiol et al., 2015, pp.242-243). Knowledge is both the KIBS' input and output, delivered in the form of consulting or built into products and services (Bolisani et al., 2016) in all sectors of the economy (Asikainen, 2013).

Table 1.1

KIBS features based on the literature review [Created by the author].

Source	**KIBS feature**
(Bettencourt et al., 2002) (Doloreux & Shearmur, 2010) (Belso-Martínez, et al., 2011) (Camuffo & Grandinetti, 2011) (Exposito-Langa, M., et al., 2015) (Bettiol, Grandinetti, 2015) (Bolisani, Donò, & Scarso, 2016)	Knowledge accumulation, creation, and dissemination
(Windrum & Tomlinson, 1999 as cited by Abecassis-Moedas et al., 2012) (Miozzo and Grimshaw, 2006 as cited by Asikainen, 2013) (Rubalcaba et al., 2008 as cited by Asikainen, 2013) (Biege, Lay, Zanker, & Schmall, 2013) (Bolisani et al., 2016)	Strong reliance on professional knowledge and expertise of employees and organizational routines
(Abecassis-Moedas et al., 2012) (Exposito-Langa, M., et al., 2015) (Bettiol et al., 2015)	High service customisation vs. wholly or largely standardized services
(Andersson, Baltzopoulos, & Lööf, 2012) (Bettiol et al., 2015)	Intense relationship with a customer
(Doloreux & Shearmur, 2010) (Biege, Lay, Zanker, & Schmall, 2013)	Production organised as projects or carried out using a project-based way of thinking
(Sveiby, 2012)	Production of the result is often done in teams requiring a combination of different kinds of professional expertise
(Den Hertog, 2000) (Exposito-Langa, M., et al., 2015)	A facilitator, a carrier, or a source of innovation
(Miozzo and Grimshaw, 2006 as cited by Asikainen, 2013) (Bettiol et al., 2015)	An enabler of business processes
(Doloreux & Shearmur, 2010) (Bettiol, De Marchi, Di Maria, & Grandinetti, 2012) (Delmar and Wennberg, 2010 as cited by Fernandes & Ferreira, 2013)	A knowledge conveyor, a producer and a mediator in clusters and regional economies
(Camuffo & Grandinetti, 2011) (Bettiol et al., 2012)	A part of knowledge-related networks and cooperates with multiple actors

KIBS firms rely heavily on the exploitation of employees' knowledge, skills, and specialisations, often in a very narrow field, due to their high knowledge-intensity (Biege, Lay, Zanker, & Schmall, 2013; Bolisani et al., 2016; Windrum & Tomlinson, 1999 as cited

by Abecassis-Moedas et al., 2012; Miozzo and Grimshaw, 2006 as cited by Asikainen, 2013). Unlike traditional services, KIBS are characterised by the central role of knowledge accumulated in the employees and organisational routines (Rubalcaba et al., 2008 as cited by Asikainen, 2013).

KIBS enterprises adapt their knowledge to the specific needs of individual customer (Bettiol et al., 2015), therefore, KIBS services and solutions have a higher degree of customization compared to goods (Abecassis-Moedas, et al., 2012; Exposito-Langa, M., et al., 2015). Even though "service customization" remains as one of the main characteristics of KIBS, several authors have found that there is a significant number of KIBS firms, for example in software and technical services, which provide wholly or largely standardised services. It means that there is some internal variation in the services provided by KIBS, as well as a degree of standardization (Bettiol, De Marchi, Di Maria, & Grandinetti, 2012; Bettiol et al., 2015).

Several authors describe the problem-solving process in KIBS as complex and time-consuming, involving problem identification, solution design and implementation, and the solution derived outcomes (Aarikka-Stenroos & Jaakkola, 2012). Therefore, business activities of KIBS usually are either organised as projects or are carried out using a project-based way of thinking, thus maintaining ability to react flexibly to changing customer requirements (Biege, Lay, Zanker, & Schmall, 2013; Doloreux & Shearmur, 2010). KIBS production is frequently carried out in teams, requiring a combination of various types of professional expertise to produce the result (Sveiby, 2012).

A high level of service customization requires closer interaction with the client, therefore, employees of KIBS enterprises often have higher contact-intensity with customers than employees of manufacturing firms (Andersson, Baltzopoulos, & Lööf, 2012; Bettiol et al., 2015). The complex and often customized nature of KIBS provided demands more frequent in person interaction with the client, starting even before the service itself is produced (Bettiol et al., 2012). There is an academic debate on the nature and geography of the interactions. Although spatial proximity between provider and client is regarded as necessary for service co-production, there is evidence that once trust and understanding exist between them, service relationships can successfully be conducted at a distance (Shearmur & Doloreux, 2013, p.754).

Enterprises providing KIBS are regarded as facilitators, carriers or sources of innovation (Den Hertog, 2000 as cited by Asikainen, 2013). They develop and commercialize new products, processes and services, acting both as an external knowledge sources and co-producer of innovation for their client firms and introducing internal innovation (Exposito-Langa, M., et al., 2015) that are scientific, technological, organisational, financial, and commercial (Doloreux & Shearmur, 2010). Therefore, KIBS are more often engaged in intra- and extra-mural R&D than manufacturing firms (Asikainen, 2013).

KIBS are considered to be enablers of different business processes (Miozzo and Grimshaw, 2006 as cited by Asikainen, 2013). They provide knowledge intensive inputs to the business processes such as engineering, R&D services, software development, advertising and market research, accounting, and management services. KIBS support

innovation activities of their customers and help them upgrade their technology, organisational processes and business models (Bettiol et al., 2015).

Several studies have emphasized the role of KIBS in fostering innovation not only at a company-level but also in clusters and regional innovation systems (Bettiol et al., 2012; Shearmur and Doloreux, 2008 as cited by Doloreux & Shearmur, 2010). KIBS play the role of gatekeepers, acting as intermediaries between cluster firms and external sources of knowledge, enabling this knowledge to be further distributed within regional system (McDermott et al., 2009 as cited by Exposito-Langa, M., et al., 2015). KIBS are particularly valuable because of their bridging qualities, which offer firms access to a variety of knowledge resources that would otherwise be difficult for them to access, especially for small enterprises (Camuffo & Grandinetti, 2011). The presence of KIBS in a particular location is proved to be an important leverage to regional competitiveness. Several authors have identified a correlation between the rate of employment at KIBS enterprises and the level of productivity of non-KIBS companies in the surrounding region of location (Dall'erba et al., 2007; Delmar and Wennberg, 2010 as cited by Fernandes & Ferreira, 2013).

Finally, cooperation has a central role in the innovation process in KIBS. To manage the production of services and innovation processes successfully, KIBS need to interact with a plurality of actors, not only on the downstream side of the supply chain, with their customers, but also upstream with suppliers of services (Bettiol et al., 2012). KIBS absorb existing knowledge by the access to sources such as journals, conferences, etc. and by relations developed with similar institutions, university departments and research centres located in different countries and inside the country, region, or district (Camuffo & Grandinetti, 2011).

We can conclude from the characteristics of KIBS that:

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 that 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 types of professional expertise to produce the result.
7. Networking with a variety of actors is critical for KIBS enterprises to successfully manage service production.

These characteristics are the most well-known features of KIBS enterprises, and they are frequently but incoherently used to define the research context. Although characterizing KIBS based on shared characteristics is reasonable, it does not reveal differences and heterogeneity among KIBS. Various authors have focused on developing KIBS classifications for this purpose.

Although the term KIBS is frequently used to refer to a homogeneous sector, there are numerous KIBS sub-sectors and differences at the firm level. The following sections will go over the most frequently cited categories for analysing KIBS differences and heterogeneity.

Industrial classifications

KIBS categorisation along industry line and economic nomenclatures (table 1.2) is one of the most frequently used approaches.

Table 1.2

KIBS industrial classification based on literature review [Created by the author].

Classification category	Description	Source
Industrial nomenclature (NACE), rev.2.	The KIBS activities are distributed across four groups: knowledge intensive market services; high-tech knowledge intensive services; knowledge intensive financial services; and other knowledge intensive services	(EC, 2008)
Knowledge and technology types used	Three groups of KIBS are differentiated: T-KIBS (technology-based KIBS), P-KIBS (professional KIBS), C-KIBS (creativity-intensive KIBS)	(Miles, 2005) (Freel, 2006) (Doloreux & Shearmur, 2010) (Huggins, 2011) (Carmona-Lavado et al., 2013) (Miles et al., 2018)
Core business activities	KIBS are grouped in three types: technology-based KIBS, marketing-related KIBS, professional KIBS	(Pino, et al., 2016)
Core business activities	KIBS are classified as market KIBS, company KIBS, technical KIBS, event KIBS	(Borodako, Berbeka, Rudnicki, Łapczyński, Mariusz, 2019)
Customer base	Knowledge intensive service industries are classified into two broad categories: market-oriented services and public-sector oriented	(Javalgi, Gross, Joseph, & Granot, 2011)

The European statistical classification of economic activities NACE (Nomenclature of Economic Activities) is one of the most widely used categorisations of KIBS. According to

NACE Rev.1.1., that was valid until 2008, the KIBS sector belonged to the NACE codes 72 (computer related activities), 73 (research and experimental development) and a set of sub-sectors from code 74 (other business activities) (Muller & Doloreux, 2009 as cited by Bettiol et al., 2012). NACE Rev.2 substantially reorganised the KIBS sector by distributing them across four main groups: 1. knowledge intensive market services; 2. high-tech knowledge intensive services; 3. knowledge intensive financial services, and 4. other knowledge intensive services (table 1.3). It is worth noting that traditional industrial classifications and economic nomenclatures, such as NACE, are primarily based on the nature of the goods and services produced, as well as inputs, processes, and production technology, and do not address the issue of the various types of enterprises and ownership structures that comprise the KIBS sector (Bolisani, Paiola, & Scarso, 2014).

Table 1.3

Statistical classification of KIBS [Created by the author based on NACE Rev.2., 2008].

NACE	Description
Knowledge intensive market services	
50 to 51	Water transport, air transport
69 to 71	Legal and accounting activities. Activities of head offices, management consultancy activities Architectural and engineering activities, technical testing, and analysis
73 to 74	Advertising and market research. Other professional, scientific, and technical activities
78	Employment activities
80	Security and investigation activities
High-tech knowledge intensive services	
59 to 63	Motion picture, video and television programme production, sound recording, and music publish activities Programming and broadcasting activities Telecommunications Computer programming, consultancy, and related activities Information service activities
72	Scientific research and development
Knowledge intensive financial services	
64 to 66	Financial and insurance activities (section K)
Other knowledge intensive services	
58	Publishing activities
75	Veterinary activities
84 to 93	Public administration and defence, compulsory social security (section O). Education (section P). Human health and social work activities (section Q). Arts, entertainment, and recreation (section R).

Other well-known KIBS categorization is based on the types of knowledge and technology used in the KIBS production process. Originally, it differentiated between technology-based or technical KIBS (T-KIBS) and professional KIBS (P-KIBS) (Miles, et al., 1995; Freel, 2006). The term “T-KIBS” usually relates to new technology-based services such as IT, R&D, technical engineering services and consultancy whereas p-KIBS include traditional professional services such as legal, financial, accounting, marketing, advertising services (Carmona-Lavado et al., 2013; Miles, 2008 as cited by Doloreux & Shearmur, 2010; Huggins, 2011). Miles has argued that a further distinction within KIBS must be considered by introducing the third type of “C-KIBS”. Those would include KIBS

that require symbolic and cultural knowledge, as compared to professional knowledge of administrative and juridical systems, and technical knowledge of science and engineering. Advertising, architecture, and design services are representatives of C-KIBS where such type of knowledge plays an important role (Miles et al., 2018).

Some authors claim that that T-KIBS are more innovative than P-KIBS (Miles et al., 1995; Tether and Hipp, 2002 as cited by Carmona-Lavado et al., 2013) as they spend significantly more on innovation per employee than high knowledge intensity other service firms, thus suggesting a greater commitment to innovation (Muller & Doloreux, 2009).

A classification of KIBS along their core business activities is proposed by Pino, Capestro, Guido, Tomacelli, & Abate (2016). They group KIBS in three main types: 1. technology-based KIBS which refer to IT-related services (e.g., data processing, network services, consulting engineering, etc.); 2. marketing-related KIBS (e.g., market research, advertising planning, branding development, etc.); 3. professional KIBS (e.g., accountancy and book-keeping, legal services, labour recruitment services, etc.). Borodako, Berbeka, Rudnicki, Łapczyński (2019) have extended the classification of KIBS based on core business activities and group KIBS in four types: 1. market KIBS (e.g., market and public opinion research, media representation activities, advertising agency activities, scientific research in social sciences and humanities), 2. company KIBS comprising legal activities, accounting and bookkeeping, PR, management services, temporary employment agency services, 3. technical KIBS such as specialist design activities, scientific research in the natural and technical sciences, technical research and analysis, architectural and engineering activities and related technical consultancy, software and IT, data processing and website managemnet, and 4. event KIBS (e.g., activities related to organisation of fairs, exhibitons, and congresses, tour operator activities, performing arts activities, organisers of entertainmnet and recreational attractions).

Javalgi, Gross, Joseph, & Granot (2011) have expanded and modified the classification of knowledge intensive services of the National Science Board of the United States. It classifies knowledge intensive service industries in two broad categories – market-oriented services and public-sector oriented. The first one includes communications, financial, computer software development, and business services such as management consulting. The second one includes services such as education, health, entertainment, and tourism.

To conclude, KIBS categorization along the industry lines has been challenged as it does not allow investigating internal variety of KIBS sector and identifying common patters across different sub-sectors (Corrocher et al., 2009 as cited by Bolisani et al., 2014). Moreover, quite a few KIBS companies operate at interfaces between different subsectors. For example, many technical consultants often provide business consulting, or vice versa, and book-keeping and software development are highly intertwined tasks that are often carried out by a single firm and are not separable in the balance sheets (Horgos & Koch, 2008).

KIBS features-based classification

According to Bolisani et al. (2014), KIBS cover diverse service sub-sectors and activities; therefore, KIBS' studies based on traditional taxonomies, such as industrial classifications and economic nomenclatures like NACE, fail to provide the specific characters, structural differences and distinct behavioural patterns that distinguish individual company. Several studies have discovered that KIBS differ widely in terms of their organizational forms, knowledge base and absorptive capacity (Doloreux & Shearmur, 2010), cognitive features and knowledge management practices (Bolisani et al., 2014). The most often cited features-based classifications are presented in table 1.4.

Table 1.4

KIBS features-based classifications based on the literature review [Created by the author].

Classification category	Description	Source
Knowledge types	Four types of KIBS are proposed – expert dependant organizations, knowledge-routinized organisations, symbolic-analyst dependent organisations, communication intensive organisations	(Blackler, 1995)
Inputs to innovation	Four types of knowledge intensive service activities are discriminated: renewal services, routine services, compliance services, and network services	(OECD, 2006)
Innovation, functional integration, and spatial proximity	Based on three main KIBS characteristics, seven clusters of KIBS are defined	(Horgos & Koch, 2008)
Tie strength with client	Four types of KIBS are identified: operational service, experimental service, tactical service, and high potential service	(Smedlund, 2008)
Knowledge intensity, capital intensity and a professionalised workforce	Based on three main KIBS characteristics four types of KIBS are identified: classical professional firms, professional campuses, neo-professional firms, and technology developers	(Von Nordenflycht, 2010)
Knowledge base and formalisation of production processes	KIBS are grouped in four categories: R&D suppliers, integrated solutions providers, professionalised service firms, multi-unit service firms	(Miozzo, et al., 2012)
Level of skills- and knowledge- intensity	KIBS are grouped into three categories – low, medium, and high skills- and knowledge-intensity	(Javalgi, et al., 2011)
Knowledge base	Three categories of KIBS are differentiated based on the types of primarily used knowledge: analytical, synthetic, and symbolic knowledge	(Pina, 2015)
Cognitive features and knowledge management practices	Four clusters of KIBS are identified based on knowledge sources used for competing in the market and tools applied for knowledge sharing and exchange	(Bolisani et al., 2014)
Knowledge strategies and networking strategies	Four types of KIBS are defined based on their knowledge sharing strategy and networking strategy	(Paiola, Bolisani, & Scarso, 2013)
Business development activities	Three types of KIBS are identified: conservative KIBS, innovating KIBS, and middle ranged KIBS	(Bumberová & Milichovský, 2019)

One of the earliest classifications of KIBS was proposed by Blackler (1995). He identified four types of knowledge intensive organizations based on the types of knowledge they depend on. First, expert dependent organizations which rely on the embodied competences of key members. In such enterprises, performance of specialist experts is crucial, and status and power are derived from professional reputations. Second, knowledge-routinized organizations which act based on knowledge embedded in technologies, routines, and procedures. Such organisations are typically capital, technology, or labour intensive with hierarchical division of labour and control. These can be considered as least corresponding to definitions of KIBS reviewed in the previous sections. Third, communication-intensive organizations which lay emphasis on encultured knowledge and collective understanding. As the name itself implies, the key processes in such organizations are communication, collaboration-intensive with a focus on knowledge co-creation and integration. Finally, the fourth type of organizations is symbolic-analyst-dependent organisation which are dependent on embrained knowledge of their members. They are characterised by entrepreneurial problem solving, symbolic manipulation as a key skill, and status and power being generated from creative achievements.

In 2006, OECD published a report "Innovation and Knowledge-Intensive Service Activities" which included but was not restricted to KIBS enterprises. While KIBS are experts in offering such services to support the business processes of their customers, the study of OECD also included activities undertaken by public sector organisations, and activities within business organisations. Focusing on inputs to innovation, OECD classified knowledge intensive service activities in four types: 1. Renewal services (those directly related to innovation, for instance R&D and strategic management consulting); 2. Routine services (contributing to improvement of maintenance and management of various subsystems within organisations, e.g. accounting); 3. Compliance services (enabling organisations to work within legal frameworks and regulatory regimes, e.g. auditing and some legal services); 4. Network services (supporting communication, knowledge exchange and flexible allocation of resources). Although the OECD classification raised several interesting dimensions for further exploration of KIBS activities, it has not received widespread attention in scholarly and policy discussions (Miles et al., 2018).

As a result of the analysis of 547 German KIBS firms, Horgos & Koch (2008) have differentiated seven clusters of KIBS according to the three main characteristics: the degree of innovativeness, functional integration (cooperative behaviour), and spatial proximity to clients, suppliers, and partners. The proposed classification has demonstrated strong correlation with such important firm characteristics as the development of the employment and the development of the turnover, thus a new possibility arises to apply this grouping of KIBS for forecasting the development of economic variables in the first years after the KIBS founding process.

Smedlund (2008) proposes classification of KIBS based on the strength of ties the company holds with its customer. As a result, he discriminates four types of KIBS. The operational service companies deliver a service off-the-shelf and the relationship with the client is characterised as weak. The experimental service companies produce custom-made,

often radically new to the market solutions that solve a specific customer problem. As a customer is not involved in the service development, the ties with the company are classified as weak. The third type of KIBS is the tactical service company which has strong ties with a customer. The client is strongly interested in the service success, whereas the respective type of KIBS has developed competences and operational process which allow delivering services daily. The typical example of tactical service company would be a law firm. The fourth type of KIBS is named as a high-potential service. In this case, the company holds close ties with the customer, as he bears a portion of the risk of innovation in this service when a radically new service for the market is innovated. A high-potential service may ultimately benefit both the client and the KIBS firm.

A comprehensive classification of KIBS is given by Von Nordenflycht (2010) where he presents a set of distinctive characteristics of professional services firms and their organisational implications – challenges, opportunities and managerial responses. He identifies three main characteristics of KIBS: knowledge intensity, low capital intensity and a professionalised workforce. From these characteristics, Von Nordenflycht groups professional services firms into four categories: 1. the classical professional firms like law and accounting firms that share all three features; 2. professional campuses as hospitals which are characterised by knowledge intensity and a professional workforce but they require a high capital investment; 3. neo-professional firms such as consulting and advertising companies which also share two features – knowledge-intensity and low capital intensity but they do not involve professionalism; and 4. technology developers like research labs and biotechnology firms which involve high knowledge intensity.

Miozzo, et al. (2012) have developed a taxonomy of KIBS firms organized along two dimensions, one regarding the type of knowledge base (technical or professional) of the firm and the other - the formalization of processes of production. This taxonomy groups KIBS in four categories: 1.R&D suppliers (e.g., software consultancy firms) who have rapidly evolving technical knowledge bases and less formalized process. The competitive advantage of this type of KIBS lies in the service product innovation enabling firms to compete through reputation and prestige; 2. Integrated solution providers (e.g., IT services firms) contains technology-based firms with rapidly evolving knowledge bases and more formalised processes. This type of firms develops distinctive capabilities by managing specific knowledge of staff transferred across multiple clients, allowing firms to compete through operational excellence and exploit economies of scale and scope; 3. Professional service firms (e.g., legal service firms) which rely on professionally specialised knowledge base and less formalised processes, exploiting economies of professional expertise through customer intimacy; 4. Multi-unit service firms (e.g., large design firms) which rely on a combination of professional knowledge bases and somewhat formalized processes to provide unique service offerings through the capacity to exploit a multi-unit skill system resulting in economies of scope.

Javalgi et al. (2011) propose to classify KIBS based on the level of skills or knowledge intensity and group them in three categories – low, medium, and high skills/knowledge

intensity implying that some KIBS require high levels of skills and expertise (e.g., technical consulting) compared to others (e.g., data entry or customer call centres).

Pina (2015) proposes a KIBS classification based on their knowledge-base, that is, in the types of knowledge they use primarily: be it analytical, synthetic, or symbolic knowledge. According to findings of this study, KIBS with different knowledge bases behave differently, specifically in relation to investments in R&D activities and design, and their propensities to innovate. At the same time, the author concludes that that there is no one–to-one matching of the knowledge-based classification and classification by industry.

Based on the analysis of 375 KIBS companies located in the Northeast of Italy, Bolisani et al. (2014) have developed a new categorization of KIBS firms considering their cognitive features and knowledge management practices. KIBS are clustered in four categories based on the sources of knowledge (suppliers, customers, business partners, internal) they use for the development of new services and competing in the market and practices and tools they apply for sharing and exchanging knowledge.

Paiola, Bolisani, & Scarso (2013) propose to classify KIBS firms based on knowledge strategies and networking strategies pursued by companies. The study reveals the ways KIBS set their networking strategies based on the capability and necessity to share knowledge with business partners like customers, suppliers, services providers, and others.

Bumberová & Milichovský (2019) classify KIBS according to their business development activities. Their study identified three types KIBS. The conservative ones are those who extend their markets through a repositioning of existing and revised services. Innovating KIBS focus on complementing or extending line to existing services based on changes in technology. Middle-ranged KIBS build their business development strategy based on placing more services under one roof.

Overall, the literature review on KIBS classification shows that narrow categorizing 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.

1.3. Quantitative data describing KIBS sub-sector

As discussed in the previous sections, there is no one optimal definition or classification of KIBS, and different methods are used to identify KIBS. According to Nählinder (2005), KIBS are most often operationalised based on 1. a list of specific services, 2. no specific definition, 3. input-output tables, 4. industrial classifications, and 5. indicators or the features of the firm. Each method has its advantages and disadvantages, and all of them are imperfect in relation to the KIBS characteristics discussed in previous sections.

From the KIBS sector quantitative characterisation perspective, industrial classification has the most advantages compared to disadvantages. The application of this method allows identifying which of the KIBS firms should be included in the population. Comparing studies and countries is also relatively easy. It is also possible to differentiate which types of firms are included in the description and gathering of statistics and using previously

established statistics is less challenging. Therefore, the author will describe the current state of KIBS sector by applying the industrial classification (based on NACE rev.2) and official statistics following the scheme elaborated by Miles et al. (2018) (figure 1.3). A detailed list of covered KIBS activities is given in table 1.5. Furthermore, the current KIBS landscape analysis will be structured around and address the most used KIBS features as summarized in table 1.1.

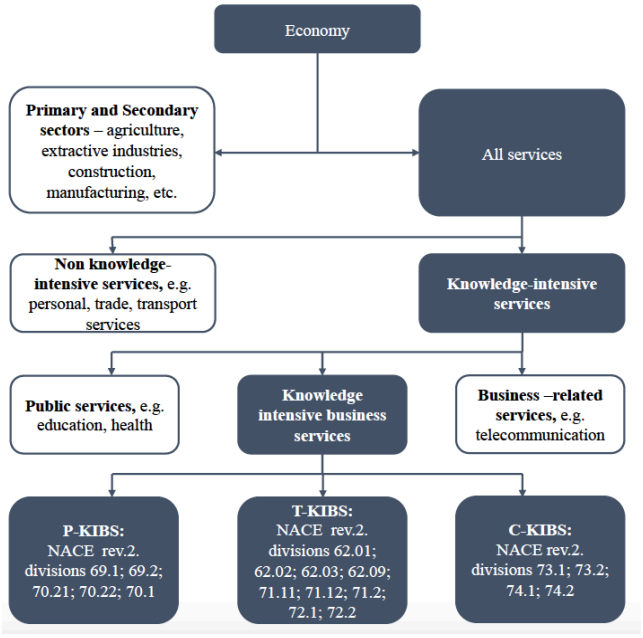


Fig. 1.3. Scheme for analysing the current state of KIBS [Adopted from Miles et al., 2018].

As KIBS is one of the sub-sectors of knowledge intensive services (KIS) and belongs to the category of services, the author will first analyse data on the overall performance of the services sector in the world economy.

Many previously non-tradable service sectors have become highly tradable – because they can now be delivered remotely over great distances – thanks to digitalization, the internet, and low-cost telecommunications. However, the fact that the services sector is growing does not imply that manufacturing is diminishing or declining in importance. Many advanced economies are simply "post-industrial," meaning that manufacturing employs a smaller proportion of the workforce. Manufacturing output is increasing even in the world's most deindustrialized, service-dominated nations, thanks to mechanization and automation enabled in part by sophisticated services (World Trade Organization, 2019).

Table 1.5

KIBS activities covered by statistical analysis [Created by the author based on NACE Rev.2, 2008].

KIBS category	KIBS activities
P-KIBS	[69.1] Legal services [69.2] Accounting, Book-keeping, and Tax Consultancy services [70.21] Management Consultancy Services (divided into public relations (70.21) and Strategic, Organizational, Human Resources and Financial Planning (70.22)) [70.1] The Activities of Head Offices (oversight and management of other units of the same enterprise)
T-KIBS	[62.01] Computer Programming [62.02] Computer Consultancy [62.03] Computer Facilities Management [62.09] Other Information Technology and Computer Services [71.11] Architectural activities [71.12] Engineering activities and related technical consultancy (This class includes a wide range of activities such as engineering design (of machines, materials, instruments, structures, process, and systems) and consulting activities (for machinery, industrial processes and industrial plant, civil engineering, and a list of numerous other types of projects), geophysical, geological, and seismic surveying, and cartographic and spatial information activities. [71.2] Technical testing and analysis [72.1] Scientific Research and Development Services in natural sciences and engineering [72.2] Scientific Research and Development Services in social sciences and the humanities
C-KIBS	[73.1] Advertising [73.2] Market Research and Public Opinion Polling [74.1] Specialised design activities, including fashion design related to textiles, wearing apparel, shoes, jewellery, furniture and other interior decoration and other fashion goods as well as other personal or household goods; industrial design, i.e. creating and developing designs and specifications that optimise the use, value and appearance of products, including the determination of the materials, mechanism, shape, colour and surface finishes of the product, taking into consideration human characteristics and needs, safety, market appeal in distribution, use and maintenance; activities of graphic designers; activities of interior decorators [74.2] Architectural and engineering activities and related technical consultancy

According to the World Bank national accounts data and OECD National Accounts data files, the world economy is dominated by services[1] in terms of output, sector value added

[1] The services category corresponds to the United Nations Statistic Division (ISIC) 50-99 and includes value added in wholesale and retail trade (including hotels and restaurants), transport and government, financial, professional, and personal services such as education, health care, and real estate services.

to GDP and employment. In 2018, the value added of service sector accounted for 65% in the world's total GDP compared to 25,6% generated by the industry (Figure 1.4). The ratio of the services value added to industry value added reached 2,5 times in 2018 (Figure 1.5).

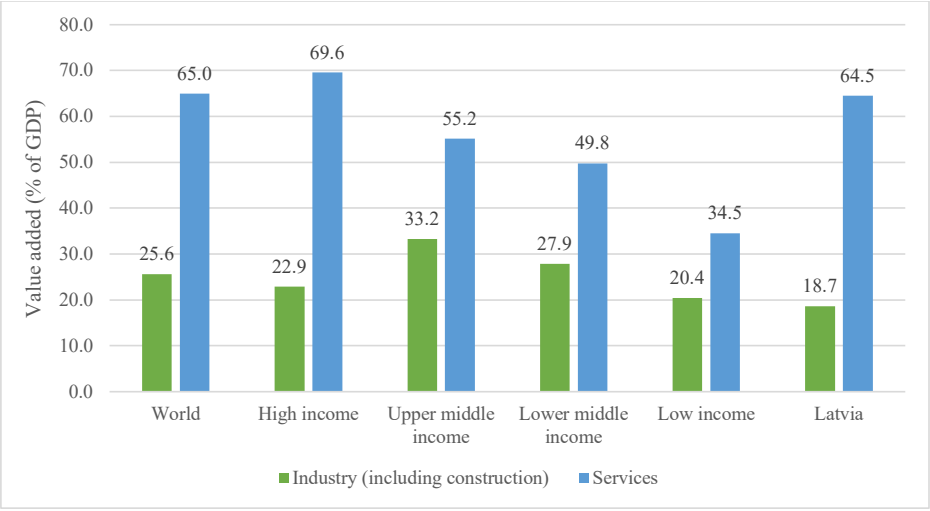


Fig. 1.4. Share of services value added to GDP in comparison to industry [Created by the author based on the data derived from the World Bank national accounts, 2018].

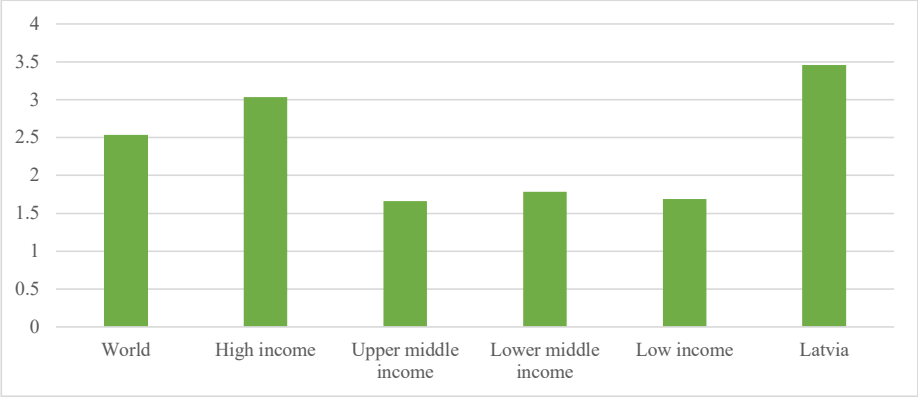


Fig. 1.5. Ratio of services added value to industry added value [Created by the author based on the data derived from the World Bank national accounts, 2018].

The growth of the value added of service sector has been steady in all parts of the world since 1997, but even more prominent in upper-middle and lower-middle income countries (Figure 1.6). The rise in service output and value added is largely due to technological advancement.

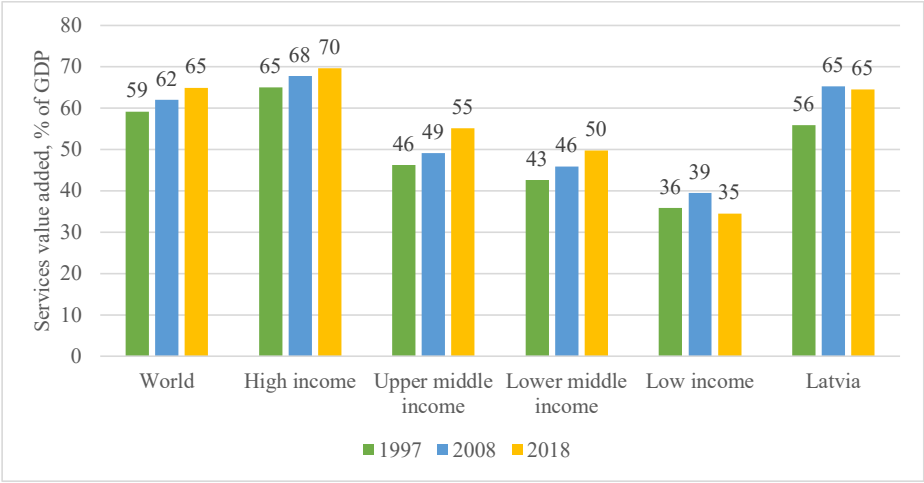


Fig. 1.6. Changes in the share of services value added to GDP from 1997 to 2018 [Created by the author based on the data derived from the World Bank national accounts, 2018].

The overall growth of the services sector output has also made an impact on the world's trade structure. According to the WTO, the world exports of commercial services[2] in the dollar value regularly exceeds the exports of merchandize (Figure 1.7).

[2] WTO defines commercial services category as being equal to services minus government services and further sub-divided into transport, travel, goods-related services, and other commercial services. The latter one corresponds to the business-related services and KIBS, comprising communication, construction, insurance, financial, computer and information services, royalties and licence fees, other business services and personal, cultural, and recreational services (World Trade Organization, 2021).

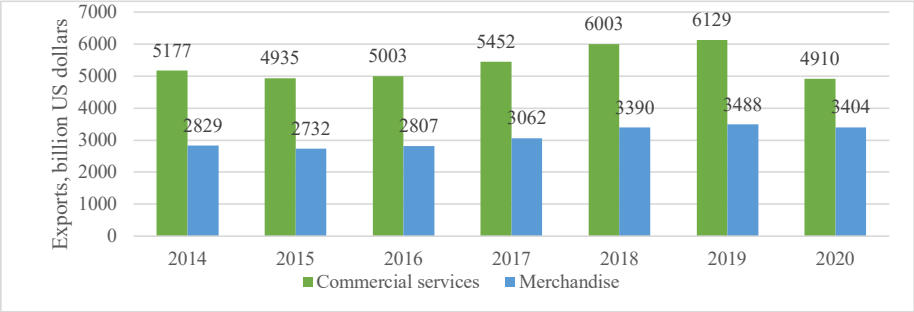


Fig. 1.7. World exports of commercial services and merchandise from 2014 to 2020 [Created by the author based on the World Trade Organization data, 2021].

Considering the dollar value exports, the sub-category of "other commercial services" remains the largest and fastest growing category of commercial services (Figure 1.8). The decrease in the overall commercial services exports in 2020 is attributed to COVID-19 pandemic which disrupted normal economic activity and life around the world. According to WTO, international travel limitations stifled services trade, preventing the delivery of services that required physical presence or face-to-face engagement (World Trade Organization, 2021) However, it is worth to highlight that the category "Other commercial services" held up well in 2020, falling only 3%, which can be explained with the widespread adoption of technologies allowing remote work.

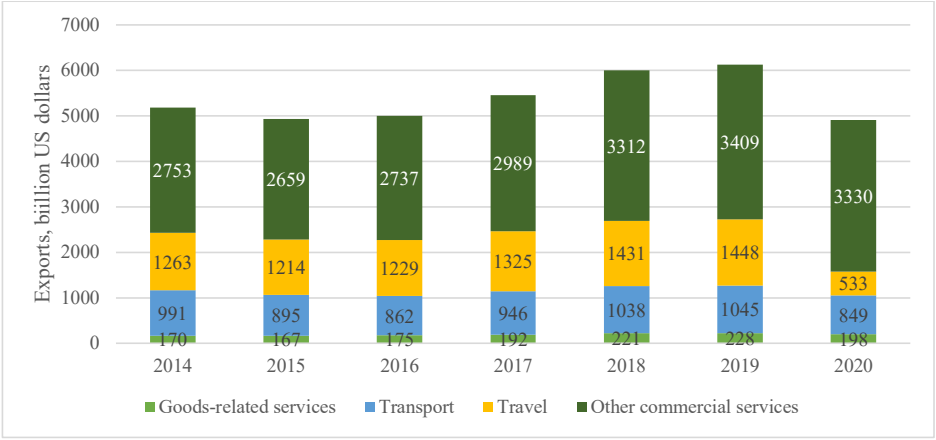


Fig. 1.8. World exports of commercial services from 2014 to 2020 [Created by the author based on the WTO data, 2021].

With the overall economic growth, the service sector will also continue to grow. Nevertheless, the prosperity of an economy is determined not by the relative size of its industrial or service sectors, but by the overall productivity of the economy, which is

determined by efficiencies and innovations in all sectors, as well as the amount to which they are mutually reinforcing. Like an efficient services sector aids manufacturing expansion, an efficient manufacturing sector aids services growth. In essence, all economies, whether agrarian, resource-based, or manufacturing-based, are "service economies," because producing any good necessitates the provision of a service (World Trade Organisation, 2019).

As in other highly developed economies, the service sector in the Europe's euro zone accounts for the biggest part of total output (73,9%) and is the main contributor to growth and employment, as indicated in table 1.6. (European Central Bank, 2021). Around 70% of the EU employment is generated by the service sector (Eurostat, 2021), the process known as "tertiarization of economy".

In 2015, about 77.7 million people were employed in Knowledge Intensive Services (KIS) in the EU-28, which represented 36% of total employment (Eurostat, 2018). The KIS development has been observed in practically all EU nations in a period of 2008-2017, which is illustrated by the increasing share of this sector in total employment. The KIS sector's employment climbed from 37% to 40% in the EU-28 in the given period.

Table 1.6

Value added by economic activity in the euro area and other major economic areas in 2020 [European Central Bank, 2021].

	Unit	Euro area	USA	Japan	China
Value added by economic activity					
Agriculture, fishing, forestry	% of total	1,7	1,0	1,0	7,4
Industry (including constructions)	% of total	24,4	18,8	29,0	39,2
Services, including non-market services	% of total	73,9	80,2	70,0	53,4

The most dynamic KIS development has happened in so called Moderate Innovators' countries (Czech Republic, Portugal, Malta, Spain, Estonia, Cyprus, Italy, Lithuania, Hungary, Greece, Slovakia, Latvia, Poland, and Croatia), where it raised by 4.42% from 31,54% to 35,96%. Whereas, in the group of Innovation Leaders (Sweden, Denmark, Finland, the Netherlands, the United Kingdom, and Luxembourg), the average share of employment in the KIS sector grew by only 0,88% from 47,37% to 48,25%. This has urged the scholars to raise a question on whether there exists a "glass ceiling" in the level of employment in KIS sector, corresponding to the conditions characterising the country (Godlewska-Dzioboń, Klimczyk, & Witoń, 2019).

Looking deeper into the KIBS industries statistics, the data show that the EU's KIBS sector (NACE rev.2 Section M and division 62 of Section J) numbered 4,9 million enterprises in 2018, employing 14.4 million persons and generating EUR 798,6 billion of value added (table 1.7). The KIBS sector's contribution to non-financial business economy (Sections B to J and L to N and Division 95) was 22,2% of enterprise population, 11,5% of the employment, and 12,9% of the value-added.

The apparent KIBS' labour productivity in 2018 was between 51 000 EUR to 61 900 EUR per head, which was above the non-financial business economy average of EUR 50 700 per person employed. Along this high apparent labour productivity, average personnel costs within the analysed KIBS industries were between 46 400 EUR and 58 000 EUR, which was above the average for the non-financial business economy (EUR 35 500 per employee).

The wage-adjusted labour productivity ratio shows that value added per person was equivalent to 111,0% of average personnel costs per employee in Professional, scientific & technical activity and 118,0% in Computer programming, consultancy, and related activities. These ratios were under the non-financial business economy average (143,0%). The EU's professional, scientific, and technical activity sector recorded a gross operating rate of 17.9 % in 2018, almost twice the 10.2 % average for the whole of the non-financial business economy (Eurostat, 2021).

Table 1.7

Key indicators of KIBS industries in EU, 2018 [Eurostat, 2021].

	Value	
	Professional, scientific & technical activity (NACE Section M)	**Computer programming, consultancy, and related activities (NACE Section J, Division 62)**
Main indicators		
Number of enterprises	4 310 784	654 900
Number of persons employed	11 099 373	3 318 300
Turnover (EUR million)	1 212 771	523 800
Personnel costs (EUR million)	354 047	165 100
Value added (EUR million)	570 815	227 800
Gross operating surplus (EUR million)	216 768	62 856
Share in non-financial business economy total (%)		
Number of enterprises	19,4	2,8
Number of persons employed	8,9	2,6
Value added	9,2	3,7
Derived indicators		
Apparent labour productivity (EUR thousand per head)	51,0	69,0
Average personnel costs (EUR thousand per head)	46,4	58,0
Wage-adjusted labour productivity (%)	111,0	118,0
Gross operating rate (%)	17,9	12,0

Performance of KIBS sub-sector according to CIS 2018 data

Next, the author will characterise the EU's KIBS sub-sector based on the data derived from the Community Innovation Survey (CIS) 2018. CIS is a bi-annual survey of innovation activity in enterprises carried out by EU member states and number of European Social

Survey member countries, and it is one of the most important data sources for measuring innovation activity in Europe.

Due to high knowledge-intensity, KIBS firms depend heavily on the exploitation of employees' knowledge, skills, and specialisations. CIS 2018 data confirm that KIBS, especially T-KIBS, are outstanding in terms of their employees' qualifications and the share of the workforce with graduate level education (figure 1.9). 55% of the surveyed T-KIBS, 42% of C-KIBS and 25% of P-KIBS report that above 50% of their employees hold university-level education. The category of T-KIBS stands out with the fact that 31% of the surveyed companies have more than 75% of the employees with university education.

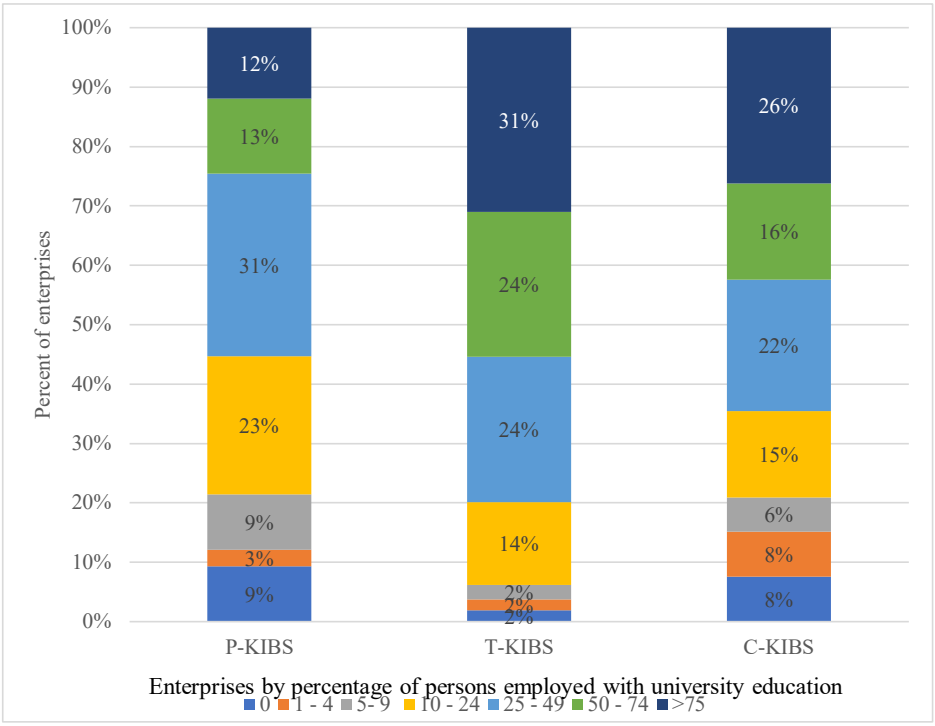


Fig. 1.9. Enterprises by percentage of persons employed with university education [Created by the author based on the CIS data, 2018].

The current literature emphasises that KIBS primary value-added activities are knowledge accumulation, creation and dissemination for developing a service or production solutions to satisfy the customer's needs (Bettencourt et al., 2002; Doloreux & Shearmur, 2010; Belso-Martínez, et al., 2011; Camuffo & Grandinetti, 2011; Exposito-Langa, M., et al., 2015; Bettiol, Maria, & Grandinetti, 2015; Bolisani, Donò, & Scarso, 2016). The production of KIBS is often done in teams requiring a combination of different kinds of

professional expertise (Sveiby, 2012). And, in this process KIBS firms cooperate with multiple actors (Camuffo & Grandinetti, 2011; Bettiol et al., 2012).

According to the CIS 2018 data, all three types of KIBS cooperate on various business activities with other enterprises, however, T-KIBS are the most active collaborators (figure 1.10) in research and development (R&D) or other innovation activities. Whereas P-KIBS and C-KIBS cooperate more on other business activities with other businesses rather than on R&D or innovation activities.

Interesting is the fact that the absolute majority, from 95% to 99% of the surveyed KIBS collaborate in R&D and innovation activities with national partners (Figure 1.11.).

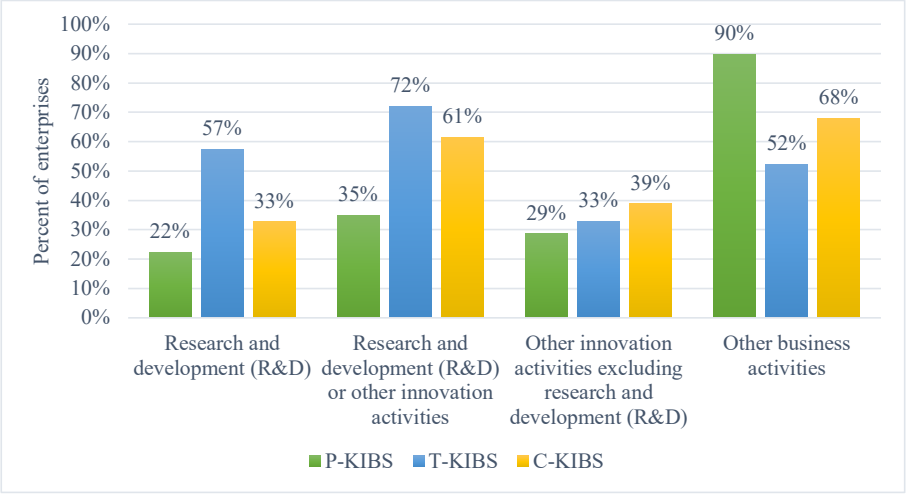


Fig. 1.10. Enterprises that co-operated on business activities with other enterprises or organisations by field of activities [Created by the author based on the CIS data, 2018].

Only P-KIBS, compared with T-KIBS and C-KIBS are more active in collaborating with partners from foreign countries. That could be explained with the fact that P-KIBS firms providing legal services, accounting, book-keeping, and management consultancy services, more often belong to multinational professional services networks.

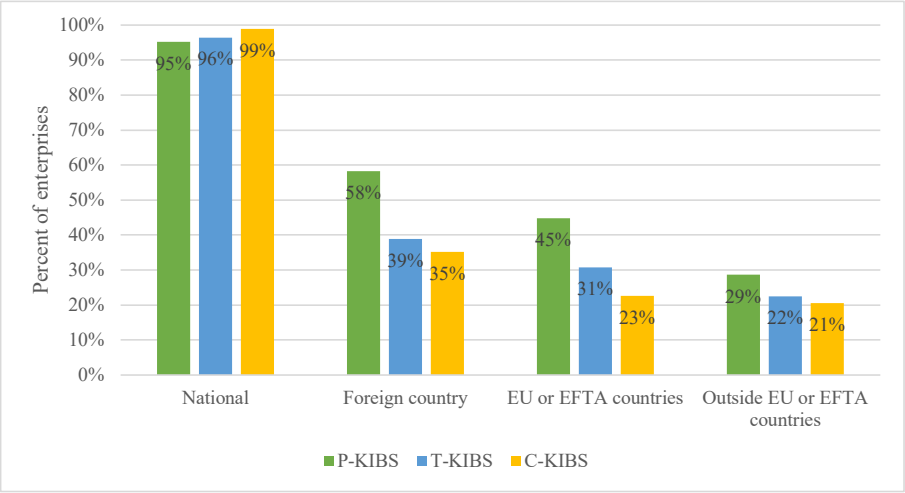


Fig. 1.11. Percent of enterprises that co-operated on R&D and other innovation activities with other enterprises or organisations, by kind and location of co-operation partner [Created by the author based on the CIS data, 2018].

Based on the study of Hipp (1999), KIBS use external sources of knowledge for innovation such as marketing, consultants, suppliers, competitors, and enterprises. Additionally, they use market research and sources of information such as conferences, journals, and computer-based networks more frequently than non-KIBS. According to CIS 2018 publicly available data provided by France, Germany, Malta, and Italy, conferences, trade fairs or exhibitions, scientific or trade publication and professional associations are the most often used channels to acquire information relevant for innovation by all three types of KIBS (figure 1.12).

P-KIBS seem to be more frequent users of these channels, whereas T-KIBS are more active users of published patents, social web-based networks or crowdsources, open business-to-business platforms or open-source software, and reverse engineering as sources for innovation.

Meanwhile, KIBS also utilise internal resources to develop and provide services to their customers. CIS 2018 data highlight that all three types of KIBS both acquire and transfer technical knowledge, financial resources, personnel, and business activities within the enterprise group (figure 1.13). Yet, T-KIBS seem to be more active in resource acquisition and transfer within the enterprise group than P-KIBS and C-KIBS.

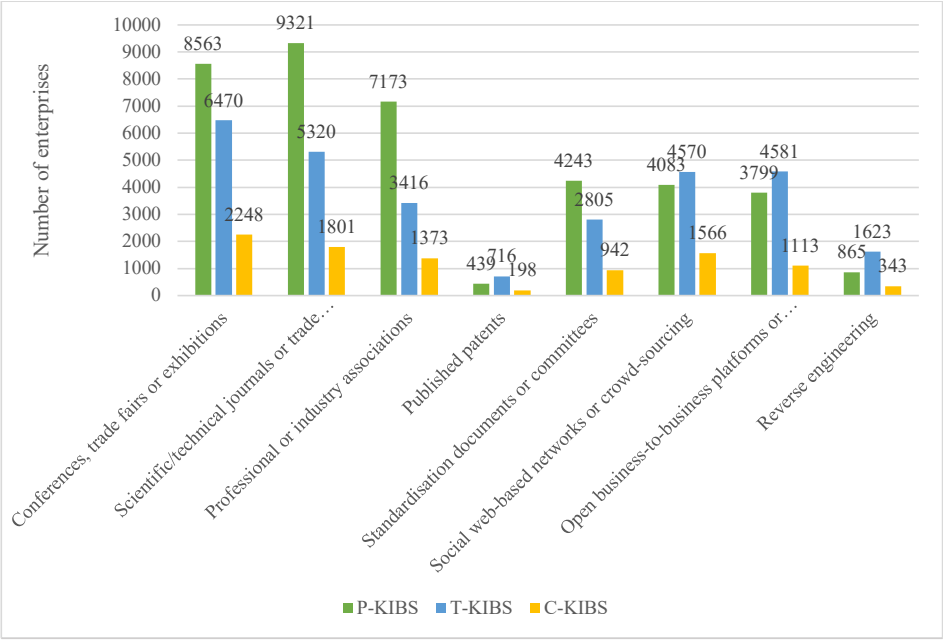


Fig. 1.12. Enterprises by kind of channels to acquire information relevant for innovation. Source: Created by the author based on the CIS data (2018).

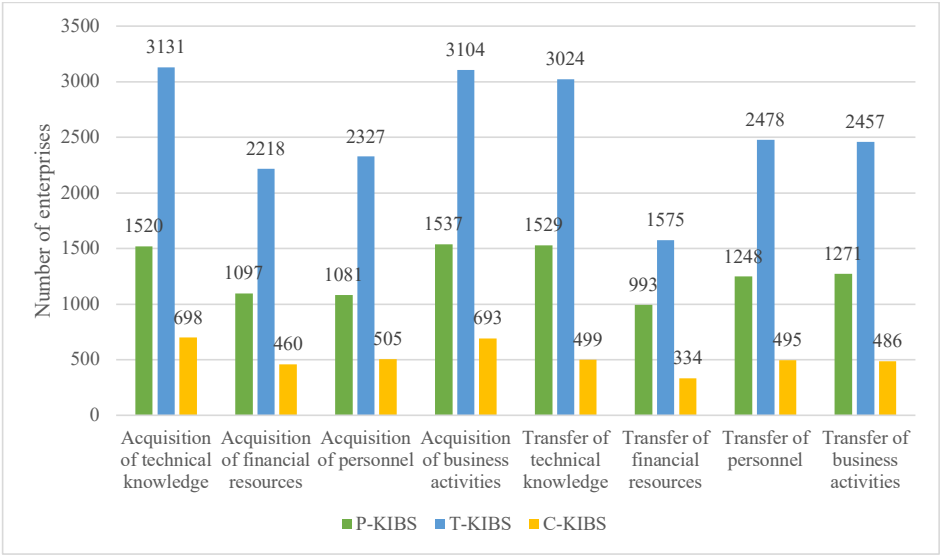


Fig. 1.13. Enterprises that acquire or transfer resources and business activities within the enterprise group, NACE Rev. 2 activity and size class [Created by the author based on the CIS data, 2018].

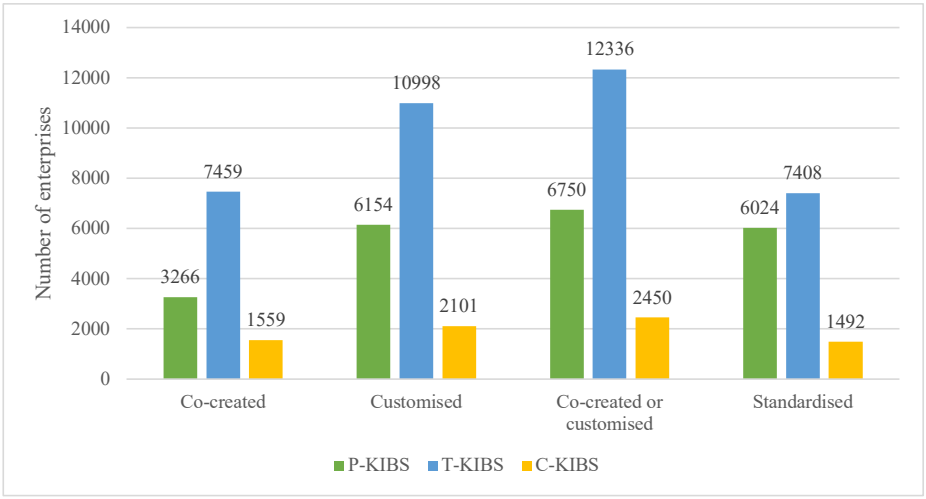


Fig. 1.14. Enterprises that offered standardised, customised, or co-created goods or services by type of goods and services [Created by the author based on the CIS data, 2018].

Even though "service customization" and "solution co-creation" remain as one of the main characteristics of KIBS, several authors have found that there is a significant number of KIBS firms, for example in software and technical services, which provide wholly or largely standardised services. The shift from customized to more standardized services will most likely remain as a trend (Susskind and Susskind, 2015), at the same time, we can also expect that there will be companies which will continue demanding customized services as a strategy to sustain their competitive advance. According to CIS 2018 data of France, Italy, Malta and Sweden, customized and co-created solutions still dominate in the production activities of all three types of KIBS (figure 1.14) but prevail more in T-KIBS.

The economic significance of KIBS cannot be overstated. They perform tasks that require specialized knowledge that their customers either lack in quality or quantity. Our economies are still grappling with massive issues such as the climate crisis and other looming ecological and existential issues, including the effects of the Covid-19 pandemic. If we are to transition to more sustainable methods of producing and consuming goods and services, KIBS could play a critical role in developing, sharing, and implementing critical knowledge.

Despite minor growth in the employment of KIBS industries in some EU countries, Cedefop (2016) forecasts that services – particularly "business and other services" will grow by 1.1% per year, compared to 0.4% for transportation and distribution, 0.3% for nonmarketed services, and 0.1% for construction. Cedefop also predicts that automation will replace much routine and data processing work, such as legal secretaries, bookkeeping, accounting, and auditing, but will increase demand for specialized skills and high qualifications.

Because KIBS in general are responding to customer needs, their contribution to a more sustainable future will be heavily reliant on businesses recognizing the need for green and digital transition (Miles, 2020). According to McKinsey Global Institute's report on the future of work in Europe, the KIBS industry – professional, scientific, and technical services – will account for more than 70% of Europe's potential job growth through 2030, generating 2,6 million jobs, along with human health and social work (4,5 million jobs), and education (2.0 million jobs) (McKinsey Global Institute, 2020).

Susskind and Susskind (2015) conclude that a shift from customized to more standardized services, the rise of new forms of accessing knowledge (e.g., new online services, communities of knowledge and experience, etc.), a shift from reactive to proactive services (anticipating customer needs, problem-solving inputs), and efforts to provide "more-for-less" will transform many professions, including those in KIBS. The COVID-19 pandemic-caused restrictions have already accelerated this process.

KIBS prospects will differ depending on their industry, size, location, and specialization. Many KIBS firms will face significant challenges, especially if they try to resume "business as usual." However, there will be numerous opportunities for new services and markets, as well as pressures to adapt to new ways of working. Many assumptions about how KIBS services are developed and delivered may be called into question.

1.4. KIBS competitiveness

In the preceding chapters of thesis, the author reveals that KIBS play a crucial role in the knowledge economy and are considered to be one of the driving forces behind economic growth. KIBS are also a significant source of high-skilled employment and are frequently involved in the creation and dissemination of new technologies, products, and services. By examining the competitiveness of KIBS, policymakers, researchers, and businesses can gain insight into the factors that contribute to successful innovation, identify best practices for promoting innovation, increase productivity, and promote overall economic growth.

Organizational competitiveness is a complex and multidimensional concept that has been studied in macro-, meso-, and microeconomic contexts (Sauka, 2014) and at different levels: national, regional or industry, and firm level. The industry-based perspective and the Resource Based View (RBV) have been the two dominating approaches for analysing competitiveness at a firm level (Zuñiga-Collazos, Castillo-Palacio, & Padilla-Delgado, 2019). One of the most notable contributors to the industry-based view on competitiveness was Michael Porter who defined organizational competitiveness as the firm’s capability to operate in the market in a strategic way based on the pressure of competition in the industry. In his view, organizational competitiveness is achieved by analysing external factors in the industry (Porter, 1980). Recently, the industry-based perspective has placed the focus on the importance of value-chain management as a way to enhance organizational competitiveness in the industry (Bruno, Esposito, Genovese, & Simpson, 2016).

RBV emphasizes firm’s specific capabilities and internal resources rather than the industry context in which the firm operates. Cohen and Levinthal (1990) assert that

organizational competitiveness is obtained through effective use of the organisation capabilities and knowledge management.

A recent extension of the resource-based theory is the knowledge-based view (KBV), which states that the sources of competitive advantage are not all the firm's internal resources, but just the intangible or knowledge-related assets of the organisation and its capability to integrate knowledge (Grant, 1996). Knowledge, particularly tacit knowledge, can be argued to be a source of advantage because it is unique, imperfectly mobile, imperfectly imitable and non-substitutable (Meroño-Cerdan, Lopez-Nicolas, & Sabater-Sánchez, 2007).

According to Man, Lau, & Chan (2002), the organizational competitiveness is characterised by 1. long-term orientation rather than possession of temporary competitive advantage; 2. controllability meaning the firm's various resources and capabilities rather than simply the favourable external conditions that contribute to superior results; 3. relativity concerned with how competitive a firm is compared to the rest of industry; and 4. dynamism which involves a more proactive and dynamic transformation of competitive potentials through competitive process into outcomes. Sauka (2014) refers to the organizational competitiveness as an ability to adapt to environmental factors while develop the firm's business successfully. Zhu & Cheung (2017) define competitiveness as the firm's ability to realize its own value in the long term. All in all, the organisational competitiveness describes the firm's absolute ability to survive in the long-term and the ability to outperform its competitors (Pina, 2015).

Buckley, Pass, & Prescott (1988) suggest that the competitiveness at a firm's level can be measured by incorporating quantitative indicators such as costs, prices and profitability, and qualitative indicators of non-price factors, for example, quality of products and services.

Building on Buckley et al. (1988), Blandinières, et al. (2017) propose a three-dimensional approach to measuring organizational competitiveness, each with its own set of qualitative and quantitative indicators:

1. competitive performance refers to a firm's past and current market performance as measured by indicators such as market share, export share, profit margin, return on capital, survival, growth, and productivity;
2. competitive potential refers to internal factors that may influence a firm's current or future competitive performance. Product innovation, in-house cost efficiency, supply-side cost efficiency, and productivity are some of the indicators used to assess it. Firm capabilities such as skills and knowledge, managerial practices, management attitudes, corporate culture, absorptive capacities, networks and linkages, and others are critical for translating competitive potential into actual or future performance;
3. external factors such as the institutional and regulatory framework, infrastructure provision, education, monetary environment, and factor markets, as well as the market structure of the markets in which a firm operates. The elements of market structure, such as the number of competitors, the size of demand, the type of competition (price/quality), entry/exit barriers, and international openness, shape a firm's competitive performance.

The author now turns to what is known, theoretically and empirically, about KIBS competitive performance and how it is measured. Following the competitiveness dimensions proposed by Blandinières, et al. (2017), the author reviewed 93 research articles with a purpose to identify indicators and measures used to assess the competitiveness of KIBS (Appendix 2).

According to the literature review, KIBS competitiveness is measured using all three dimensions proposed by Blandinières, et al. (2017). However, the dimensions of competitive performance and competitive potential appear to be more widely used than the dimension of external factors. To assess KIBS's competitive performance, the overall business performance indicator and related accounting measures (e.g., market share, profit, sales, turnover, return on investment, cash-flow from market operations, export share) and innovation performance (e.g., sales, market share, profit, patent counts) are most commonly used. It is not surprising, given that the benefit of these measures is their objectivity and direct relationship with the enterprise's financial performance. However, it is important to note that at least some accounting measures, such as market share growth, profit growth, sales growth, and turnover growth, are viewed from the perspective of an organization's performance over time, allowing to assess the firm's ability to realize its own value and survive in the long run. The difficulty in applying these measures stems from the difficulty in obtaining firm-level data from public sources, particularly in the case of privately-owned KIBS firms.

The second most important set of indicators used to assess KIBS competitiveness is related to the creation of customer value and its impact on customer business performance. These include metrics such as customer satisfaction, customer loyalty and retention, value-added perception, the firm's image in the eyes of its customers, adaptation to changing customer needs, and impact on customer business performance (profit level and change, sales volume, market share, and so on). Although some of these measures have been criticized for being subjective, they do have the advantage of assessing the performance of specific phenomena and are often easier to obtain than confidential and accounting data. KIBS rely on reputation and customer satisfaction to build long-term relationships with clients. Therefore, measuring the quality of their services and the level of customer satisfaction can provide insights into their ability to deliver value to customers and to differentiate themselves from competitors.

A minority of the studies reviewed focus on KIBS competitive potential indicators such as productivity, internal processes, quality, human relations, skills, collaboration with other firms, and intellectual capital management. The majority of these measures are used in subjective evaluations of firm performance and assume that respondents are well-informed, particularly about specific areas of action.

Even fewer articles address indicators related to external factors influencing a firm's competitive performance. These include talent availability and access, information and communication technology access, service relocation to low-cost markets, and distribution channel access. These indicators, in the author's opinion, should be viewed as enabling or

disabling factors in a firm's attempts to successfully compete in the market, rather than direct indicators of a firm's competitive performance.

The reviewed articles identified 41 KIBS competitiveness measures in total. On the one hand, such disparity reveals a lack of consensus on what constitutes KIBS performance and what the critical dimensions of KIBS competitiveness are. On the other hand, the review helped identifying the key competitiveness indicators of KIBS that have the potential to be incorporated into the methodological framework developed for this doctoral dissertation. Those are centred around KIBS ability to innovate, deliver high-quality services, expand into markets, collaborate effectively with their customers, and attract and retain talent.

1.5. KIBS innovation process

The ability to reinvent an enterprise and introduce successful innovations is now regarded as a critical success factor for both manufacturing and service firms (Tuominen & Toivonen, 2011). It is determined by the increasing competitive pressures on firms in almost all sectors as a result of market globalization, shorter product lifecycles, more demanding customer expectations, and public-sector-induced regulations. Innovation is particularly important KIBS, as their products are difficult to protect through patents and copyrights (O'Cass & Sok, 2013).

In the last ten years, scholars have reached two major consensuses regarding the innovation phenomenon. Firstly, there is an agreement that innovation is multi-dimensional, and it hinges on new development or on a significant improvement (Doloreux & Frigon, 2019). According to the Oslo Manual of OECD/Eurostat (2018), "an innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (p.20). This definition is further developed and operationalised for the business sector stating that "a business innovation is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm" (OECD/Eurostat, 2018, p. 20).

Secondly, a consensus has been reached on the idea that, whatever form it takes, innovation is the result of the interaction between the firm with organisational capacity and resources and a network of multiple stakeholders with whom the firm is exchanging new knowledge (Edquist, 2005 as cited by Doloreux & Frigon, 2019). This implies that innovation happens in an interactive knowledge exchange system consisting of external networks, ecosystems and communities (West, Salter, Vanhaverbeke, & Chesbrough, 2014).

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).

Based on the review of 53 studies on forms of innovation in KIBS, Pina (2015) concludes that the product (including service) innovation (54% of studies), organisational innovation (33%), and process innovation (30%) are by far the most studied types of innovation, followed by marketing, service delivery, business strategy, client interaction, technological, design, and channels innovations. This is particularly observed in the cases where researchers have used datasets based on the innovation definition of the OECD Oslo Manual's 3rd edition (2005) which, at that time, defined innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practises, workplace organisation or external relations" (OECD, 2005, p.46).

The most recent edition of Oslo Manual has reduced the definition of business innovation to two main types: product innovations and business process innovations. It has also reduced the ambiguity of the requirement for a "significant" change" by comparing both new and improved innovations with the firm's existing products or business processes (OECD/Eurostat, 2018). Nevertheless, scholars continue standing for the importance of studying different new forms of innovation of service firms as a potential substitute or a complement to product-based innovation. According to Muller & Doloreux (2009), service-based innovations can take the forms of a new idea, a new function, a new approach, or a new method. They may also be related to the service sectors exclusively, with no link to manufacturing (Dautel, 2015 as cited by Doloreux & Frigon, 2019).

The study on KIBS innovation activities conducted by Amara et al. (2016) concludes that KIBS firms are actively engaged in the development of both technological innovations, namely, product and process innovations, and non-technological forms of innovation such as delivery, strategic, managerial and marketing innovations.

It is well understood that KIBS play a variety of roles in innovation processes and systems. This is primarily determined by their ability to transfer new knowledge via the services they provide. Notably, the current literature emphasizes that KIBS firms connect their consumers' knowledge with knowledge that exists elsewhere, thereby improving knowledge exchange, availability, and usability. Each KIBS solves a specific customer problem, integrating and transferring knowledge that would otherwise be unavailable to or ignored by the customer (Doroshenko et al., 2013).

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

1. innovation enablers, or sources, carriers, and facilitators of innovation for their customers. As KIBS cannot develop and integrate, by themselves, all the information and knowledge necessary for innovation, 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 combing 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 that are of scientific, technological, organisational, financial, and commercial character.

Several studies have explored how innovation activities and processes are carried out in 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 frequently 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 the formation of a temporary, cross-border team comprised of individuals with diverse knowledge and from various domains and organizations.

While KIBS produce more non-technological innovation, KIBS 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 and Brax, 2007).

According to Tuominen & 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 inovative behaviors (figure 1.15)

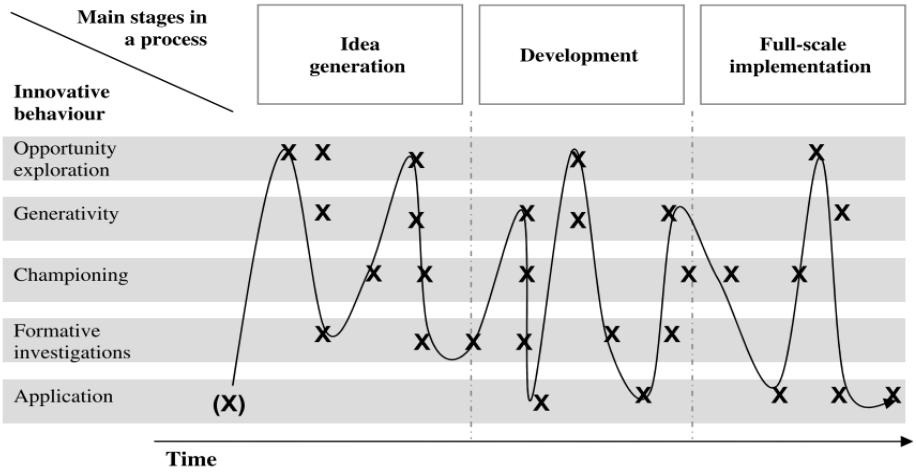


Fig. 1.15. The iterative nature of innovative behaviour types in an innovation process [Adopted from Tuominen & Toivonen, 2011].

As stressed before, KIBS firms' innovation process is based on the professional knowledge and skills of their employees, and KIBS produce innovative solutions that are frequently intangible. In knowledge-intensive industries, employees are equivalent to technology in manufacturing (Rubalcaba, Michel, Sundbo, Brown, & Reynoso, 2012), therefore, KIBS-developed innovations result more from new combinations of knowledge rather than from new combinations of physical devices.

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 organisations 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.

Because the information and knowledge required for innovation comes from different sources, cooperation partners and network relations, **knowledge transfer in the KIBS' innovation process is challenging**.

First, **knowledge that is embodied in a person and a specific context is more difficult to share** with customers than codified knowledge. For example, the knowledge documented

in reports, publications, or patents, is easy to transfer, but its full exploitation by customers may demand the transfer of both codified knowledge and some tacit knowledge held solely by the KIBS firm (Landry et al., 2012). Knowledge transfer is a mechanism how to convert tacit knowledge into explicit knowledge, and both types of knowledge are essential to achieve innovation (Castaneda & Cuellar, 2020).

Second, when organizations form groups of individuals with diverse knowledge, from various industries and organisations 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 of a variety of boundaries**, the most common of which are **knowledge boundaries** - syntactic, semantic, and pragmatic boundaries (Edmondson & Harvey, 2018), **cognitive boundary** (Smith, 2016), **organizational boundaries** (Wilhelm & Dolfsma, 2018; Smith, 2016), **interest boundary** (Smith, 2016), **a power boundary** (Filstad, Simeonova & Visser, 2018), **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. The term "absorptive capacity" refers to an organization's ability to recognize the value of new information, assimilate it, and apply it to improve business performance, and is considered critical for organizational innovation (Cohen and Levinthal, 1990). Absorptive capacity is viewed at the individual, organizational and multi-organizational levels (Scaringella & Burtschell, 2017), and as a connector between knowledge transfer and innovation (Castaneda & Cuellar, 2020). When partner organizations have different degrees of absorptive capacity, success of knowledge transfer can be hampered (Scaringella & Burtschell, 2017).

Fourth, **knowledge hiding** is an obstacle for knowledge creation, transfer and innovation in KIBS (Labafi, 2017). Zhao, Qingxia, He, Sheard, & Wan (2016) indicate to three dimensions of knowledge hiding in organisations – evasive hiding, rational hiding, and playing dumb, and a high distrust and competitiveness as key predicators of these knowledge hiding behaviours. Evasive hiding is related to deception, for example, incorrect information provision. Playing dumb also involves deception and an intention of not helping by pretending that information being requested is not understandable. Rational hiding means that the knowledge hider gives an explanation why the requested information will not be forthcoming (Connelly, Černe, Dysvik, & Škerlavaj, 2019). One or another way, knowledge hiding hampers complete knowledge transfer and has negative effect on the overall organizational performance.

1.6. Knowledge transfer boundaries in innovation processes in KIBS

To identify knowledge creation and transfer boundaries that KIBS face during the innovation processes, at the beginning of 2022 the author conducted an online survey of enterprises. It was carried out by applying a combination of the non-probability sampling techniques: voluntary response sampling, snow-ball sampling, and purposive sampling. The invitation to participate in the survey was distributed in two ways. First, a general post on the author's social media sites (Facebook and LinkedIn) with a call to participate in the survey and share the invitation with others was made. Second, using the author's e-mail and social media accounts (Facebook and LinkedIn), the author sent a personalized invitation to 346 employees of various firms from various industries, with a hyperlinked address to the questionnaire website. The author's personal and professional contact list was used to select the potential responders.

The survey was anonymous, which helped to maintain confidentiality. A total of 103 surveys were returned out of a total of 346, representing a 30% response rate. 24 respondents worked in the primary and secondary sectors of economy, while 79 worked in KIBS (according to NACE rev.2). In the following analysis, only responses from respondents working in KIBS are considered.

The questionnaire consisted of 20 questions divided into five sections (Appendix 3). The first set of questions gathered information on the respondent's organization's innovation activities from 2019 to 2021. In the second set of questions, respondents were asked to rate the extent to which they had encountered various knowledge boundaries during the innovation process. In total, 15 statements were created based on the knowledge boundaries identified in the literature, which included syntactic, semantic, and pragmatic boundaries derived from Carlile (2002) and Rau, Moslein, Neyer (2016). Respondents were asked if they had encountered the given knowledge boundaries. Each statement was graded on a 5-point Likert scale, with 5 equalling always and 1 equalling never. The third set of questions requested that the respondent share information on the approaches and tools that his or her organization used to overcome different knowledge boundaries and ensure effective knowledge sharing during the innovation process.

Grounded in Edmondson & Harvey (2018) and Filstad, Simeonova & Visser (2018), the fourth set of questions asked the respondent to name up to five other boundaries encountered by individuals during the innovation process, based on his or her experience. The fifth set of question collected general information about the survey participant's organization, such as the main economic activity, the sector represented, geographic location, age, number of employees, and the respondent's position within the organization.

The data were analysed using R version 4.1.2 and MS Excel software. The open-ended questions were analysed with the help of conceptual content analysis, which identifies the presence and frequency of concepts in a text. A concept is chosen for examination in conceptual analysis, and the analysis entails quantifying and counting its presence. The main goal is to look at the frequency of occurrence of certain terms in the data. The analysis

level used - word, word sense, and phrase. Through the coding process, the categories were created, allowing for the introduction and analysis of new and important material that could have significant implications for the research question. The coding was done for concept frequency.

90% of KIBS respondents admitted that their organization worked on the development of new or improved products (goods and/or services) between 2019 and 2021. Only 6% of the KIBS polled created innovations solely for their own business. The vast majority of KIBS – 86% – created innovations for other customers, such as private businesses, public and non-governmental organizations, and a small percentage (8%) for individuals and households.

The majority of KIBS that innovated did so within their own organization, in collaboration with other organizations and actors (65%). Only 30% created innovations within their own organization, while the remaining 5% used the services of other organizations to create innovations.

KIBS were also asked what type of knowledge was required to develop these innovations. The majority (67%) said, "Knowledge from a variety of predefined fields of expertise and/or specialities," whereas 21% said, "Knowledge from one field of expertise and/or speciality," and 13% "Any type of knowledge from any type of expertise and/or specialty was useful."

As Figure 1.16. summarizes, the majority of KIBS companies innovate for a variety of customers outside their organization. Most innovations are generated in collaboration with different experts, requiring knowledge from various disciplines and specialities.

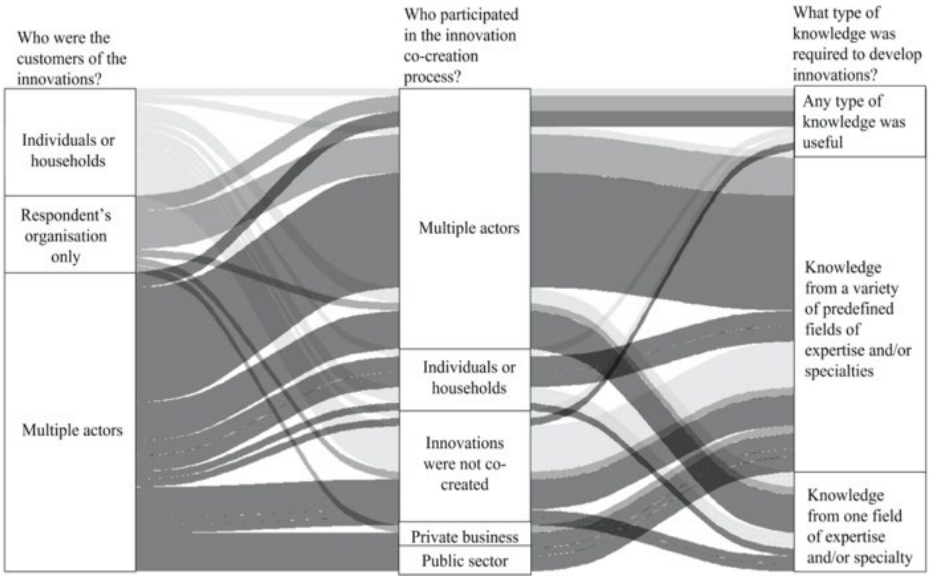


Fig. 1.16. Diversity of actors involved in KIBS innovation development and expertise required for innovation creation by customer type [Created by the author based on the online survey results].

The survey results confirm that KIBS employ multi-disciplinary and multi-organizational teams to develop innovative solutions. These group members, who represent multiple knowledge domains, specialities, and skills, are expected to pool their knowledge and expertise to arrive to an innovative solution that no single group member could achieve along. However, as previously stated, numerous studies have demonstrated that knowledge in the development of innovation across functions and disciplines can be both a source and a barrier to innovation. Based on Carlile (2002) and Rau, Moslein, Neyer (2016), these obstacles are known as “knowledge boundaries”.

Differences in how language and lexicon are used manifest the syntactic boundary. Although individuals who work in cross-boundary contexts recognize and respect their differences and they are also aware when their performance is dependent on the contributions of others (Edmondson & Harvey, 2018), language difficulties and inability to develop common lexicon are still well-observed in the KIBS innovation process (Figure 1.17). This boundary makes it difficult to communicate accurately and hinders successful innovation development.

The second boundary is semantic, which manifests itself in various interpretations of knowledge despite the existence of a common lexicon or syntax (Lavikka, Kallio, Casey, & Airaksinen, 2018). According to the findings, surveyed KIBS companies have encountered various manifestations of semantic boundaries during the innovation process. Individuals from different fields of expertise and specialties, for example, interpret and understand the same terminology differently. Individuals also struggle to explain the meaning of terms so that others can understand. Most respondents have been in a situation where they recognized that individuals did not understand a specific term but avoided clarification, or they made incorrect assumptions about the counterparts' work practices, timelines, and other aspects of the innovation project. The semantic boundary necessitates the development of common meanings through shared mutual involvement of the innovation team members around the problems addressed (Edmondson & Harvey, 2018). One reason for the emergence of the semantic boundary in the innovation process is that levels of knowledge, as well as interpretations of this knowledge, change on a regular basis. It changes because what is thought to be "true" one moment is discovered to be false the next due to new research finding (Smith, 2016).

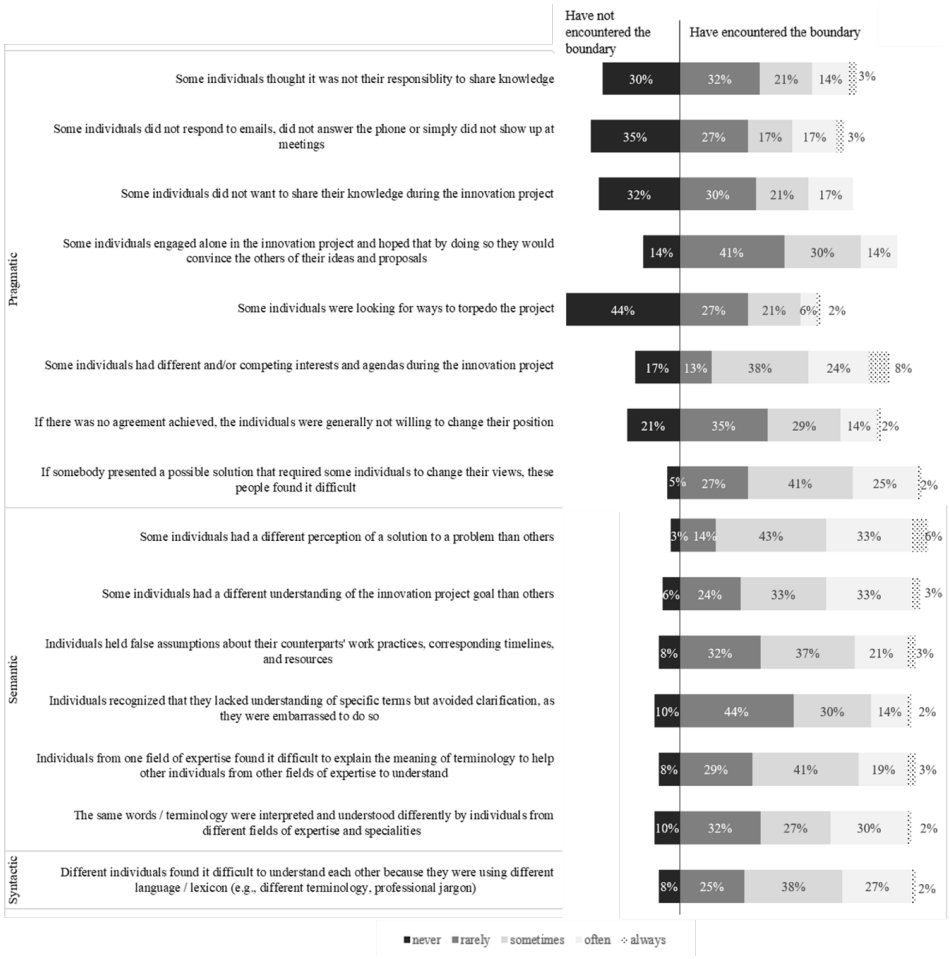


Fig. 1.17. Percent of KIBS enterprises encountering Syntactic, Semantic and Pragmatic boundaries during the innovation process [Created by the author based on the online survey results].

The third type of boundary is pragmatic in nature, and it refers to circumstances in which the interests of several individuals involved in the innovation process are at odds with one another. The findings confirm the presence of various manifestations of the pragmatic knowledge boundary during the KIBS innovation projects. For example, 86% of the surveyed KIBS have observed that some individuals engage in the innovation project alone in the hope that by doing so, they will persuade others of their ideas and proposals. Individuals are hesitant to change their positions in the project team due to a lack of agreement. The vast majority of the KIBS polled have encountered situations in which someone presented a possible solution that required some people to change their minds, and

these people found it difficult. This finding is consistent with other studies (Edmondson & Harvey, 2018) that have discovered that people tend to resist or, in the worst-case scenario, sabotage innovations that jeopardize their current knowledge, practice, prestige, and principles. Nevertheless, for the innovation project to succeed, cross-boundary teaming necessitates the development of shared interests and motivation to transform current knowledge into new knowledge, which fuels the transformation of others' knowledge.

Aside from knowledge boundaries, several authors have identified other types of boundaries or contextual factors that organizations face when engaging in multi-boundary knowledge creation, transfer, and innovation processes. Edmondson and Harvey (2018), for example, list factors such as the environment in which the innovation team is embedded, the nature of a task to be completed, the temporal dimension (project lifespan, typical task duration, or time required to achieve a goal), and leadership. A power boundary is another barrier that must be crossed within organizational settings (Filstad, Simeonova & Visser, 2018). Smith (2016) has identified knowledge transfer boundaries such as the cognitive boundary which emerges when an individual is not able or not willing to see the importance of others professional work and knowledge to their own resulting in difficulties to kick off the project and interacting; the organizational boundary which involves knowledge and information hiding, being silent and absent, differing interests of team members; the interest boundary which relates to strong manifestation of invididual interests an objectives with the project as opposed to organizational interests; the professional identity boundary which manifests when innovation team members label themselves and each other according to their educational background, their approach to jobs to be done, or their role in the project, thus causing prejudice among project members and consequently affecting knowledge transfer. Finally, Smith (2016) discusses the in-group/out-group boundary, which is related to the formation of sub-groups based solely on the interests of the individual member rather than professional background, resulting in situations in which individuals from one sub-group are unaware of what is going on in other sub-projects.

As part of this study, survey respondents were asked to freely name up to five boundaries encountered by individuals during the innovation process based on their own experiences. According to the content analysis, respondents identified 19 distinct categories of knowledge transfer boundaries faced by KIBS during the innovation process (Appendix 4). Most of the identified boundaries could be embedded in the categories of boundaries discussed above (table 1.8). The boundary most frequently cited by survey respondents was collaborative communication. This type of boundary prevents individuals from collaborating to achieve a common objective by sharing resources, knowledge, and insights

Table 1.8

Knowledge transfer boundaries in innovation processes in KIBS as identified in the literature review and the online survey [Created by the author].

Knowledge transfer boundaries identified in the survey	**Knowledge boundaries derived from the literature**													**Contextual boundaries** (Edmondson & Harvey, 2018)			
	Syntactic (Carlile, 2002)	**Semantic** (Carlile, 2002)					**Pragmatic** (Carlile, 2002)										
	Syntactic boundary	**Semantic** (Carlile, 2002)	**Fuzziness** (Rau, et al., 2016)	**Terminology** (Rau, et al., 2016)	**Unbalanced mental model** (Rau, et al., 2016)	**Cognitive boundary** (Smith, 2016)	**Pragmatic** (Carlile, 2002)	**Trajectory** (Rau, et al., 2016)	**Everybody is an innovator** (Rau, et al., 2016)	**Organizational** (Smith, 2016)	**Professional identity boundary** (Smith, 2016)	**Interest boundary** (Smith, 2016)	**Power boundary** (Filstad, et al., 2018)	**Environment**	**Task**	**Time**	**Leadership**
Individual boundaries																	
Collaborative communication boundary		x	x	x	x	x	x	x	x	x	x	x	x				
Lack of domain expertise							x	x		x							
Individual differences		x			x	x											
Fear							x						x	x			
Language boundary	x		x	x													
(Inter)organizational boundaries																	
Hierarchy of authority										x			x	x			
Leadership													x				x
Deficient process														x			
Conflicting agendas							x	x	x			x					
Regulatory framework														x			
Multitasking														x	x		

Table 1.8 (continued)

Knowledge transfer boundaries identified in the survey	**Knowledge boundaries derived from the literature**													**Contextual boundaries** (Edmondson & Harvey, 2018)			
	Syntactic (Carlile, 2002)	**Semantic** (Carlile, 2002)					**Pragmatic** (Carlile, 2002)										
	Syntactic boundary	**Semantic** (Carlile, 2002)	**Fuzziness** (Rau, et al., 2016)	**Terminology** (Rau, et al., 2016)	**Unbalanced mental model** (Rau, et al., 2016)	**Cognitive boundary** (Smith, 2016)	**Pragmatic** (Carlile, 2002)	**Trajectory** (Rau, et al., 2016)	**Everybody is an innovator** (Rau, et al., 2016)	**Organizational** (Smith, 2016)	**Professional identity boundary** (Smith, 2016)	**Interest** (Smith, 2016)	Power boundary (Filstad, et al., 2018	**Environment**	**Task**	**Time**	**Leadership**
Established patterns and habits		x					x	x									
Cultural differences		x					x			x				x			
Scarce resources																	
Temporal boundary																x	
Financial boundary														x			
External environment																	
Changes and uncertainty														x			
Legislative boundary														x			
Gender inequality and stereotypes														x			
Specific working conditions																	
Geographical distance and different time zones														x			
Online working environment														x			

and learning to reach consensus. It manifests itself through insufficient multi- and inter-disciplinary and multi-stakeholder collaboration skills, lack of open and trustworthy communication, weak information sharing skills, and siloed work. Time and money are the second and third most frequently mentioned categories of impediments to the innovation process, respectively. The temporal boundary relates to the time allocated for the completion of a task or project. Typically, it takes the form of time constraints and deadlines that are difficult to meet. This problem is related to another challenge that KIBS has, that is multitasking and multiple commitments. Multitasking pertains to the ability to complete multiple task goals in the same general time-period by switching between individual tasks frequently. Knowledge workers' daily tasks are information-intensive, and they frequently switch between more solitary critical thinking and highly communicative collaboration with others.

It was found in the UK study of R&D service providers that multitasking is widespread in the R&D industry. Staff members conduct new project proposals, feasibility studies, and development projects in parallel while also providing specialist inputs to other teams (Suija-Markova, Briede, Gaile-Sarkane, Ozoliņa-Ozola, 2020).

The financial boundary occurs when the innovation project is constrained by its budget or lacks sufficient financial means. How the organization's hierarchy of authority functions, including division of labour, delegation of authority, command chains, positional roles, and functions, has been cited as another frequently encountered knowledge transfer boundary in KIBS innovation process. It is characterized by excessive hierarchy, the absence of a clear hierarchy, unclear roles, a failure to delegate authority, and ineffective decision-making. The survey results also showed that leadership was one of the things that got in the way of innovation either in the form of insufficient or complete absence of direction of people towards accomplishment of a goal.

This survey also uncovered a category of boundary related to conflicting agendas, which includes contradictory insights, agendas, and goals manifested at various levels – individual versus team, team versus organization, organization versus organization, and sector versus sector.

Domain expertise or boundaries associated with individuals lacking knowledge and understanding of essential elements of a domain or specific field of inquiry were mentioned to impede the innovation process of KIBS.

The category of boundaries known as "individual differences" encompasses obstacles relating to the life experiences, emotions, attitude, and behaviour of innovators. It manifests as incompatibility of personalities, varying levels of activity, motivation, and sense of responsibility regarding the desired outcomes. This category may be related to fear, which entails boundaries relating to unpleasant emotions caused by anticipation or awareness of impending danger, evil, or pain.

Although mentioned less than ten times, there are several categories of boundaries that are worth to discuss in the light of knowledge transfer in the innovation process. Legal and regulatory framework is one of them. This category of boundary is related to a rule, law, or policy that makes it difficult or impossible for innovation process to happen or innovation to be achieved. Several respondents cited their experience with European Union-funded innovation projects. One of the respondents wrote that the project call regulations "required that you describe the solution in order to receive funding; however, by innovating, we were unable to foresee the final solution prior to the project, and we ended up doing something different than planned". Other references were made to rigid innovation procurement laws and internal procedures that impede the innovation process.

Another boundary identified was the difficulty of innovating in a rapidly changing environment and uncertain conditions. It entails modifications to innovation project objectives, shifts in priorities and strategic plans, and can result in the discontinuation of idea development or project termination.

A final knowledge transfer boundary encountered in the innovation process is the adherence to established thought patterns and habits. It manifests as the use of established concepts, replication, and repetition of tried-and-true methods, resulting in a certain degree of stagnation.

In conclusion, 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 in the presence of knowledge transfer and the spanning of various boundaries**. The author will address this issue in the next section of the thesis

2. KNOWLEDGE TRANSFER IN THE CROSS-DISCIPLINARY INNOVATION PROCESS

Nowadays, more and more businesses recognize that their knowledge and ability to learn is the most important strategic asset from which to draw a long-term growth and outperform its competitors. Technology, by itself, has struggled to offer this benefit due to its relative ease of replication.

Research on knowledge transfer has developed out of the evolution of approaches to strategic analysis of a firm. The classic approach was developed in the 1960s and it is based on a notion that a firm's main objective is to maximize long-term profit and to develop continuous competitive advantage over it rivals in the external market. The most influential contributors to the literature were A.D.Chandler, P.Selznick, I.Ansoff, and P.Drucker. According to the classic approach, a strategy is a confrontation between the firm's strengths and weaknesses versus the opportunities and threats in its environment, and a strategic choice is made based on environmental and internal analysis (Rolland, Chauvel, 2000). With the economic change of the 1990s, more attention was paid to a firm's resources and how they could be applied to elaborate its strategy.

RBV is a theory about the nature of firms, as opposed to transactional and industrial economics approaches (the Classic view) which seek to explain why firms exist. It focuses specifically on the inside of the firm. RBV is rooted in thoughts of influential economists such as Say (1803), Ricardo (1817), and Penrose (1959) (Rolland, Chauvel, 2000). According to RBV, the firm's possession of specialized resources allow it to enjoy a competitive advantage over its rivals, which, if appropriately managed, is transformed into a visible performance advantage (Lockett, Thompson, & Morgenstern, 2009). Thus, competitive wisdom resides in the specific capabilities of the firm and its ability to leverage these resources according to strategic direction rather than product or market positioning (Rolland, Chauvel, 2000).

"Resources are firm-specific assets that are difficult, if not impossible to imitate" (Teece, Pisano, & Shuen, 1997, p.516). Some users of RBV distinguish between two main types or resources: tangibles such as physical capital (land, equipment) and intangibles such as organisational routines and capabilities. The first ones represent assets that are used as appropriate over a definite life-time, whereas the intangible resources are embedded in firm's capabilities such as organisation's capacity for learning (Lockett et al., 2009). According to Barnie (1991), the firm's resources can be physical, human and organisational, and also include socially complex resources such as interpersonal relationships of firm managers, the firm's culture and reputation within the suppliers or customers (Curado & Bontis, 2006).

The consensus is that tangible resources can be acquired but intangible ones are organisation-specific, difficult to transfer, imitate or substitute, seldom-communicated and more challenging to understand to outsiders (Rolland, Chauvel, 2000). Intangible resources are frequently found in the firm in the form of tacit knowledge (Curado & Bontis, 2006).

As a result, the intangibles are considered to be of greater strategic value and interest and a source of firm-specific competitive advantage.

Knowledge is generally regarded as an intangible. The interpretation of knowledge as a resource has led to the development of KBV of the firm), an extension of the RBV (Curado & Bontis, 2006). The KBV is rooted in the classical works on economic rationality (Simon, 1947) and the organization sociology (Polanyia, 1962) which concentrate on the essence of human knowledge and its relationship to operation. Nelson and Winter's (1982) evolutionary theory is also considered as a contributer to the KBV by introducing concepts such as organizational routines and the tacit knowledge hidden within the organization (Rolland, Chauvel, 2000).

The KBV states that the firm exists to create, transfer and transform knowledge into competitive advantage (Kogut & Zander, 1992), however, knowledge transferring in an organizational context can be difficult. The firm is a complex system comprising different types and levels of knowledge possessed by individuals, groups, teams, alliances and networks, and knowledge as such is not simple and stable quantity. As discussed in the previous section, the aspect of knowledge transferability is crucial for both manufacturing and service companies. It is especially critical for businesses whose success and innovation capacity depends on their competence to effectively accumulate, create, and disseminate knowledge, and coordinate and integrate a broad range of external sources of knowledge, like KIBS. What then does "knowledge transfer" actually imply? The author will start deconstructing the concept of knowledge transfer by defining the term knowledge.

2.1. Knowledge and its types

In the knowledge management literature, the term "knowledge" is often defined by distinguishing among knowledge, information, and data. From a perspective of a firm, data are raw numbers and facts which do not have any meaning of itself. Tiwana (2000) defines data as "a set of particular and objective facts about an event or simply structured records of a transaction" (p.39). Information, in its turn, is defined as processed data, that gives us the facts. Information is characterised as clear, crisp, structured, and simplistic, and something that can be easily expressed in a written form either as a database, a book, a manual or a document. Information is formalised, captured, explicated, and reusable (Distanont et al., 2012, Tiwana, 2000). The definition of term "knowledge" goes far beyond this. One of the most comprehensive definitions is proposed by Davenport and Prasak (1998) who state that "knowledge is a fluid mix of framed experiences, values, contextual information, expert insight, and grounded intuition that provides an environment and framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms" (Tiwana, 2000, p. 37). According to this, knowledge is something that evolves with experience, success, errors, and continuous learning. Compared to information,

knowledge is actionable, allows making predictions, casual associations, or predictive decisions. It is muddy, fuzzy, partly unstructured, intuitive, hard to express, and difficult to express in words and illustrations (Tiwana, 2000). In organizations, knowledge is created and recreated through the interaction of four processes: socialisation, externalisation, combination and internalisation (Nonaka & Konno, 1998).

There have been numerous attempts to classify knowledge but no one universal classification has been found yet. However, there is widespread agreement that knowledge types are multiple and consequential.

One of the most widely cited knowledge classifications is that of Polanyi (1962) and Nonaka (1994) who differentiate between two forms of knowledge: tacit and explicit. Tacit knowledge is "non-verbalised, intuitive and unarticulated knowledge" (Polanyi, 1962 as cited by Liyanage, et al., 2009, p.119), therefore difficult to capture, codify and diffuse (Liyanage, et al., 2009). It is subjective and experience-based, and also includes cognitive skills (e.g., believes, images, mental models) and technical skills, e.g., know-how (Distanont et al., 2012). Tacit knowledge is commonly articulated through metaphors, analogies, diagrams, or prototypes (Rolland, Chauvel, 2000). Tacit knowledge is acquired and accumulated by the individual and embedded in an organisation's cultures, values and routines (Bhagat, Kedia, Harveston, & Triandis, 2002). Nonetheless, it brings greater value to the organization than explicit knowledge. The latter type of knowledge can be expressed in formal language, sentences, symbols and formulas (Distanont et al., 2012), easily transmitted amongst individuals, and has a character of public good (Osterloh & Frey, 2000).

Tiwana (2002) proposes to classify knowledge along four main dimensions: type (technological, business, environmental), focus (operational strategic), complexity (explicit, tacit) and perishability (low, high). Pavese (2021) distinguishes three types of knowledge, first, acquaintance knowledge which entails something that we are acquainted with, e.g., relatives, friends, pets, etc. Second, knowledge-that implies the sort of knowledge which we acquire when we learn. Third, knowledge-how means knowledge how to do something. Despres & Chauvel (2000) propose a slightly different classification of knowledge by differentiating among knowledge what (cognitive knowledge about something), knowledge-how (skill or competence), knowledge why (systems knowledge incorporating context and understanding of how the parts relate to the whole).

In organizational context, the most comprehensive classification of knowledge is developed by Blackler (1995). Adapting and extending the categorization of knowledge types proposed by Collins (1993), Blacker differentiates five types of knowledge that is embrained, embodied, encultured, embedded, and encoded (see Table 2.1).

As useful as it can be to differentiate various types of knowledge, according to Blackler (1995), the concept of knowledge is problematic. Referring to the Activity theory, Blacker notes that instead of studying knowledge as something that individual and organizations supposedly possess, the focus must be shifted towards knowing as something they do and the dynamics of the systems through which knowing is accomplished. The Activity theory defines knowing as a phenomenon which manifests itself in systems of language,

technology, collaboration, and control (i.e., it is mediated); located in time and space and specific to contexts (i.e., it is situated); constructed and constantly developing (i.e., it is provisional), purposive and object-oriented (i.e., pragmatic), and linked to power (e.g., it is contested) (Blackler, 1995).

Table 2.1

Knowledge types in organizational context [Created by the author based on Blacker, 1995].

Type of knowledge	Characterisation	Explicit vs. tacit	Individual vs. collective	Related organizational aspects
Embrained	Dependant on conceptual skills and cognitive abilities; it is formal, abstract, or theoretical knowledge; typically learnt through reading books and in formal education; knowledge-that	Explicit	Individual	Individuals' mind
Embodied	Action-oriented, is acquired by doing and in training based on apprenticeship relations; it is context-specific and becomes relevant considering the practical problem-solving experience; knowledge-how	Tacit	Individual	Individuals' body - mind
Encultured	The process of achieving shared understanding; depends heavily on language, are socially constructed and open to negotiation	Explicit	Collective	Social agents such as individuals, teams, departments, and communities
Embedded	Knowledge resides in systemic routines; it is analysable in system terms, in the relation between technologies, roles, formal procedures, and emergent routines; cannot easily be transformed into information systems; is relation specific and dispersed; it is an emergent form of knowledge capable of supporting complex patterns of interaction in the absence of written rules	Tacit	Collective	Technologies, processes, routines, organizational structure, artefacts
Encoded	Information conveyed by signs and symbols. Traditional forms of encoded knowledge are books, manuals, codes of practice, written rules and procedures, and formal information systems.	Explicit	Collective	Code, including textual, visual, audio, and multi-media elements

From the perspective of new product and innovation development, it is important to bring to the attention the knowledge classification proposed by Carlile (2002). Building on the community of practice literature and his own ethnographic study, Carlile differentiates three types of knowledge in practice: localised, embedded, and invested. The localised knowledge is confined to particular problems faced in a given practice. The embedded

knowledge resides in individuals engaged in a given practice and also in the technologies, methods, and rules of thumb used by individuals in a given practice. One of the basic premises associated with the embedded knowledge is that the more distant and disengaged individuals are from each other's practice, the more complicated it is to communicate the embedded knowledge they use. The invested knowledge involves knowledge invested in methods, ways of doing things, and accomplishments that demonstrate the value of the knowledge developed. According to Carlile, when knowledge proves to be successful, individuals prefer to use that knowledge to solve the problems in the future. That is one of the reasons why individuals are reluctant and not willing to change their knowledge to accommodate the knowledge developed by another group (Carlile, 2002).

Understanding these different notions of knowledge is crucial as knowledge is the main object of knowledge transfer and the importance of each varies by an individual's role and context in which knowledge transfer takes place.

2.2. The concept of knowledge transfer

Although a vast number of 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".

The author conducted a review of the knowledge transfer research area through the scientometrics methods based on the citation data collected from the Web of Science Core Collection (WoSCC). Web of Science (WoS) is one the most important and widely used academic databases (Zhu & Liu, 2020), and its literature records are considered to be more consistent, internationalized, and standardised than those found in other databases, for example, Scopus (Bartol & Mackiewicz-Talarczyk, 2015). Therefore, in this study, all records related to knowledge transfer in management sciences from 1985 to 2019 were obtained from WoS for further bibliometric analysis and visualisation.

CiteSpace is an open access computer programme in Java for visualising and analysing the literature of a scientific domain. CiteSpace allows users to navigate and explore trends uncovered from scientific publications and obtain a better understanding of the scientific literature much more efficiently than a random search through the literature. The process of CiteSpace takes input data (in this case scientific articles from WoSCC uploaded as plain text), constructs network models of bibliographic entities, and visualises the networks for further interactive exploration of trends and patterns identified from the dataset (Chen, 2020). In this thesis, the CiteSpace document co-citation analysis and the keyword burst detection were applied to reveal the hotspots and to identify research focus in the concept of knowledge transfer. The outline of a review of the knowledge transfer research area based on the citation data of WoSCC is depicted in Figure 2.1.

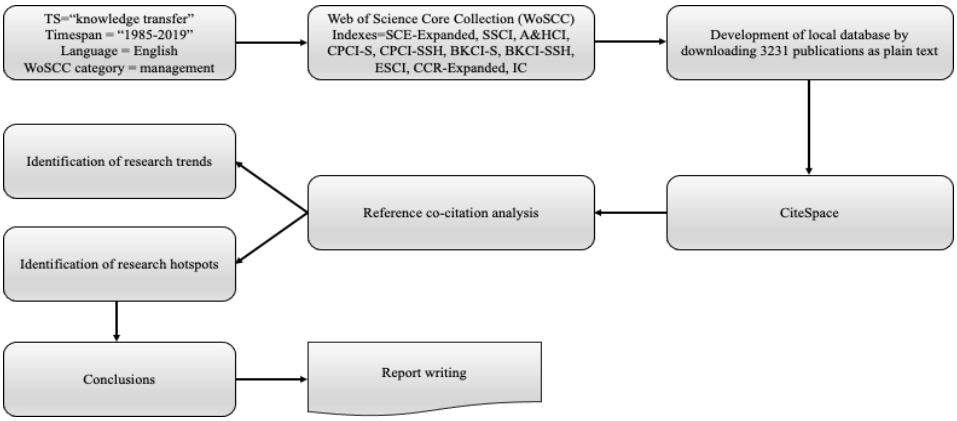


Fig. 2.1. The outline of a review of the knowledge transfer research area based on the citation data of WoSCC [Created by the author].

In this study, a total of 3231 publications related to knowledge transfer in the category of management were retrieved from the WoSCC, published in the period between 1985 and 2019. The publications were searched by applying the term "knowledge transfer". The results show that the earliest knowledge-transfer related research was published in 1992 with a focus on knowledge transfer within university-industry cooperation (Groenewegen, 1992) and the transfer of expert knowledge to novices through computer-assisted training (Gal & Steinbart, 1992). Interest in the research of knowledge transfer increased steadily around the year 2000, which can be explained with the fact that knowledge has been given value as an economic asset and a central role in the achievement of firm's competitive advantage and growth. Figure 2.2. depicts the chronological distribution of knowledge transfer publications in WoSCC.

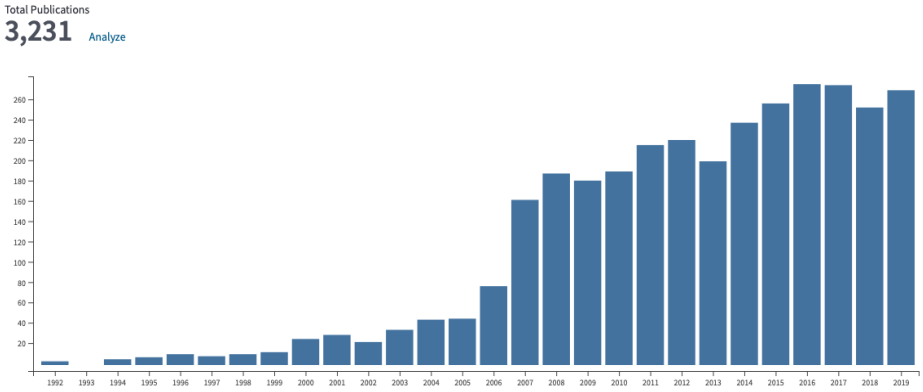


Fig. 2.2. Chronological distribution of knowledge transfer research publications in Web of Science Core Collection (1992 – 2019) [WoSCC, 2021].

Components of knowledge transfer analysis

Based on the literature review, seven themes emerged to represent the units of knowledge transfer analysis (table 2.2). 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, that is the source or sender that transfers the knowledge, and the receiver who acquires the knowledge (Liyanage, Elhag, Ballal, Li, 2009). The stakeholders can be either the individuals or the organizations (Albino, Garavelli, Schiuma, 1998). Prihodova, et al. (2019) highlight the third group of actors, namely, knowledge beneficieries meaning wider groups of society who benefit from the knowledge implementation.

Table 2.2

Components of knowledge transfer analysis based on the literature review [Created by the author].

	Component						
Author	Knowledge	Content and message	Stakeholders / actors	Process	Context	Mechanisms	Effectiveness
Prihodova, Guerin, Tunney, & Kernohan (2019)		√	√	√	√		√
Milagres & Burcharth (2019)	√				√		√
Distanont, Haapasalo, Rassameethes, et al. (2012)	√					√	
Liyanage, Elhag, Ballal, Li (2009)	√		√	√	√	√	√
Minbaeva, (2007)	√		√				√
Lavis, Robertson, Woodside, McLeod, & Abelson, (2003)		√	√	√		√	√
Albino, Garavelli, Schiuma (1998)		√	√		√	√	

Research hotspots of knowledge transfer

In Citespace, the document co-citation analysis is applied to uncover and visualise the underlying intellectual structure of the given scientific field.

At first the merged network is constructed characterising the development of the field over time, showing the most important footprints of the related research activities. In Figure 2.3 lines that connect nodes are co-citation links and the colours of these lines are designed to show when a connection was made for the first time. Some of the references shown with labels are highly cited, suggesting that they are probably landmark papers in the field. The top ten landmark papers in the knowledge transfer domain in management sciences are listed in table 2.3.

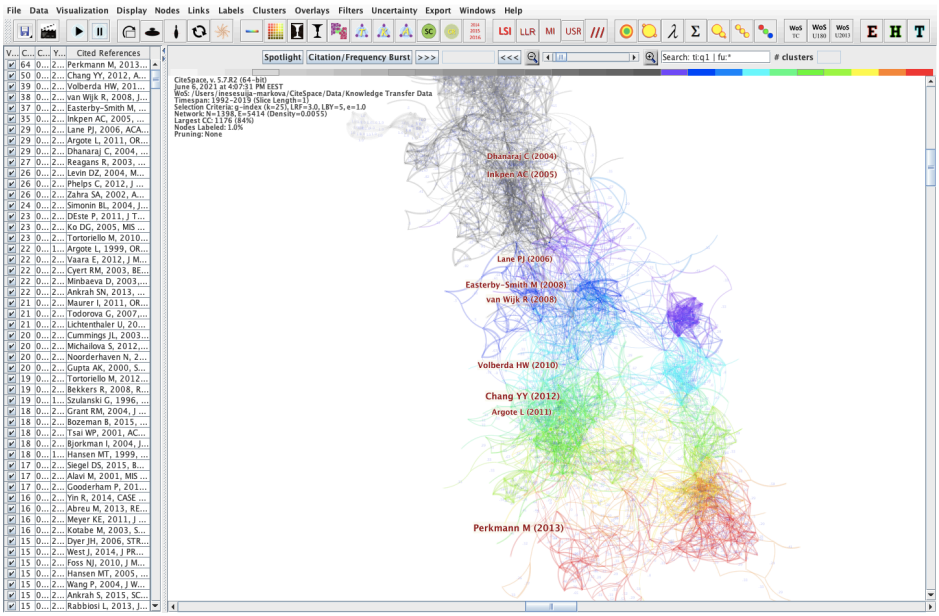


Fig. 2.3. The co-citation network visualisation window [CiteSpace, 2021].

In this study, the total document co-citation network consists of 1398 nodes and 5414 edges. The network density value is 0.0055. The network density value is defined as the number of direct links in a network divided by the number of total possible direct network connections. The highest possible density is 1.00. Lower densities are associated with less-centralized, dispersed networks. Density results in this study indicate towards a de-centralized and strongly dispersed network of co-citations.

A decentralized and strongly dispersed network of co-citations refers to a type of network structure that emerges when multiple authors cite each other's work in a non-hierarchical and widely distributed manner. In such a network, there is no central authority or hub that dominates the citation landscape. Instead, authors are linked together through a complex

web of interconnected citations that span multiple domains, disciplines, and geographic regions. In this study, the decentralized and strongly dispersed network of co-citations reflects the dynamic and multi-dimensional nature of scholarly communication, where ideas and knowledge are constantly being shared, refined, and debated by a diverse and geographically dispersed community of researchers.

Table 2.3

Top 10 landmark papers in the knowledge transfer domain [CiteSpace, 2021].

No	Author	Title	Year	Total citations	Journal
1	Perkmann, M., et al.	Academic engagement and commercialisation: A review of the literature on university–industry relations	2013	2772	Research Policy
2	Chang, YY., Gong, Y., Peng, M.W.	Expatriate knowledge transfer, subsidiary absorptive capacity, and subsidiary performance	2012	654	Academy of Management Review
3	Volberda H.W., Foss, N.J. and Lyles, M.A.	Perspective—Absorbing the Concept of Absorptive Capacity: How to Realize Its Potential in the Organization Field	2010	1722	Organization Science
4	van Wijk R., Jansen, J.J.P., Lyles, M.A.	Inter and intra-organizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences	2008	1595	Journal of Management Studies
5	Easterby-Smith, M., Lyles, M.A., Tsang, E.W.K.	Inter-organizational knowledge transfer: current themes and future prospects	2008	1414	Journal of Management Studies
6	Inkpen, A.C., Tsang, E.W.K.	Social capital, networks and knowledge transfer	2005	5632	Academy of Management Review
7	Lane P.J., Koka, B.R., Pathak, S.	The Reification of Absorptive Capacity: A Critical Review and Rejuvenation of the Construct	2006	3915	Academy of Management Review
8	Argote, L., & Miron-Spektor, E.	Organizational Learning: From Experience to Knowledge.	2011	2187	Organization Science
9	Dhanaraj, C.	Managing Tacit and Explicit Knowledge Transfer in IJVS: The Role of Relational Embeddedness and the Impact on Performance	2004	1456	Journal of International Business Studies
10	Reagans, R., McEvily, B.	Network Structure and Knowledge Transfer: The Effects of Cohesion and Range	2003	5052	Administrative Science Quarterly

Based on the CiteSpace's log-likelihood ratio (LLR) cluster algorithm and according to the title of the citing, the document co-citation network is divided into fourteen clusters. LLR refers to the probability of a term appearing in a cluster. In CiteSpace, the terms in a

cluster are sorted by this ratio, and then the term with the highest value is used to name the cluster. Detailed information on fourteen clusters is given in table 2.4.

As a part of cluster analysis of the co-cited network, parameters such as the mean "modularity" and mean "silhouette", and size of the cluster are applied to measure cluster quality and discover the structural properties and the clusters scale. The modularity and silhouette usually range from 0 to 1. Larger modularity values indicate closer clusters of nodes, and a modularity of >0.3 means that the network community structure is significant. The silhouette column shows the homogeneity of a cluster. According to Chen (2020), the higher the silhouette score, the more consistent the cluster members are. The silhouette >0.7 generally suggests that the cluster has high credibility. However, high silhouette score can be deceptive if the formation of the cluster is the artifact of citations made by a very small number of articles. Therefore, it is important to double check how many citing articles are associated with a particular cluster (Chen, 2016). The average year of publication of a cluster indicates whether it is formed by generally recent papers or old papers. In this study, the mean modularity and silhouette score of fourteen clusters are 0.7876 and 0.9142, respectively. Based on the silhouette score analysis of each individual cluster, the author concluded that clusters #7, #9, #10, #12, #13 and #14 should be excluded from further analysis as the number of co-citing articles varies from one to seven per cluster or does not contain input values, as in the case of cluster #12.

Table 2.4

Top 10 co-citation clusters sorted by the number of co-citing articles [CiteSpace, 2021].

Cluster-ID	Size	Silhouette	Mean year	LLR, p-level
0	216	0.897	2011	missing link (299.31, 1.0E-4)
1	201	0.866	2004	alliance performance (321.57, 1.0E-4)
2	173	0.926	2000	relational embeddedness (257, 1.0E-4)
3	157	0.908	2014	entrepreneurial university (483.22, 1.0E-4
4	125	0.894	2007	governance mechanism (290.39, 1.0E-4)
5	90	0.947	2014	absorptive capacity (323.15, 1.0E-4)
6	70	0.977	2008	public research organisation (586.61, 1.0E-4)
7	58	0.939	1996	international strategic alliance (74.92, 1.0E-4)
9	26	0.971	1992	transformative capacity (19.08, 1.0E-4)
10	22	0.982	2002	university-industry linkage (70.65, 1.0E-4)
12	14	0.995	1992	postcolonial perspective (NaN, 1.0)
13	13	1	1996	joint venture (20.12,1.0E-4)
14	11	0.996	2008	dynamic model (70.31, 1.0E-4)

The largest cluster #0 named "missing link" has 216 references, and the average year of publication is 2011. The cluster silhouette score is 0.897, suggesting a reliable quality. The publications in this cluster are exploring things needed ("missing links") to ensure successful knowledge transfer process leading to strengthened organizational competitiveness. Three of the most cited publications in cluster #0 pay particular attention to deconstructing the concept of knowledge creation and transfer among firms in alliances. (Chang, Gong, & Peng, 2012; Easterby-Smith, Lyles, & Tsang, 2008; Volberda, Foss, &

Lyles, 2010). The role of social capital and its various elements in the knowledge transfer process is another focus area in this cluster. For example, Maurer, Bartsch, Ebers (2011) evaluated the importance of inter-organisational social capital, including number of social ties, relational embeddedness, relational empowerment and how it fosters absorptive capacity, knowledge transfer, innovation and a firm's growth. Barner-Rasmussen, Ehrnrooth, Koveshnikov, & Mäkelä (2014) and Brannen, Piekkari, & Tietze (2014) explored the role of cultural and language skills as resources for individuals' boundary spanning ability in multinational and international alliances. Bouncken, Pesch, & Reuschl (2016) analysed the concept of "co-poiesis". The term co-poiesis implies mutual knowledge creation among firms in alliances through interaction of individuals, their collective creativity and reciprocal learning. It explains the emergences and birth of new knowledge based upon novel transformation of knowledge in and across firms (Bouncken & Teichert, 2013).

Labelled "alliance performance", the second largest cluster (#1) contains 201 member references, with a mean year of 2004 and a silhouette value of 0.866. Multiple studies have been conducted to extend the notion that firms improve their performance by cooperating with and acquiring knowledge from other organizations. The most actively publications in this cluster focus on how social capital dimensions of networks affect the transfer of knowledge between network members (Inkpen & Tsang, 2011), and how relational embeddedness between alliance partners influences success of knowledge transfer (Dhanaraj, Lyles, Steensma, & Tihanyi, 2004). This cluster of publications has also placed strong attention on multinational corporations as knowledge creating and diffusing entities, their organizational policies facilitating or hindering knowledge sharing between multinational units, and inter-partner relationship between alliance partners on the effectiveness of knowledge transfer mechanisms (Fey, Furu 2008; Feller, Parhankangas, & Smeds, 2009).

The third cluster (#2), labelled "relational embeddedness", has a mean year of 2000, a silhouette value of 0.926, and 173 member references. The three of the most cited scholarly publications focus on how different formal and informal features or elements of relational networks affect knowledge transfer between individuals and organizations (Reagans & McEvily, 2003; Argote & Ingram, 2000; Gupta & Govindarajan, 2000). Reagans & McEvily (2003) have examined the ease of knowledge transfer depending on the strength of ties, social cohesion and range of relational network. Argote & Ingram (2000) have deconstructed the concept of knowledge repositories according to which knowledge is embedded in the three basic elements of organizations—members, tools, and tasks—and the various subnetworks formed by combining or crossing the basic elements. Building on communication theory, Gupta & Govindarajan (2000) have explored the importance of five elements in the knoweldge transfer process: knowledge value possesed by the source unit; motivational disposition of the source unit regarding the sharing of its knolwedge; the existence, quality, and cost of transmission; motivational disposition of the target unit regarding acceptace of incoming knoweldge, and the traget unit's absorptive capacity for the incoming knowledge. The citing articles of this cluster focus on various aspects of

relational embededdness, for example, strength of social ties, level of trust, shared values, level of formality in communication, and their impact on the success of knowledge transfer and a firm's performance. Another important research dimension of knowledge transfer process emerges in this cluster of publications, and that is related to the concept of knowledge stickiness, defined as difficulties encountered in the knowledge transfer process (Szulanski, 2000; Jensen & Szulanski, 2004).

The fourth cluster (#3) is labelled "entrepreneurial university" and has a mean year of 2014, a silhouette value of 0.908, and 157 member references. The actively cited publications in this cluster are mainly about knowledge and technology transfer from academia to industry and various public policy measures supporting knowledge transfer activities (Perkmann et al., 2013; Ankrah, Burgess, Grimshaw, & Shaw, 2013; Bozeman, Rimes, & Youtie, 2014). According to Straujuma, et.al (2018), Thomas & Paul (2019) and Velez-Rolon, Mendez-Pinzon, Acevedo, (2020) universities have switched to interacting with industries to achieve excellence. At the same time companies are forced to innovate by ever-increasing competitive market forces and are looking forward to partnering with universities. The researchers in this cluster of publications aim to explore the development and performance of university spin-offs (Mathisen & Rasmussen, 2019; Marzocchi, Kitagawa, & Sánchez-Barrioluengo, 2019), researchers' motivations and barriers to engage in cooperation with firms and government agencies (Ramos-Vielba, Sánchez-Barrioluengo, & Woolley, 2016), factors affecting the knowledge diffusion and success of a university-industry partnership (Capaldo, 2016).

The fifth cluster (#4), called "governance mechanism", has 125 member references, a silhouette value of 0.894 and a mean year of 2007. This cluster draws attention to how different knowledge and organizational governance mechanisms affect knowledge transfer. For example, Rabbiosi (2011) has studies the coordination mechanism of reverse knowledge transfer, which implies knowledge flows from the subsidiary to the parent company. This cluster also addresses knowledge sharing and transfer in buyer-supplier relationship and importance of justice or fairness as perceived by both parties in promoting successful relationship (Liu, Huang, Luo, & Zhao, 2012). Bond, Houston, & Tang (2008) analyse the governance models of knowledge transfer networks composed of interconnected firms, government entities, and research organizations, specifically paying attention to start-up knowledge transfer networks.

The sixth cluster (#5) is labelled "absorptive capacity". It has 90 member references, a silhouette value of 0.947 and a mean year of 2014. Knowledge transfer and integration within a company has been widely researched from the perspective of absorptive capacity. In this cluster, the most actively cited publication of West & Bogers (2014) focuses on the review of research of open innovation considering how and why firms commercialize external sources of innovations. The second actively cited publication of Song (2014) reviewed literature on subsidiary absorptive capacity and knowledge transfer within multinational corporations. The other studies in this cluster have explored the effects of absorptive capacity on product innovation (Zhang, Zhao, & Lyles, 2018), university – industry collaborations and product innovation performance (Kobarg, Stumpf-Wollersheim,

& Welpe, 2018), development of absorptive capacity over time and across boundaries (Omidvar, Edler, & Malik, 2017).

Labelled "public research organisation", cluster seven (#6) has 70 references, a silhouette value of 0.977 and a mean year of 2008. Like cluster #3, the publications in this cluster are also focused on the interaction between universities and businesses. However, if the third cluster of publication laid stronger focus on the entrepreneurial side of universities such as establishment of spin-offs, knowledge and technology transfer mechanisms, public support instruments to research commercialisation, the seventh cluster pays more attention to industry collaboration with public research organizations such as scientific institutes. The most cited publication explores motivation why scientists engage with industry and concludes that most academics interact with industry to further their research rather than commercialise their knowledge (D'Este & Perkmann, 2011). Bozeman, Fay, & Slade (2013) has carried out the state-of-the-art analysis of research collaboration in universities and academic entrepreneurship. Several publications in this cluster focus on the analysis of channels and benefits of interactions between public research organizations and industry in Latin American countries (Orozco & Ruiz, 2010).

Research trends of knowledge transfer

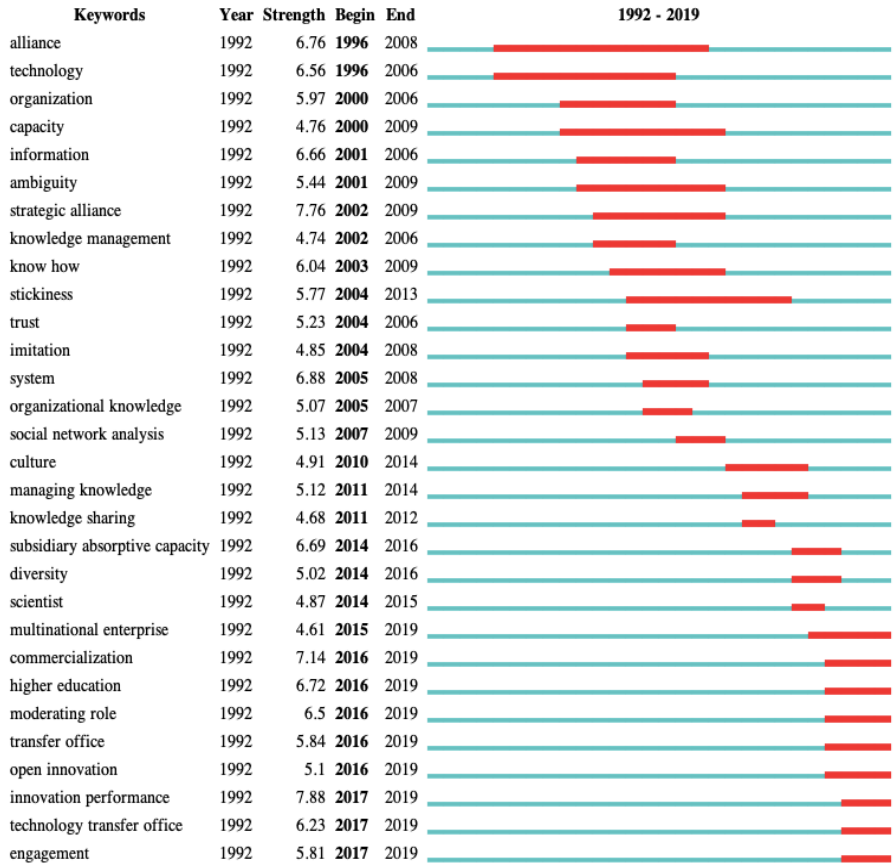
Burst detection can be used to identify emerging trends and new breakthroughs in a field by looking at scholarly publications that have received a large number of citations in a short period of time. Burst detection is a frequently used computational approach for detecting abrupt changes in events. A citation burst indicates that the research community has given the underlying work a great deal of attention. If a cluster has a large number of publications with strong citation bursts, then the cluster as a whole is thought to capture an active area of research, or an emerging trend (Chen, 2020).

In this research study the keyword burst detection was carried out to identify the research hotspots and determine the research trends in the knowledge transfer domain from the perspective of management sciences. A total of 30 bursty keywords were obtained in the keyword co-occurrence network. Keywords with high burstiness are listed in figure 2.4. Additionally, the author carried out a citation burst analysis which indicates the list of articles to which the scientific community has paid or is paying particular attention. Top 25 references with the strongest citation burst are depicted in figure 2.5.

Knowledge transfer is a process that involves exchange of knowledge between the source that shares the knowledge and the recipient who acquires the knowledge. It can happen at multiple levels – between individuals, firm's units, and organizations. With an increasing recognition of knowledge as a source of firm's competitiveness, the process of knowledge transfer in an organizational context has been central to the researchers' attention. Hence, it is not a surprise that "alliance", "organisation", "strategic alliance" and "system" were detected as keywords with a strong citation burst.

The knowledge transfer process presupposes that there is a knowledge object in the source context that can be transferred. Therefore, another active area of research is related to the knowledge types and objects being transferred, as confirmed by highly cited

keywords such as “know-how”, “information”, “technology”, “organizational knowledge” and difficulties encountered within the knowledge transfer process, as indicated by widely



cited keywords “knowledge stickiness” and “ambiguity”.

Fig. 2.4. Top 30 keywords with the strongest citation bursts [CiteSpace, 2021].

The success of the knowledge transfer is strongly linked with the recipient’s ability to acquire and apply the knowledge. Accordingly, the researchers’ attention has been placed on the investigation of the recipient’s capacity, as supported by terms “capacity” and “subsidiary absorptive capacity”, another group of keywords with a strong citation burst. In the last decade researchers have been intensively exploring a link between knowledge transfer and innovation. Consequently, terms such as “innovation performance” and “open innovation” have gained prominent attention in scholarly literature. Finally, keywords related to university-industry collaboration (“higher education”, “transfer office”, “technology transfer office”, “scientist”, “commercialisation”) have become hot research topics since 2014, as supported by the cluster analysis performed above.

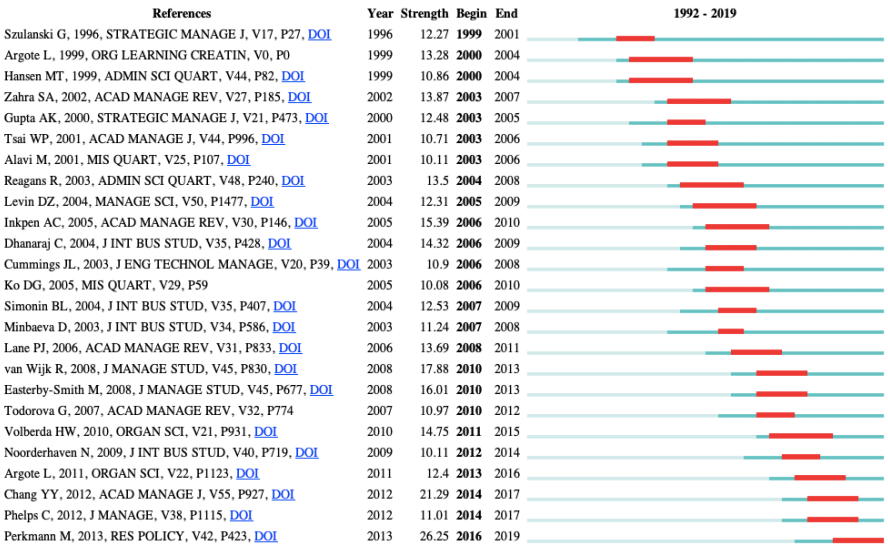


Fig. 2.5. Top 25 references with the strongest citation bursts [CiteSpace, 2021].

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

2.3. The definition of knowledge transfer

Having carried out the content analysis of twenty-three definition (Appendix 5), 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 process of continuous learning (Argote, Miron-Spektor, 2011) and communication, involving information processing activities (Albino, Garavelli, Schiuma, 1998; Ko, Kirsch, King, 2005).

Knowledge transfer process covers several stages (Minbaeva, 2007), the number of which varies from a 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, 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 organised process, and organisation can establish various internal policies, structures, and processes to facilitate learning.

Knowledge transfer is a process of dyadic exchanges of knowledge between the source or sender that 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 emphasize 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). To put it 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, 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, & Ismail (2016) conclude that "knowledge sharing" and "knowledge transfer" are two different while interconnected concepts. Depending on the perspective of knowledge sharing and the strategy used to transfer knowledge, the processes involved in each of these concepts vary. The authors conclude that knowledge transfer can be achieved using two strategies – the 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 act of 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 (figure 2.6.), 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 success

Researchers have defined knowledge transfer success from different perspectives, including as a number of knowledge transfers completed in a given time period, the knowledge transfer that is accomplished on time, on budget and with a satisfied knowledge recipient, the degree to which the knowledge recipient recreates the transferred knowledge, as well as the degree to which the recipient gains ownership of, commitment to, and satisfaction with the transferred knowledge (Cummings, Teng, 2003).

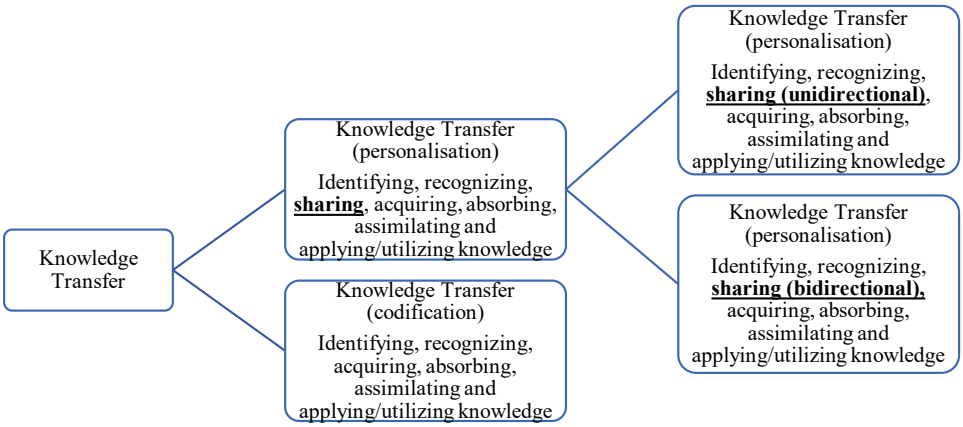


Fig. 2.6. Interconnections of "knowledge transfer" and "knowledge sharing" from the perspective of involved processes [Adopted from Tangaraja et al., 2016].

According to Argote & Ingram (2000), successful knowledge transfer manifests itself in the achievement of firm's competitive advantage and growth. The competitiveness at a firm's level can be measured by incorporating quantitative indicators such as costs, prices and profitability, and qualitative indicators of non-price factors, for example, quality of products and services (Buckley, Pass, & Prescott, 1988). Regardless of which indicators are applied, the organisational competitiveness describes the firm's absolute ability to survive in the long-term and the ability to outperform its competitors (Pina, 2015).

Although the roles of KIBS in knowledge creation and transfer have been extensively explored and some research has been done on how knowledge is transferred by KIBS, (for example, Landry et al. (2012), Doroshenko et al. (2013)), there is limited research on practices (tools, methods, and approaches) of knowledge transfer in the innovation process.

2.4. The development of the concept of "innovation": invention or imitation

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 it is dependent on new development or significant improvement**. Second, innovation, in whatever form it takes, is the result of 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, **creation of innovative solutions and approaches** to fixing

difficult **issues calls for the transfer of knowledge from a variety of fields and cross-disciplinary collaboration**.

Benoit Godin, a political scientist, and sociologist, has conducted the most comprehensive analysis of the historical development of innovation. This section summarises the key findings of Godin's study "Innovation: the history of a category" published in 2008.

The origins of the term "innovation" traces back to the term "novation" which was applied in law in the 13th century and meant "renewing an obligation by changing a contract for a new debtor" (Godin, 2008, p.23). Although the word "novation" means "new," it was rarely used in the arts and sciences before the twentieth century; instead, terms like "invent" and "create" were used to describe man's productive power and creative abilities. N.Machiavelli's (The Prince, 1513) and F.Bacon's (Of Innovations, 1625) works were among the first written sources to use the term "innovation" as such and to describe people's resistance to it (Godin, 2008).

The meaning of innovation in the twentieth century is a reconciliation of the two opposing terms of imitation and invention that have evolved from ancient Greek philosophy over the centuries. Plato's primary theme, for example, was the imitation of reality, and there has been a constant debate over the centuries about art imitating, copying, or being an interpretation of reality (Taylor, 2017). To stimulate economic growth in the 16th and 17th centuries, patents were granted to importers of existing inventions rather than to inventors, and in the 18th century, imitation of consumer goods was considered an invention to improve the quality, design, and appearance of these goods (Berg, 2002). More recently, R.R.Nelson and S.G. Winter (2002) proposed imitation as one of two business strategies, the other being innovation. In the twentieth century, imitation gave rise to another critical step in the innovation process known as diffusion or use (Godin, 2008). Despite the fact that imitation is inextricably linked to invention, imitation has been regarded as copying since the middle of the 18th century, whereas originality has become the standard for true invention.

The European Renaissance of the 14th century sparked a spirit of discovery and discovery in many knowledge domains and disciplines, including the arts, science, literature, history, and economics. Because discovering and inventing implied a challenge to the established order, innovation was met with opposition from all walks of life, particularly the church, politics, and economics. Despite this, the concept of invention spread everywhere and under various names, with the common denominators being the concepts of novelty, originality, and utility. The historical conceptions of innovation are listed in fig. 2.7.

While the concept of invention was initially associated with scientific discovery and artistic imitation, it gradually and increasingly became associated with mechanical and technological invention, particularly in areas such as architecture, navigation, metallurgy, and the military. The consumer and industrial revolutions, the incorporation of technologies into industrial processes, and the advancement of industrial research are viewed as driving forces that fueled technological inventions in the twentieth century (Godin, 2008).

1. Imitation	8. Organizational change
2. Invention	9. Political innovation
3. Discovery	10. Creativity
4. Imagination	11. Technological change
5. Ingenuity	12. Technological innovation
6. Cultural change	13. Commercialised innovation
7. Social change	

Fig. 2.7. Historical conceptions of innovation [Adopted from Godin, 2008].

Since the end of the nineteenth century, the term "innovation" has played an important role in theories of social and economic change. According to sociologists, innovation is an activity and a process in which the creation of an invention and its application are debated, and invention and imitation (use) are steps in a sequential sequence. For them, innovation is also the catalyst for social and cultural shifts. According to economists, innovation is defined as the commercialization of a (technological) invention (Godin, 2008). W.E. Maclaurin of the Massachusetts Institute of Technology was the first to use the terms "technological change" and "technological innovation" in the economic literature, kicking off the economics of industrial research and the commercialization of technological inventions. Based on the literature on economic change, J.A. Schumpeter identified five types of innovation as a source of creative destruction implying disturbance of existing structures: 1. introduction of a new good; 2.introduction of a new method of production; 3. opening of a new market; 4. conquest of a new source of supply; and 5. implementation of a new form of organisaition. According to Schumpeter, innovation is introduced by an entrepreneur, or later, by the large firm (Godin, 2008).

While technological and commercialized innovation became the dominant concepts of innovation in the literature, other concepts of innovation emerged in the twentieth century, such as social innovation, institutional or political innovation, public service innovation, and organizational innovation. The twenty-first century has seen a broadening of the definition of innovation as technological innovation. Nowadays, there is a significant number of definitions of innovation across different fields in academia, industry, government and non-governmental services and new types of innovation occur (Godin, 2008), for example, eco-innovation, user-centered innovation, frugal innovation, blue-ocean innovation, and others. This trend shall not be considered as bad per se because the primary objective of proponents of these novel concepts is not to simplify the innovation concept, rather than to ensure that policymakers consider non-technological components of innovation when formulating policies. Further, **the author will review various classifications of innovation and discuss them in light of knowledge transfer challenges**.

2.5. Classifications of innovation

In professional literature, the term "innovation" is subject to numerous classifications, typologies, and categorisations. Attempts to classify innovation have evolved in lockstep with the concept of innovation itself. It has grown from a more or less structured system to a highly complex and difficult to structure classification system. Additionally, the majority of this classification hardly qualifies as strict terminology classification.

One of the most comprehensive literature reviews on classifications of technological innovation is conducted by R.Garcia and R.Calantone (2002). Based on the OECD study, the authors define innovation as "an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention which leads to development, production and marketing tasks striving for a commercial success of the invention" (Garcia, Calantone, 2002, p.112). This definition clarifies two critical points. First, the innovation process entails the technological development of an invention in conjunction with its market introduction to end users via adoption and diffusion. Second, the innovation process is iterative, and it entails the initial introduction of an innovation and the subsequent reintroduction of an improved innovation.

The iterative nature of innovation process implies varying degrees of innovativeness, necessitating the development of a typology to describe different types of innovation. The study of Garcia and Calantone revealed that innovations were frequently classified into typologies to indicate their innovative characteristics or degree of innovativeness. Categorizations identified are listed in table 2.5.

Garcia and Calantone (2002) conclude that so many typologies have resulted in the same label being used for different types of innovations and the same innovations being classified under different typologies. This ambiguity in classification scheme makes comparing research findings problematic, if not possible. To address this challenge, the authors have proposed a new typology for identifying technological innovations from the perspective of a firm by defining differences between radical, really new, and discontinuous innovation, and between an incremental and imitative innovation. The proposed typology evaluates product innovativeness upon two dimensions: macro level (the world, industry, and market) and a micro level (the firm and a customer), and the marketing and technological discontinuity (table 2.6).

1. **Radical innovation** contains a new technology that results in a new market infrastructure. Implementation of radical innovation results in discontinuities at a macro level and a micro level. Radical innovations often create a demand which has not been identified by the customer beforehand and serve as the catalyst for emergence of new markets and/or new industries. Such a type of innovations is rare in occurrence.
2. **Really new innovation** will result in a market discontinuity or technological discontinuity on a macro level but will not entail both. On a micro level, the really new innovation will occur in any combination of marketing and/or technological

discontinuity, and can evolve into new product lines, product line extensions with new technologies, or new markets with existing technology.

Table 2.5

Classifications of technological innovations [Created by the author based on Garcia, Calantone, 2002].

Number of categories	Innovation types based on innovative characteristics or degree of innovativeness of innovations	Authors
8	- Reformulated/new parts/remerchandising/new improvements/new products/new user/new market/new customers	(Johnson, Jones, 1957)
5	- Systematic/major/minor/incremental/unrecorded	(Freeman, 1991)
4	- Incremental/modular/architectural/radical	(Henderson, Clark, 1990)
	- Niche creation/architectural/regular/revolutionary	(Abernathy, Clark, 1985)
	- Incremental/evolutionary market/evolutionary technical/radical	(Moriartry, Kosnic, 1990)
	- Incremental/market breakthrough/technological breakthrough/radical	(Chandy, Tellis, 2000)
	- Incremental/architectural/fusion/breakthrough	(Tidd,1995)
3	- Low innovativeness/moderate innovativeness/high innovativeness	(Kleinschmidt, Cooper, 1991)
	- Incremental/new generation/radically new	(Wheelwright, Clark, 1992)
2	- Discontinuous/continuous	(Anderson, Tushman, 1990; Robertson, 1967)
	- Instrumental/ultimate	(Grossman, 1970)
	- Variations/reorientations	(Normann, 1971)
	- True/adoption	(Maidique, Zirgmer, 1984)
	- Original/reformulated	(Wind, Mahajan, 1988)
	- Innovations/reinnovations	(Rothwell, Gardiner, 1988)
	- Radical/routine	(Miles, Snow, 1978)
	- Evolutionary/revolutionary	(Utterback, 1996)
	- Sustaining/disruptive	(Christensen, 1997)
	- Really new/incremental	(Schmidt, Calantone, 1998; Song, Montoya-Weiss, 1998)
	- Breakthrough/incremental	(Rice, Colarelli, Peters, Morone, 1998)
	- Radical/incremental	(Balachandra, Friar, 1997; Freeman, 1994; Atuahene-Gima, 1995; Kessler, Chakrabarti, 1999; Lee, Na, 1994; Schumpeter, 1934; Stobaugh, 1988)

3. **Discontinuous innovation** can be either a radical innovation or a really new innovation depending which level (macro/micro) and which S-curve (marketing/technology/both) is influenced by the implementation of innovation in marketplace.
4. **Incremental innovation** implies products with new features, benefits, or improvements to the existing technology in the existing market. Incremental innovations will occur at a micro level influencing either the marketing and/or technological S-curve. Opposite to radical innovation and really new innovation, incremental innovation will not cause discontinuity at a macro level. Nevertheless, incremental innovations are considered to be central for many firms as due to iterative nature they can occur at any stage of the new product development.
5. **Imitative innovation** will most often be new to the firm, but not new to the market. This type of innovation usually has low technological innovativeness and low market innovativeness. Imitative innovations will almost always be incremental though on rare occasions they will be really new innovations (Garcia, Calantone, 2002).

Garcia and Calantone (2002) do not consider discontinuous innovation and imitative innovation as a stand-alone type of innovations, instead they classify all technological innovations as radical innovations or really new innovations or incremental innovations. Although being a comprehensive framework for studying different kinds of innovations, the typology of Garcia and Calantone does not address service forms of innovation (e.g., a new function, a new approach, a new method) and non-technological forms of innovations (e.g., delivery, strategic, managerial, and marketing innovations). These types of innovations are in the strong focus of KIBS firms (Muller & Doloreux (2009), Pina, (2015), Amara et al., (2016)).

Table 2.6

Framework for identifying technological innovation type [Adopted from Garcia, Calantone, 2002].

Inputs: Discontinuities				Outputs: Innovation types		
Macro-Marketing Discontinuity	Macro-Technology Discontinuity	Micro-Marketing Discontinuity	Micro-Technology Discontinuity	Radical innovation	Really new innovation	Incremental innovation
1	1	1	1	1	0	0
1	0	1	0	0	1	0
0	1	0	1	0	1	0
1	0	1	1	0	1	0
0	1	1	1	0	1	0
0	0	1	0	0	0	1
0	0	1	0	0	0	1
0	0	0	1	0	0	1

Based on the systematic review of 1445 articles, Klarin (2019) has proposed a classification of product and service innovations from a firm 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. Table 2.7 depicts thirteen characteristics through which the identified product and service innovation types were compared.

Table 2.7

Product and service innovation types, characteristics, and overlaps [Adopted from Klarin, 2019].

	Radical	Incremental	Imitative	Disruptive	Value	Frugal	Reverse	Jugaad
Patentable	√	√		√	√	√	√	
Scalable	√	√	±	√	√	√	√	
Commercializable	√	√	√	√	√	√	√	
Existing markets	√	√	±			±	±	
New markets	√		±	√	√	√	√	√
Underserved markets due to cost			√	±	√	√	√	√
Largely developed on existing products/ services		√	√	√	√	√	√	±
High technological novelty	√	√		√				
New users	√			√		±		√
BoP to ToP markets				±			√	
Market positioning by choice	√	√		±	√		±	
Use of institutional voids			√		±	√	±	√
A degree of product localisation			√			±		√

± refers to the characteristic flexibility regarding the innovation type.

Based on the framework of Ansoff's matrix, A. Klarin has developed the innovation classification along two main dimensions - cost and market novelty (figure 2.8).

The literature analysis carried out by A.Klarin (2019) indicates that radical vs. incremental and disruptive vs. sustaining (incremental) are the two most prominent typologies of innovation, especially in the context of developed countries. The interpretation of these four types of innovations is very similar to the classification proposed by Garcia and Calantone (2002).

The term "radical innovations" refers to large-scale technological advancements that result in major or revolutionary changes to their surrounding environments. Also, words like break-through, new-to-the-world or industry, path-breaking, first-mover, pioneering or lead are used to denote radical innovations. The nature of these innovations allows placing them into high cost – high market novelty segment. A synthesised interpretation of the term "incremental innovations" implies improvements to current technologies in existing environments; therefore, this type of innovations does not create macro-level discontinuities. Incremental innovations also require significant capital investments to maintain and improve product and service offering for the masses of early adopters and

most developed country markets; however, maintenance and continual development expenses are lower than those associated with lead innovations, and the result is less market novelty than the lead innovation (Klarin, 2019).

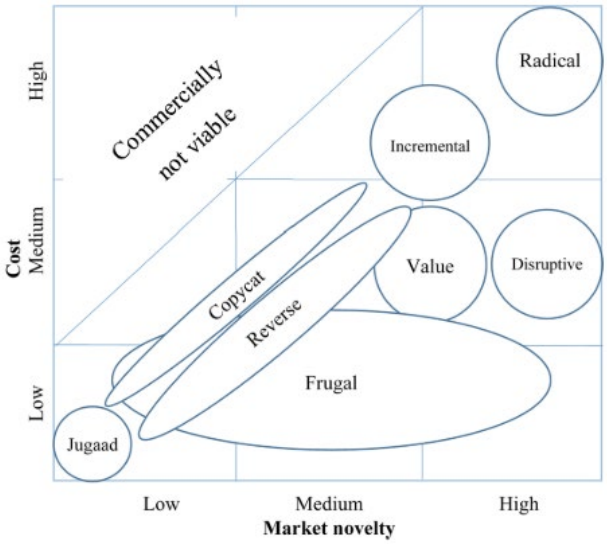


Fig. 2.8. Product and service innovation typology matrix [Adopted from Klarin, 2019].

The fundamental traits of disruptive innovations include lesser performance, lower gross margins, smaller target markets, simpler goods, and services that may not appear as appealing as established alternatives. Disruptive innovations establish new markets and value chains, disrupt existing markets and value chains, and may also supplant prior technologies. Consequently, market novelty is at the highest when compared to the cost of sustaining (incremental) and radical innovation. It's about fully addressing those underserved sectors and establishing a footing through the provision of more appropriate functionality at a reduced price (Christensen, Raynor, & McDonald, 2015).

Unlike the study of Garcia and Calantone (2002), the systematic literature review of A. Klarin (2019) reveals a classification of low-cost innovations which overlap considerably, as seen in figure 2.8. Value innovation is used to create products and services which have no direct competitors by deliberately aligning differentiation with low cost. The result is a leap in value for both the customers and the company (Kim, Mauborgne, 2005). Key characteristics of frugal innovation include limited resources, attention to customers' urgent needs, and virtually always an affordable price that is appropriate for underserved markets with limited resources. Because of cost-cutting, frugal innovation fits within low-medium cost of development and overlaps with copy-cat, reverse, and value innovation. The market novelty of such innovations may vary from low to high (Klarin, 2019).

In terms of cost and market novelty, there is a significant overlap between frugal and reverse innovations. Frugal innovations that expand from the base-of-the-pyramid (BoP)

markets to developed countries or the top-of-the-pyramid (ToP) markets are named reverse innovations. Immitative innovations frequenty take advantage of institutional voids in order to avoid costly legal procedures in order to piggyback on existing products and adapt them to local markets at a lesser cost. Finally, jugadd innovations are socially oriented, uncommercializable, and thus unscalable inventions that address the needs of financially underprivileged individuals (Klarin, 2019).

As depicted in table 2.7., there are numerous overlaps as well as certain distinguishable characteristics among the eight major types of product and service innovations. The greatest value of this innovation classification is that it provides consistency for defining the constructs and can help avoiding of wrongful identification of innovations.

Based on the foregoing, the author concludes that the degree of novelty of the invented solution is a critical variable for the classification of 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**.

In this context, the author will review a classification of inventive solutions developed by the Soviet scientist G. Altshuller. Although it commonly agreed that invention and innovation are two rather distinct concepts, Altshuller's classification can be linked to innovation novelty levels by providing a framework for assessing the degree of novelty in an innovation solution and identifying what type of knowledge might be needed for its development and implementation.

Based on the 7-year research of numerous inventions registered in patent collections, the author of the Theory of Inventive Problem Solving (TRIZ) defined five levels of inventions (table 2.8) based on four main criteria: 1. what type of knowledge was required to find a solution; 2. if there was any contradiction resolved by a solution; 3. the number of trial-and-error attempts required to guarantee a solution of a certain level; and 4. the scale of change imposed on the original system (Altshuller, 1999).

Table 2.9 shows that different types of knowledge and ways of thinking are needed to identify and develop appropriate solutions for problems of various levels of complexity. That, in its turn, requires different approaches to R&D, deployment and management. 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, initial cohesion is minimal, 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 own knowledge to the project (Boger et al., 2016). Lack of a common language and low cohesion compelled members of a diverse team to be more conscious of their teammates. Consequently, the creation of new ideas is more effective than in interdisciplinary and intra-disciplinary teams (Sanchez-Segura et al., 2018).

Table 2.8

G. Altschuller's levels of invention and type of knowledge required [Created by the author based on Altshuller, 1999; Souchkov, 2007; and Zlotin & Zusman, 2013].

Level of invention	Description	Type of required knowledge
1	A problem, and its means of solution, exists within an area of one profession (one specific section of an industry). It results in smallest inventions or so called "non-inventive" inventions.	The problem can be solved by every professional familiar with a relevant discipline
2	A problem, and its means of solution, exists within an area of one industry	The problem can be solved by methods known within the same industry, only residing in a different area of that industry. The knowledge and assistance of colleagues working in the same division or company, or industry.
3	A problem, and its means of solution, exists within an area of one science. One of the elements of a technical system is completely replaced. Other elements are partly changed.	Knowledge how to solve the problem reside within the borders of the same science.
4	A problem, and its means of solution, exists outside the boundary of the science where the problem originated. Level 4 solutions reside within the blue ocean strategy since they create something which has not existed yet and thus create new systems and new markets	The problem is solved by means which can reside far away from the borders of science where the problem belongs to. For instance, "mechanical" problems are solved with knowledge of chemistry. A wide range of knowledge is required, e.g., knowledge available within a large community of professionals, such as the entire engineering community.
5	A problem, and its means of solution, exists outside the boundary of contemporary science. It is necessary to make a new discovery and then, based upon this new scientific data, solve the inventive problem. These are scientific discoveries yet to be used to design new technical systems.	The invention is made based on all that is knowable. Any knowledge could be useful.

- **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).

Table 2.9

Type of knowledge required to develop innovations of different degrees of novelty [Created by the author].

Level of invention based on Altshuller	Type of knowledge required to solve a problem and invent a solution	The degree of novelty of the invented solution based on Garcia and Calantone (2002) and Klarin (2019)				
		Radical	Really new	Discontinuous/ disruptive	Incremental / Sustaining	Imitative
5	All that is knowable. Any knowledge could be useful.	√		√		
4	Knowledge which resides far away from the borders of science where the problem belongs to.	√	√			
3	Knowledge which resides within the borders of the same science.		√	√		
2	Knowledge which resides within the same industry, only residing in a different area of that industry				√	√
1	Knowledge which resides in a relevant discipline				√	√

- **Transdisciplinary**. There are several interpretations of transdisciplinarity. According to Norris, O'Rourke, Mayer, & Halvorsen (2016), members of transdiciplinary 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 asserts 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 in order to tackle challenging 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 innovative solution, the more revolutionary and far-reaching the idea is, 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 multiple 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 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.

2.6. 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; Carlile, 2004; Bechky, 2003), dialogue-based approaches (Majchrzak, More, & Faraj, 2012), collaborative prototyping (Schrage, 2008), acting out scenarios (Muller, 2003) are a few examples.

Rau, Neyer, & 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 pragmatic boundaries encompass “anticipate interests”, “reframe interests”, and “negotiate interests” (table 2.10).

Table 2.10

Knowledge boundaries, boundary-crossing mechanisms, and innovation practices [Adopted from Rau, Neyer, & Möslein, 2012].

Knowledge boundary	Boundary-crossing mechanisms	Examples of innovation practices (methods, tools, strategies, concepts)
Semantic boundaries	Rely on a joint structure	Narrative structure: joint transformation of stories, scenarios, cognitive walkthroughs, narrative vignettes, transfer of personal representations, metaphors, written/action logs. Abstract structure: collaborative analysis of requirements and design (CARD), creating folksonomies, diagrams, prototyping, mindmaps, sketches/pictures/drawings
	Engage a translator	Explanation-based: ethnographer, an intermediary to complement transfer of visual representations and persona descriptions Visualisation-based: brainstorming with graphic facilitator; comicboarding, visualising ethnographers
	Learn and adapt the counterparts' language	Apprenticeship, contextual inquiry, enhanced ethnography, diaries, participant observation, real-world ethnographic enactments, protoyping
	Develop a mutually understood language	Solely discussions: activity analysis and development, feedback on stories, discussions, ideation, a co-creation platform, scenarios, protyping, real-world simulations Amendment of representation: scenarios, CARETTA, NiCE Discussion room, collaborative prototyping, multi-user CAD, collaborative wikis, metaphors, future labs, sketches, stories, user games, technology games
Pragmatic boundaries	Anticipate interests	Counter-parts provide cues: Activity analysis and development (ActAD), customer job mapping, interviews based on cultural probes, repository grid technique (RGT), uncovering untold stories, written/actions logs Actors extract cues based on observations: contextual inquiry, enhanced ethnography, environmental analysis, prototyping Actors collect cues while being put in the counterparts' situation: apprenticeship, experience prototyping, participant observation
	Reframe interests	Challenge assumptions: scenarios, prototyping, pastiche scenarios, apprenticeship, ethnography, participant observation Internalise vs. shared vision: metaphors, joint transformation of stories, telling narrative vignettes
	Negotiate interests	Scenarios, CARETTA, prototyping, wikis, multi-user CAD, designers' outpost, discussions based on visualisations of offerings, diagrams, video, future labs, scenario-based prototyping

The mechanism "rely on a joint structure" anticipates the sharing of knowledge through verbal descriptions or representations, e.g., diagrams, prototypes, mindmaps encoded in the pre-defined elements of the joint structure. Consequently, individual interpretations become irrelevant. However, it is essential that all actors involved in the process of knowledge sharing have the same understanding of the structure's elements; otherwise, interpretative disparities go unnoticed. Moreover, in innovation projects it might be challenging to select

a structure capable of reflecting the knowledge because it may be difficult to describe the nature of the knowledge to be conveyed from the outset. Lastly, the structure itself can have an impact on which knowledge is shared.

"Engage a translator" is a mechanism that involves a third party who acts as an intermediary, getting information from one actor, translating it, and giving it to the other actor. This is done by changing or adding to the way the knowledge is provided, such as through explanations and visuals. The weakness of this mechanism is that translators may act as filters in the knowledge transfer process, and understanding alignment is only possible through the intermediary.

The boundary crossing mechanism "learn and adapt the counterparts' language" provides the involved parties with the ability to understand and share their knowledge in the language of their counterparts. This mechanism allows actors to learn about their counterparts' mental models as they observe their behavior and gain access to contextual information, thus arising understanding of the counterparts' perspective. One problem with this mechanism is that it does not work well when actors and counterparts with very different ways of seeing the world meet. If actors cannot understand how their counterparts act and how they interpret the situation, they cannot learn their counterparts' language.

The mechanism "create a mutually understood language" anticipates the sharing of knowledge through representations, such as prototypes, which are jointly discussed and modified. Contrary to the "rely on a shared structure" mechanism, this process does not require shared understanding of the representation. Instead, the communication process and the development of a new shared language occur in stages — actors construct their knowledge, validate it with their counterparts' understanding, and therefore establish a common ground. The drawback of this mechanism manifests when the collectively defined representation becomes a cognitive trap and actors stop seeking other alternatives, as well as when they lack the incentive and empowerment to modify their representations (Rau, Neyer, & Möslein, 2012).

Practices for crossing knowledge boundaries in KIBS innovation process

As a part of the online survey of enterprises conducted in 2022, 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. In the following analysis, only responses from respondents working in KIBS are considered. The provided answers were studied with the help of conceptual content analysis, which identifies the presence and frequency of concepts in a text. The main goal is to look at the frequency of occurrence of certain terms in the data. The analysis level used - word, word sense, and phrase. Through the coding process, the categories were created, and the coding was done for concept frequency.

The first three questions explored KIBS practices used to cross syntactic, semantic, and pragmatic boundaries derived from Carlile (2002) and Rau, Moslein, Neyer (2016).

KIBS practices for crossing syntactic knowledge boundary

The syntactic knowledge boundary is manifested by differences in how language and lexicon are used. Although individuals working in cross-disciplinary contexts recognize and respect their differences, and they are also aware when their performance is dependent on the contributions of others (Edmondson & Harvey, 2018), language difficulties and the inability to develop a common lexicon are still prevalent in the KIBS innovation process. This boundary makes accurate communication difficult and impedes successful innovation development. The table 2.11 summarizes the practices used by KIBS to develop a common lexicon / terminology in cross-disciplinary innovation teams.

Table 2.11

Syntactic knowledge boundary crossing practices in KIBS [Created by the author based on the online survey results].

Boundary crossing practice	**Description**	**Examples**	**Frequency**
Documentation	Written materials which provide proof or evidence of something, or are a record of something	"a shared, regularly updated document with the list of the key terms of the current innovation project", "a joint glossary", "terminology register", "document on GIT", "factsheets", "protocols", "ppt, video and audio files", "a terminology handbook", "manual", "guidelines", "terminology dictionary", "CRM tool", "project documentation"	43
Use of standardized, industry accepted terminology	Use of terminology that is regarded as a standard in the relevant domain or industry, or derives from legislation	"formal languages like BPMN2 is used", "we use domain-driven design (IT project) and ubiquitous language", "industry well-known terms", "adapt to most commonly used and most widely accepted terminology", "terms from the dedicated legislation", "terms form international standards"	29
Alignment sessions	Sessions organised to ensure all team members have the same understanding of the project and language used, and to reach agreement	"personal meetings of the team, asking questions, agreeing", "regular synchronisation meetings", "Q&A sessions", "sessions devoted to unpacking of complex terms", "conversations, presentations, discussions", "involving all sectors in the joint planning of the innovation process and by organizing joint meetings of the parties involved"	26

Table 2.11 (continued)

Boundary crossing practice	Description	Examples	Frequency
Working meetings	Meetings for innovation projects in which terminology issues are also discussed	"personal meetings of the team", "through regular meetings", "agreement usually happens during meetings", "organizing common meetings to establish the terminology and documenting them",	21
In no way	No activities are undertaken by a company to develop a common lexicon and terminology"	"no any system solutions in this regard", "in fact, it never happened in a consolidated way", "in no way"	11
Involvement of translators	Involvement of industry experts or professional translators	"special consultants that know exactly about the topic and related language", "linguists who help with translation of terms from foreign languages to Latvian"	9
Creating open and encouraging atmosphere	Development of team culture that encourages asking questions, and discussing issues openly	"by encouraging the members speak up if any of terms seem unclear", "working together, being positive (e.g., using jokes) helps to develop a common lexicon and strength cooperation.	9
Ad-hoc approach	Addressing language related boundary only when needed, for specific situation when they occur	"usually reacting to certain issues as they appear, no project charters being developed so far", "by learning by doing"	8

Based on the content analysis, we can say that one of the most common way the syntactic boundary is crossed during the innovation process is through documentation and organization of different sorts of meetings where the project team and stakeholders may talk, ask questions, and obtain answers. Documentation can be regarded as a beneficial syntactic boundary crossing practice as knowledge is encoded, made explicit, and available for retrieval whenever it is needed. In the opinion of the author, problems that are well-known in the industry or that reside in a distinct part of the industry may be better addressed by use of the standardized, industry-accepted vocabulary. However, a team culture that promotes questioning and addressing different concerns openly may be more helpful than any one approach in the development of radical, disruptive, or breakthrough innovation. In spite of this, it is still essential for any innovation project to have a system in place for recording and storing relevant information.

KIBS practices for crossing semantic knowledge boundary

As discussed before, the semantic knowledge boundary appears when different interpretations of knowledge occur despite the presence of a common lexicon or syntax. Individuals from different fields of expertise and specialties, for example, interpret and understand the same term differently or struggle to explain the meaning of terms to others. According to Edmondson and Harvey (2018), the semantic boundary necessitates the development of common meanings through the shared mutual involvement of the innovation team members in the problems at hand. The semantic boundary has to be managed throughout the innovation project life cycle. Smith (2016) concludes that having crossed the semantic boundary once does not mean that semantic boundaries will no longer be present in the project. When new topics or terminology are introduced, they reappear. In fact, the semantic boundary is never clearly crossed. Rather, as the project's knowledge evolves, new interpretations emerge on a regular basis.

In the survey, the respondents were asked to answer the question "In what ways, if any, does your organization usually secure knowledge translation (e.g., translation of terms used by biologists to economists) and common meaning development in multi-disciplinary innovation teams?" The table 2.12 summarizes the practices mentioned by the respondents.

Table 2.12

Semantic knowledge boundary crossing practices in KIBS [Created by the author based on the online survey results].

Boundary crossing practice	**Description**	**Examples**	**Frequency**
Working meetings	Events in which people gather to discuss one or more topics, most often in a formal or business setting	"common meetings", "by meetings", "through regular meetings", "meetings and taking notes", "through joint meetings"	27
Documentation	Written materials which provide proof or evidence of something, or are a record of something	"listing common terminology and using them in all developed materials", "preparing written protocols of actions", "library of terminology", "keeping knowledge base document on git", "internal documentation usually is created to fix all the things/definitions etc."	27
In no way	No activities are undertaken by a company to secure knowledge translation and development of common meaning	"not any systematic approach in use", "no specific way", "don't think we do that", "have not observed any activity", "knowledge translation is not done on purpose"	22

Table 2.12 (continued)

Boundary crossing practice	Description	Examples	Frequency
Alignment sessions	Sessions organised to ensure all team members have the same understanding of the project, concepts, and terms	"through the organization of specific meetings to explain and clarify the adopted terminologies", "by asking team members to explain knowledge, justify approach proposed or to be taken, and asking reflections and feedback in order to understand if common sense has been created and achieved"	21
Engagement of experienced professionals and experts	Involvement of highly professional team members who are domain experts and skilled in collaborative communication	"by involvement of outstanding experienced professionals", "through work with individual experts", "experts with deep knowledge in the sector/ industry"	17
Tools and approaches	Use of techniques and tools which facilitate the development of common meaning	"activities like event storming (IT projects)", "the SECI process", "artificial intelligence tools", "using Cofluence"	16
Engagement of translators	Engagement of professional translators who assist with knowledge translation and the development of common meaning	"our common practice is to hire translators with a background or experience in the field", "interpreters with deep knowledge in the field", "technology transfer experts acting as translators on daily basis"	16
Environment of continuous learning, self-assessment, and control	Development of environment that encourages asking questions, explaining opinions, and discussing issues openly	"project manager usually controls the use of correct terminology", "at least two iteration cycles help to manifest a general knowledge about the terminology. We apply a self-learning and self-assessment approach before engaging in groups and with a wider community"	16
Engagement of moderators	Engagement of professional innovation process moderators	"we engage a moderator of the team, which also includes translation between parties when needed", "moderation of common meetings", "teams and events led by moderators who have the task of building bridges between the different stakeholders and partners"	15

The content analysis reveals that KIBS apply many of the same practices for crossing the semantic boundary as those identified by Rau, Neyer, & Möslein (2012) (table 2.10). Individual interpretations and misunderstandings are reduced by knowledge coding in the form of various types of documents as well as verbal descriptions in regularly held team meetings, discussions and alignment sessions. Surprisingly, the third most frequently given answer was that companies did not use any practices for spanning semantic boundaries.

This could mean that some of the respondents were either unaware of the existence of such a boundary, or that they address issues as they arise, without any consistent practices.

One of the ways how KIBS span the semantic barriers in the innovation process is by involving specialists with extensive experience and deep expertise in the field or industry where innovation is sought. However, expertise can be an asset if it is combined with excellent collaborative communication skills that allow for the sharing of resources, knowledge, insights, and learning in order to reach a consensus. In the lack of such capacities, engagement of innovation process moderators can be of help.

According to some respondents, the semantic boundary is crossed by the development of a team culture that is based on trust and encourages learning, asking questions, explaining opinions, and openly discussing issues. This practice is critical because the semantic boundary tends to reappear at various stages of the innovation project.

Finally, few responders offered particular approaches or tools for eliminating the semantic barrier, for example, event storming, using Cofluence, artificial intelligence tools, and the SECI process. This may be due to the prevalence of more traditional means of communication, such as regular team meetings, as daily tools for addressing difficulties and fostering a shared understanding.

KIBS practices for crossing pragmatic knowledge boundary

The pragmatic knowledge boundary refers to circumstances in which the interests of several individuals involved in the innovation process are at odds with one another, but the dependencies between them are still present. When competing interests exist, the knowledge developed in one domain has negative effects on another. Here, the costs for each actor include not only the expenses of acquiring new knowledge, but also the costs of changing "existing" knowledge into "new" one (i.e., common and domain-specific knowledge). These costs have a detrimental impact on an actor's desire to make such modifications, which helps explain the path-dependent nature of their knowledge despite the existence of novelty (Carlile, 2004).

Boundary spanning objects such as drawings, prototypes and practices such as apprenticeship, participant observation, ethnography, scenarios, metaphors are applied and have demonstrated their effectiveness for crossing pragmatic knowledge boundaries in the innovation process (Rau, Neyer, & Möslein, 2012).

In the survey conducted by the author, the respondents were asked to answer two questions regarding the practices for pragmatic boundary crossing. Firstly, “In what ways, if any, does your organization usually build common interests in multi-disciplinary innovation team?”. Secondly, “In what ways, if any, does your organization usually secure open knowledge sharing among specialists from different fields of expertise and specialities?” The tables 2.13 and 2.14 summarize the practices used by KIBS to cross the pragmatic boundary.

One of the basic mechanisms for crossing pragmatic knowledge boundaries is the development of common interests among the individuals and organizations involved in the innovation process. Findings from the KIBS survey indicate that sessions designed to

identify and align the interests of the innovation team members, as well as working meetings within which the interests of the relevant parties are discussed, communicated, and explained are the most commonly mentioned practices how this mechanism is implemented.

The goal of innovation is to fill a gap, solve an unsolved problem, or improve an inadequate solution. Thus, effective innovation necessitates a thorough understanding of customer needs as well as defining the value that the innovative solution will provide. According to the survey results, determining the purpose and potential impact of the innovation project aids in the development of common interests among the members of the innovation team. The KIBS companies apply a variety of tools and approaches to build common interests in the innovation team, for example, hackathons, brainstorming sessions, design thinking, co-creation, co-designing, and others.

Careful selection of team members and project partners is another approach how KIBS companies ensure that team members share common interests throughout the innovation process. If the project managers have the option to choose and decide who will be on the innovation project team, the author believes that this is a favourable circumstance that should be taken advantage of. In actuality, the members of the project teams are frequently cobbled together from the various resources that are available at a given point in time.

Table 2.13

Practices to build common interests in KIBS [Created by the author based on the online survey results].

Boundary crossing practice	**Description**	**Examples**	**Frequency**
Interest alignment sessions	Sessions aimed at identifying and aligning interests of the innovation team members	"Firstly, interests are discovered as complete as possible. Then comes moderated process of putting interests together, sometimes compromising", "by identifying different needs and interests, and then seeking for a common ground", "by clarifying the interests of all involved parties and trying to find a shared meaning of the project"	27
Defining project value and impact	The process of discovering the innovation project value, customer needs, and the impact to be made	"View from customer point, wear customer shoes. What gives value for our customer", "Building common interests only based on market or customer need", "clear goal and end value", "by clearly illustrating the impact of the project"	21
Working meetings	Events in which people gather to discuss one or more topics, most often in a formal or business setting	"joint meetings to discuss interests", "project progress meetings", "by meetings and common events", "by common meetings, by meetings 1-to-1 person", "during some operational meetings"	18

Table 2.13 (continued)

Boundary crossing practice	Description	Examples	Frequency
Methods and approaches	Tools and approaches for building common interests among the involved parties	"benchmarking", "agile tools", "brainstorming", "organising hackathons", "Working with standard settings following the ISEAL Standard-Setting Code of Good Practice Version 6.0", "design thinking"	18
Considerate recruitment of team members	Careful recruitment of the innovation team members	"careful selection of team members (organisations and individuals)", "bringing together people with similar interest (even though they would work in different sectors)"	17
In no way	No activities are undertaken by a company to build common interests in the innovation team	"currently we are not building common interested besides obtaining technical advancements while operating in a company culture/values", "not in any special way, the common interest is to finish the project successfully", "none"	13
Team building	Activities to enhance team bonding and social relations within the innovation team	"by organising parties", "team-building activities", "by common team-building events"	12
Explaining and communication	The process of explaining and communicating the project goal and expectations towards every individual and the innovation team	"spending enough time to explain in depth joint and individual targets, roles and benefits", "by communication across the company", "Project goals are set and discussed. Everyone will be explained what is expected from them"	9
Developing supportive environment	Activities aimed at building environment characterised by relationships of trust, respect, and openness	"stimulating active participation and creating an environment of serene sharing", "by creating environment where people feel safe and trust each other", "developing supportive environment"	7
Team members training	Training of the innovation team members	"courses, workshops conferences", "by training of team members"	6
Leading by example	Activities undertaken by team leaders	"leading by example", If the leader does understand, people feel more motivated to work on a common goal, not considering it as a chore".	4

Thirteen respondents stated that their organizations lacked practices for spanning the pragmatic boundary. As previously discussed, this could indicate that the respondents were either unaware of the existence of such a boundary, or that they deal with issues as they arise, with no consistent practices. A few responses highlighted the development of common interests among the members of the innovation team through the creation of a

supportive environment in which the staff felt safe and could trust one another, as well as staff training courses, workshops, and conferences. Though only mentioned twice, leading by example is also used to dissolve pragmatic knowledge boundaries in order to build common interests.

Open knowledge sharing among specialists from different fields of expertise and specialities is another mechanism how the pragmatic knowledge boundary is spanned. The table 2.14. summarizes the practices of KIBS in this area.

Table 2.14

Practices to secure open knowledge sharing in KIBS [Created by the author based on the online survey results].

Boundary crossing practice	**Description**	**Examples**	**Frequency**
Events	Different types of events aimed at open knowledge sharing	"mainly by joint events: planning, internal educational events. Sometimes specific B2B meetings/events of experts of two-three fields", "we organize weekly seminars where experts share their knowledge with other", "workshops, meetings"; "regular meetings and exchanges"	30
Documentation	Written materials which provide proof or evidence of something, or are a record of something	"agreements and protocols", "non-disclosure agreements', "by legal means, e.g. consortium agreements", "publications", "open-access publications"	26
Methods and approaches	Methods and approaches facilitating open knowledge sharing	"brainstorming sessions", "369 idea sharing method", "some parts of the Design Thinking method", "discussion groups", "establishing communities of practice", "learning circles"	24
Digital tools	Digital tools for open knowledge sharing	"idea sharing and improvement board in Mural", "git repository", "shared cloud storage", "cloud-based solutions", "using only public channels in slack, documenting everything in Atlassian or Notion", "project information management system"	24
Developing supportive environment	Activities aimed at building environment characterised by relationships of trust, respect, and openness	"we have an open-door policy where anyone can approach anyone and discuss their work", "establishing mutual values, including openness", "we try to encourage culture where everyone can express their views, opinion and not to condemn anyone", "by open, collaborative, inclusive organisational culture"	23

Table 2.14 (continued)

Boundary crossing practice	Description	Examples	Frequency
In no way	No activities are undertaken by a company to build common interests in the innovation team	"if we mean an open knowledge it is usually not secured in any way", "we don't have any specific procedure for this", "there are no special ways"	21
External experts	Engagement of external experts	"from external sources, by investing in external speakers and assigning a space and time for guest speaker events", "by cooperating and networking with external experts", "engagement of external specialists"	13
Multi-stakeholder communication	Engagement of stakeholders	"building partnership from industry, academia, and government", "using multi-stakeholder approaches"	9

According to the survey results, the most frequently mentioned practice to foster open knowledge sharing in the innovation process is various types of events, such as workshops, seminars, and cross-disciplinary meetings. It is followed by documentation, which entails the creation of various types of documents, such as agreements, protocols, and publications, in order to make knowledge explicit, protected, and shareable.

Open knowledge sharing in the innovation process is also facilitated by various methods and approaches. Respondents mentioned lateral thinking techniques such as unstructured brainstorming and the 3-6-9 technique, as well as elements of the Design Thinking method, discussion groups, communities of practice, and learning circles.

Many online collaboration, co-working, and communication solutions have been developed and adopted rapidly since the COVID-19 pandemics. As a result, it should come as no surprise that KIBS use a wide variety of digital tools, such as Mural, a Git repository, shared-cloud storage, Slack, Atlassian, and Notion, to enhance open knowledge exchange.

Open knowledge sharing is possible if project participants feel safe, motivated, and trusting of one another. The importance of creating a supportive environment was mentioned twenty-three times, emphasizing that the environment must be based on mutual values and inclusiveness and encourage open opinion expressions and discussions without judgments.

Respondents also mentioned engaging external experts and using a multi-stakeholder approach as open knowledge sharing practices.

Tools and approaches for effective knowledge transfer

As the last question in the survey, the respondents were asked to name tools and approaches their organisations use to secure effective knowledge transfer. It is worth to remind that effectiveness component of the knowledge transfer concept refers to both the knowledge transfer outputs and their effects on individual organizations. The table 2.15 summarizes the knowledge transfer practices of KIBS which respondents regard as effective ones.

Table 2.15

Tools and approaches for effective knowledge transfer in KIBS [Created by the author based on the online survey results].

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, the 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

Table 2.15 (continued)

Knowledge transfer tools and approaches	Description	Examples	Frequency
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
Creative thinking techniques	Approaches that take a novel look at a problem while still applying rigorous analysis and careful planning	"brain storming"; "idea board"; "analogy cards"; "5-Why", "Round Robin", "seeking alternatives", "lateral thinking techniques"	16
Supportive environment	Activities aimed at building environment characterised by relationships of trust, mutual respect, and openness	"Creating 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 transfer it digital. A leader, who makes others leading 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 to make the vision and perspectives tangible", "setting up a product development committee", "establishing clear roles and responsibilities in the innovation team"	9

Based on a content analysis of the responses collected, it was determined that the most frequently mentioned practice for effective knowledge transfer was the use of digital tools in the form of various software, programs, applications, platforms, and online or offline resources. The listed digital tools are used for bilateral or team communication including video meetings, chats, webinars, and as collaboration platforms for co-working, co-creation, and project management, and as shared document repositories. This finding comes as no surprise given that the Covid-19 pandemic accelerated digital transformation of companies and technology adoption by several years. As the trend toward flexible work patterns and

online collaboration strengthens its positions, it is safe to assume that all forms of digital technologies will continue to play a significant role in company operations, business decision making, and connection with partners and customers.

According to the survey results, meetings are the second most commonly reported method firms use to promote effective information transfer. This includes face-to-face and online meetings, bi- and multi-lateral meetings, one-time and recurring meetings, and meetings with diverse purposes such as reporting, progress monitoring, informing, and others.

The third type of frequently stated practices for effective knowledge transfer is the use of a variety of approaches. The respondents cited such practice-oriented approaches as Design Thinking, Agile methodology, PDCA cycle, design sprints, lean management, prototyping, and co-creation, as well as tools and concepts including the technology road map, the concept map, and technological readiness level (TRL).

The fourth most frequently mentioned practice for effective knowledge sharing is the use of written materials that provide proof or evidence of something or are a record of something. Reports, guidelines, process descriptions, and protocols are among the documents mentioned.

Aside from various types of meetings, respondents mention events as another method of knowledge transfer. According to the responses, those are moderated events where people gather to spark group creativity, co-create, and co-work. Event storming, hackathons, co-working workshops, team-building events, goal-oriented project planning workshops, and other events are examples.

In addition to use of different methodological approaches as knowledge transfer practices, the respondents have highlighted creative or lateral thinking techniques such as brainstorming, idea board, analogy cards, 5-why, seeking alternatives. Those are tools that help taking a novel look at a problem while adhering to a rigorous and structured thinking process.

The last two practices identified in the content analysis are related to the environment and organizational structure in which effective knowledge transfer can happen. That involves, firstly, activities aimed at building environment characterised by relationships of trust, mutual respect, and openness. Secondly, creating a structure of the team which determines the distribution of different roles, responsibilities, and hierarchy of authority within the team.

Overall, because the majority of respondents provided multiple responses, 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.

In the second part of the doctoral thesis, the author explored the concept of knowledge transfer and how it takes place in the innovation process, and identified different practices, tools, and approaches KIBS utilise to span knowledge transfer boundaries in the cross-

disciplinary innovation development process. These tasks were completed with the help of narrative literature review and the analysis of the responses obtained in the frame of the online survey of KIBS companies. The second part of the thesis leads us to the conclusion that:

1. the majority of KIBS companies polled by the author innovate for a variety of customers outside their organization. Most innovations are generated in multi-disciplinary and multi-organizational teams which necessitates collaboration with different experts and companies, requiring knowledge from various disciplines and specialities.
2. Because the information and knowledge required for innovation comes from different sources, cooperation partners and network relations, 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 higher levels of innovation to be achieved in the innovation project, a wider 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, 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 collaborate. Despite this, the results of the survey 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 will propose a practice-based methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process.

Although the term "methodological framework" does not have a single, widely accepted definition, McMeekin, Wu, Germeni, & Briggs (2020) define it as "…a structured guide to completing a process or procedure" (p.1). In other word, **the methodological framework provides structured practical assistance or an instrument to lead the user through a process, employing phases or a step-by-step approach**.

The scoping review conducted by McMeekin, Wu, Germeni, & Briggs (2020) revealed that methodological frameworks are developed using eight different approaches (table 2.16). McMeekin, Wu, Germeni, & Briggs (2020) conclude that the development of methodological frameworks consists of three generic phases: 1. Identifying evidence to inform methodological framework; 2. Developing the methodological framework; 3. Evaluate and refine.

The author of this 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). IES, founded in 2008, has grown into a multidisciplinary international team of scientists, researchers, and practitioners who develop innovative solutions for sustainable natural resource management. Highly educated specialists with backgrounds in physics, chemistry, agronomy, biology, forest management, computer programming, public administration, entrepreneurship, and innovation management comprise the team. As CEO, the author oversaw cross-disciplinary research and innovation projects, used a multi-stakeholder approach in the 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.

Table 2.16

Approaches used for the development of methodological frameworks [Adopted from McMeekin, Wu, Germeni, & Briggs, 2020].

Approach	**Methods used**
Based on existing methods and guidelines	Adapting the methods; integrating methods; building on the existing methods; based on the framework; combined well established guidelines which comprised the same stages; the framework as basic inspiration
Refined and validated	Piloting the framework; trialling identified stages and using the results of the trial to further develop the framework; using a case study or Delphi panel to evaluate and refine the framework; using a case study to validate the framework; testing the framework
Experience and expertise	Using experience from different levels: personal, school/university, country level, authors' experience; the experience of experts in the field of the methodological framework. Methods used to extract experience: surveys, interviews, and focus groups
Literature review	Purposeful sampling; literature review. Sources used: databases, dissertation, library catalogue, key author, databases websites and citations
Data synthesis and amalgamation	Identifying phases, themes, and dimensions; analysing and grouping or categorizing themes; thematic analysis
Data extraction	Extracting data from interviews and focus groups using transcribing methods; extracting key information from published literature
Iteratively developed	The framework evolved and developed as items were extracted, synthesised and revised
Lab work results	The results of lab tests are used to inform the framework

The third part of the doctoral thesis introduced the process of the development of the methodological framework for spanning knowledge transfer boundaries during the cross-disciplinary innovation creation, the key elements and the matrix of the methodological framework, and the results of the pilot testing.

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

3.1. Research design, process, and methods employed

This research study has been conducted in the spirit of postmodernism paradigm to research. The postmodernist viewpoint is that there is no objective natural reality, one whose existence and properties are logically independent of human beings—of their minds, societies, social practices, or investigative techniques (Duignan, 2023). Instead of relying on one approach of knowing, postmodernists support a diversity of perspectives, meaning, methods, and values. They believe that there are multiple ways of knowing. Consequently, there are multiple truths (Wilson, 1997). Postmodernism gives weight to multiple meanings rather than the expert researcher's single, authoritative voice. As researchers, we contribute to the development of a "working understanding" of reality and life, and the conclusions we reach are partly autobiographical: they reflect our "personal narrative," our unique "site and voice" in the world. The knowledge thus constructed is more concerned with probability than with certainty. It is constantly changing as each individual or group interprets it differently, reflecting different needs and experiences (Intgrty, 2016).

The goal of the doctoral thesis is to develop the methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process (hereinafter – Methodological Framework). Figure 3.1. depicts the research flow-chart containing tasks completed to reach the thesis goal. Six objectives must be attained to reach the goal as stated in the introduction of the thesis.

A variety of qualitative and quantitative research methods are used to achieve the objectives, including narrative literature review, statistical data analysis, online survey of enterprises, and pilot testing and evaluation of the methodological framework in the experimental innovation co-creation laboratory with participation of businesses, scientists, and representatives of governmental authority.

The collected data have been analysed using a variety of tools and methods, such as Publish and Perish, CiteSpace, R version 4.1.2 and MS Excel, and conceptual content analysis of qualitative (textual) data using NVivo software. Focus group discussion and semi-structured interviews with innovation co-creation laboratory participants were applied for structural evaluation of the author's developed methodological framework.

Multiple research strategies and concepts were applied to improve the author’s scientific judgements, data truthfulness and validity and reliability of the research components and results. The author used methodological triangulation to ensure the validity and reliability of research. In general, triangulation comprises multiple methods of data collection and analysis, but it does not impose a fixed method for all the researchers.

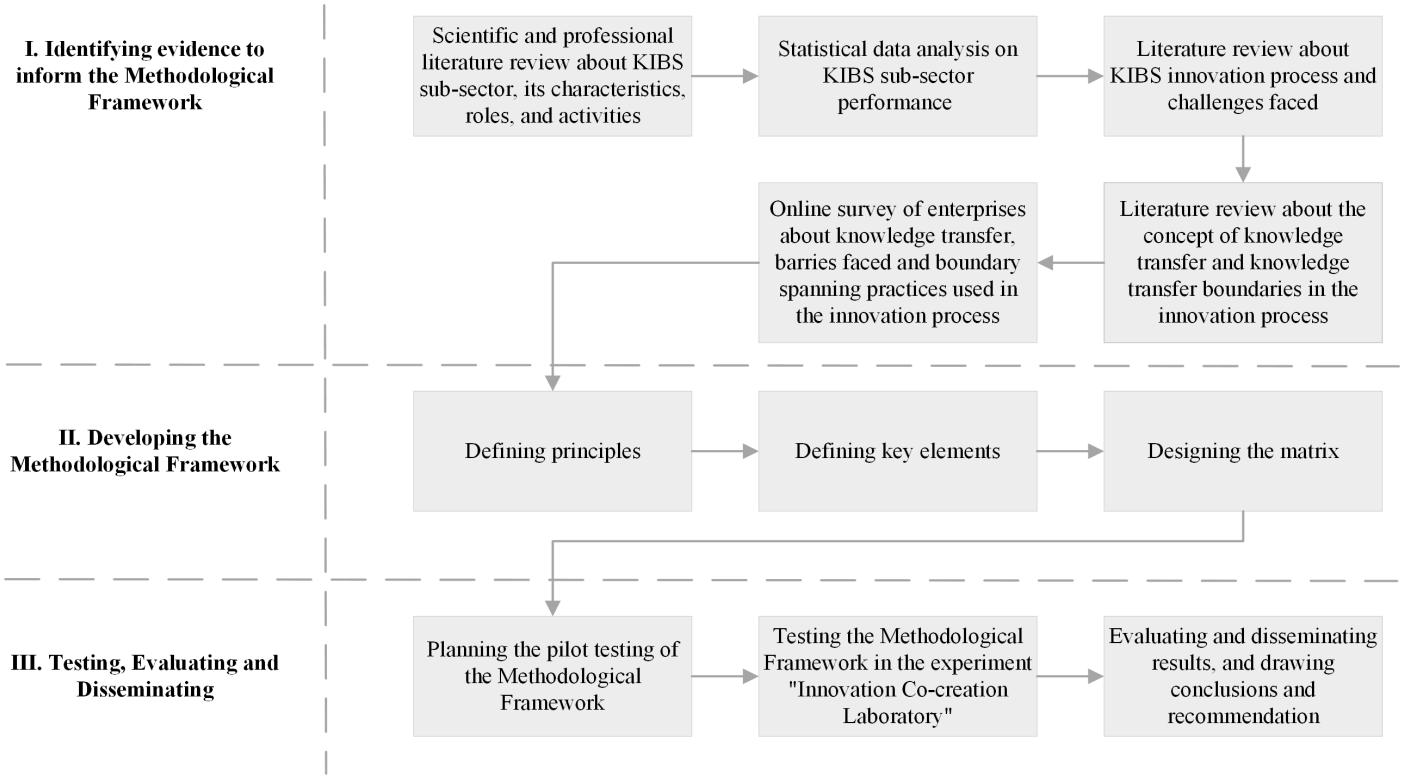


Fig. 3.1. Flowchart of tasks completed to reach the thesis goal [Created by the author].

Triangulation "…increases confidence in research data, creates innovative ways of understanding a phenomenon, revealing unique findings, challenging or integrating theories, and providing a clearer understanding of the problem" (Thurmond, 2001, p.254). Methodological triangulation occurs when qualitative and quantitative approaches are used in the same study. Blending of both approaches allows revealing unique differences or meaningful information that would have gone undetected if the study had only used one approach or data collection technique (Thurmond, 2001).

General Inductive Approach was used to design and test the methodological framework, whereas the deductive analysis was applied to validate the methodological framework, interpret the research results, and draw conclusions.

The author's research can be classified as dialectic pragmatism from the standpoint of knowledge epistemological orientation. It entails a dynamic back-and-forth listening to multiple perspectives and different theories (Ketner, 1995). As previously explained, the author conducted mixed research by carefully listening to ideas, assumptions, and approaches found in qualitative and quantitative research as well as any other relevant domain.

3.2. Structure of the methodological framework

As discussed in the section 1.1. of this thesis, providers of KIBS can have different ownership structures, they rely heavily on their employees' professional knowledge and provide primarily non-routine knowledge-intensive services to other organizations operating in various sectors and industries. In the frame of this study, it has been confirmed that KIBS companies generate innovative solutions either for themselves or customers outside their organizations by forming cross-disciplinary teams. Innovation development in cross-disciplinary environment requires knowledge transfer across different levels of expertise, disciplines, specialities, and organizational experiences. As a result, the innovation process becomes more difficult 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. Despite the fact that 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 on a regular basis. There are several reasons for that. First, managers of innovation projects and processes often are not aware of and trained to recognize the various 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 or not these practices are all 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 barriers that emerge, and the appropriate strategies to

overcome them. To address this challenge, the author has elaborated the methodological framework for spanning knowledge transfer boundaries in the process of cross-disciplinary innovation. The structure of the methodological framework is illustrated in Figure 3.2.

The methodological framework is grounded into the theoretical perspectives that underpin the concept of KIBS un knowledge transfer, and the author's own professional experience. It includes scientific works that investigate the knowledge-based view of the firm, 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 and Winter, 1982; Kogut & Zander, 1992). The innovation systems perspective which emphasis the role of KIBS 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 and 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 and Levinthal, 1990). This theory emphasises the importance of organizational learning, flexibility, and adaptability in facilitating knowledge transfer.

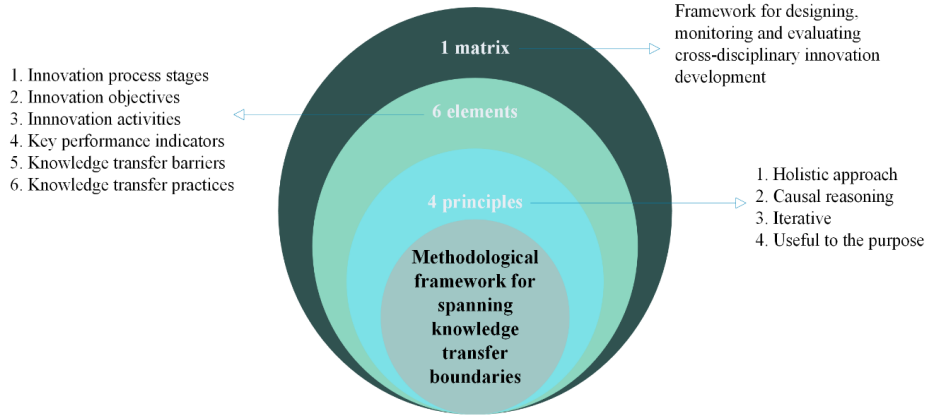


Fig. 3.2. Structure of the methodological framework [Created by the author].

The proposed methodological framework is grounded in four principles:

1. Holistic approach. The methodological framework is made up of 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 have an impact on another stage and process.

3. Iterative. The methodological framework aims to take an approach to innovation development 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 with respect to a purpose. The methodological framework shall be useful to cross-disciplinary innovation development managers in navigating the various types of knowledge transfer boundaries that may arise during the course of action.

The key elements of the methodological framework (Figure 3.3) are derived from the narrative literature review and the online survey of KIBS enterprises.

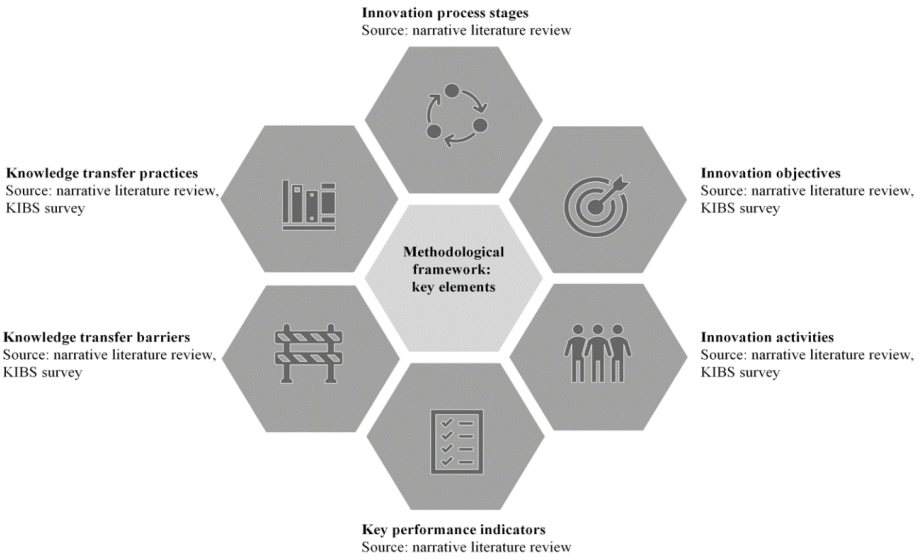


Fig. 3.3. Key elements of the methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process [Created by the author].

1. Innovation process stages. The innovation process typically involves several stages, which may vary 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 objectives, 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 innovation process step and give a framework for monitoring progress and outcomes. This allows teams to monitor

their progress, modify their strategy as necessary, and celebrate their achievements. Thirdly, 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. Fourthly, 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 both facilitated by the existence of 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 in terms of 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, as well as the monitoring of progress. By monitoring progress against certain activities, it is 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 the 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 groups of knowledge transfer related boundaries: 1. individual boundaries; 2. (inter)organizational boundaries; 3. boundaries related to scarce resources; 4. boundaries deriving from external environment; 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 span 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. Again, it is important to note that the utilization of certain

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

All six of the aforementioned components are interwoven and included into the matrix (Appendix 6). Both vertical and horizontal logic exist inside the matrix. The vertical logic shows a step-by-step guidance for cross-disciplinary innovation development implementation. Horizontal logic specifies how each innovation process step is implemented and monitored, as well as the diversity of approaches utilized to accomplish so. 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 the creation of 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 who is 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 innovation process.

3.3. Pilot-testing of the methodological framework

The methodological framework was tested in the experiment named "Innovation Co-creation Laboratory". Figure 3.4 illustrates an overview of pilot-testing.

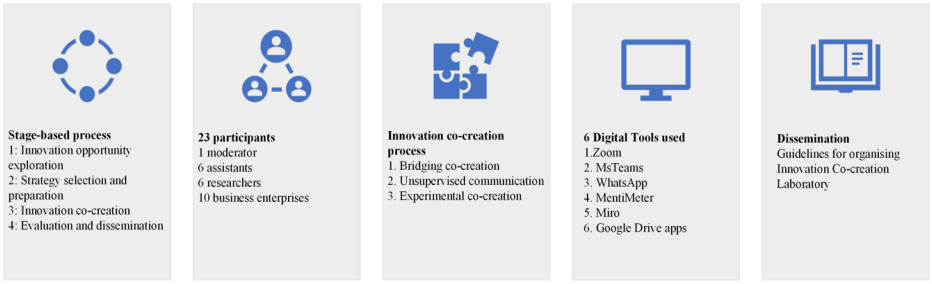


Fig. 3.4. Overview of the pilot test "Innovation Co-creation Laboratory" [Created by the author].

The pilot-test took place from May till December 2020 in four main stages: 1. Innovation opportunity exploration; 2. Strategy selection and preparation; 3. Innovation co-creation; 4. Evaluation and dissemination. In total, 23 individuals were involved in the pilot test representing government, research, and business entities. Innovation co-creation was selected as the overarching approach for the pilot-test; therefore, it was named "Innovation Co-creation Laboratory".

The innovation development 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 doctoral thesis wrote practically applicable guidelines for organising the innovation co-creation laboratory online. The material has been published in the Latvian and English languages and is available online.

Figure 3.5 depicts how the author's developed methodological framework 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 a purpose to encourage small and medium-sized enterprises operating in a smart specialisation area to open innovations and to collaborate with researchers. The pilot-test was designed and moderated by the thesis author and a team of assistants.

Innovation process stages	Innovation objectives	Innovation activities	Key performance indicators	Knowledge transfer practice
1. Innovation opportunity exploration	→ Identify opportunities for innovation related to the RIS3 implementation → Define the initial problem and its scope	→ Identify problems related to the implementation of the RIS3 → Select the RIS3 area and define the initial problem that the innovation aims to solve → Define the scope of the innovation project and the expected level of novelty of potential solutions → Select the knowlege transfer practice to tackle the challenge	→ A list of problems identified → The area of RIS3 identified → Clarity of the initially chosen problem and scope → The most suitable knowledge transfer practice selected	→ Outsourced research study → Problem root-cause analysis → Analysis of the best practices and approaches used for addressing the identified problem → Use of TRL to asess the novelty level of expected innovative solutions → Establish project management system and documentation → Develop documentation and depositories
2. Strategy selection and preparation	→ Define required knowledge domains → Identify and engage the participants and relevant stakeholders	→ Determining the type of knowledge required to develop the innovative solution → Announce the open application process for SMEs → Identify and invite researchers → Conduct exploratory interviews → Identify and engage stakeholders who are affected by the problem and who can contribute to the innovation solution → Sign the agreements	→ Knowledge domain coverage → Participant engagement score → Stakeholder engagement score → Diversity of the group of participants in terms of demographic and professional backgrounds	→ Knowledge domain mapping → Stakeholder mapping → Open call for participation → Semi-structured interviews → Formal documentation
	→ Prepare for the innovation development	→ Develop a detailed programme and scenario → Prepare information and material kits and deliver them to participants → Brief the participants → Engage assistants - moderators → Training of the assistants - moderators → Filling in the participants work-sheets	→ Timely delivery of material kits to participants → Number of briefed participants → Level of preparedness of assistants - moderators → Level of preparedness of the co-creation process → Rate of homework completion by participants	→ Selecting tools for online communication and information exchange → Selecting collaborative approaches and creative thinking techniques → High-quality and creative material kits to raise interest and motivation, and personal delivery

Fig. 3.5. Pilot-testing of the methodological framework in the experiment “Innovation Co-creation Laboratory” [Created by the author].

Innovation process stages	Innovation objectives	Innovation activities	Key performance indicators	Knowledge transfer practice
3. Innovation co-creation	Bridging co-creation → Build relationship between researchers and entrepreneurs → Get acquainted with the latest scientific insights, inventions and technological solutions → Gain a deeper understanding of the initially defined challenge → Set thematic challenges for further work	→ Getting to know one another → Analysing industry problems in greater depth → Defining researh and innovation challenges → Dividing the participants into teams → Assessing the bridging co-creation phase	→ Communication effectiveness: the level of engagement and participation, and quality of discussions → Misunderstanding rate → Co-creation process output (clearly defined prpblems for further work) → Satisfaction and turnover of the team members → Feedback of the team members	→ Creative thinking techniques → Problem analysis → Design thinking → Dialogue method → Feedback of the team members → Lectures and experience stories → Assessment questionnaire
	Unsupervised participants' communication → Give participants the opportunity to get to know each other better and to obtain more in-depth information → Ecourage participants to strengthen their mutual ties, thus laying the foundations for long-term cooperation between the entrepreneurs and the researchers	→ Independent communication among participants to obtain and discuss additional information related to the problem areas of group work, technical, social, environmental and economic aspects of potential solutions or other issues of interest to them	→ Number of bilateral or multi-lateral meetings conducted → Participants feedback on quality of meetings and future outlook	→ Online or face-to-face meetings → Organisational visits
	Experimental co-creation → Generate solutions, concepts and prototypes → Evaluate the possibilities for developing the solutions further	→ Developing and presenting innovative solutions → Assessing the potential for further development → Assessing the experimental co-creation phase	→ Communication effectiveness: the level of engagement and participation, and quality of co-working → Misunderstanding rate → Conflict resolutions → Co-creation process output → Participant satisfaction with the results achieved	→ Creative thinking techniques → Design thinking → Prototyping → Dialogue method → Feedback of the team members → Assessment questionnaire
4. Evaluation and dissemination	→ Get participants' feedback on the experiment, its efficiency and required improvements → Write and publish guidelines	→ Conduct structured interviews → Analyse interview results and draw conclusions → Write and disseminate guidelines	→ Participants' satisfaction → Rate of willingness to participate in co-creation in the future → No of downloads and reads of guidelines	→ Structured interviews → Focus group discussions → Publishing of guidelines
As you progress through the innovation co-creation process, trace hints for knowledge transfer boundaries, evaluate your progress and iterate on your knowledge transfer practices as needed				

Fig. 3.5. Pilot-testing of the methodological framework in the experiment “Innovation Co-creation Laboratory” (continued).

In the following section of the thesis, each phase of the pilot test is described in greater depth.

Stage 1: Innovation opportunity exploration

VPR identified the innovation opportunity upon which the pilot-test was based. VPR conducted the investigation on the barriers to development of smart specialisation SMEs in 2019. It is important to note that smart specialisation is a strategic, location-based economic development approach. It enables countries and regions to identify and cultivate their own competitive advantages and to generate knowledge-driven growth by capitalizing on their available assets and resources and addressing their unique socioeconomic challenges (EC, 2022). Lack of collaboration with national and international research institutions, as well as low adoption of research-based solutions, is one of the obstacles to the growth of small and medium-sized enterprises (SMEs) in smart specialization in Vidzeme Region. Consequently, SMEs, particularly those operating in less developed and sparsely populated regions without the presence of strong knowledge centres and networks, lack knowledge about the most recent scientific discoveries and developments, as well as opportunities to utilize them for their industry's needs and the development of innovation. (Vidzeme Planning Region, 2019). In this regard, VPR decided to conduct the experiment to facilitate communication between the research sector and SMEs. It would address the VPR's Smart Specialisation Area "Food and beverage production" and sustainable food packaging innovation issues, in particular. Co-creation was selected as the overarching approach for research-industry collaboration in innovation development based on an analysis of best practices used to address similar challenges in other countries; thus, the experiment was titled "Innovation Co-creation Laboratory." VPR initiated the co-creation process and was responsible for the selection of the regional smart specialisation area within which the co-creation took place, the engagement of participants (SMEs, researchers, and experts, as well as the co-creation process designer and moderator), and the overall coordination, moderation, and evaluation of the co-creation process. In this experiment, VPR acted as a knowledge intensive business service provider or KIBS.

Key performance indicators and values achieved in stage 1:

→ A list of problems identified – 1
→ The area of RIS3 identified – 1
→ Clarity of the initially chosen problem and scope – Yes, validated with food industry SMEs
→ The most suitable knowledge transfer practice selected – Yes, based on the analysis of the best practices utilised to address similar challenges in other countries.

Stage 2: Strategy selection and preparation

As stated previously, co-creation was selected as the primary innovation practice for the pilot-test. Co-creation is one of the methods for bridging the divide between industry and science, and it is particularly effective during the pre-competitive innovation phase (Haataja, et al., 2018). Pre-competitive innovation projects are a type of inter-organizational projects that are typically conducted during the exploration phase of research and development. In such initiatives, SMEs typically collaborate with researchers to conduct fundamental research or research and experimental development (Bertello, Ferraris, De Bernardi, & Bertoldi, 2021). Co-creation is defined as collaborative problem-solving that integrates consumer and supplier resources in an interactive process with the objective of producing the highest possible value. Customers provide resources such as information, business intelligence, and tools, whereas suppliers apply their specialized professional competence and judgment (Aarikka-Stenroos, Jaakkola, 2012). In the context of collaboration between universities, research institutions, and businesses, scientists and researchers are viewed as suppliers, while businesses are viewed as customers. During the co-creation process, entrepreneurs and scientists from various scientific disciplines collaborate to define and address industry-critical problems. The knowledge and skills of researchers are combined with the business expertise of entrepreneurs to create new value, such as innovations for new products, services, processes, technologies, etc.

Given the fact that the Innovation Co-creation Laboratory took place during the times of COVID and restrictions to meet in presence, six digital tools were used throughout the experiment: the Zoom, MsTeams and WhatsApp for communication, the Mentimeter for audience engagement during the innovation co-creation phase, the Miro for online collaboration among the researchers and entrepreneurs, and Google Drive and its apps. The Google Docs was used to prepare and edit various documents related to the experiment planning process, while the Google Forms app was used to create event assessment questionnaires and get feedback from participants.

Six researchers representing scientific disciplines pertinent to sustainable food packaging, such as material science, food technology, analytical chemistry, environmental science, health, and nutrition science, as well as seven SMEs involved in food production, two medium and large enterprises producing packaging materials, and the waste management company participated in the experiment. The food production SMEs participants in the experimental event were selected through an open application procedure. Entrepreneurs were selected based on the company's motivation, attitude, interest, and willingness to participate in the co-creation process, bearing in mind that the co-creation process focused on common challenges rather than company-specific issues. The list of selection criteria included the company's industry reputation.

Given the limited scientific expertise available in Latvia in the specified categories, personal contact was made with the researchers through the VPR and Riga Technical University cooperation networks. Researchers were selected based on the results of

knowledge domain mapping conducted by VPR and on their research's applicability to the industry's defined challenges, their complementary knowledge and skills, their motivation, attitude, interest in and willingness to engage in co-creation, and their professional reputation. After obtaining the application forms, individual exploratory interviews with each entrepreneur and researcher lasting for one hour were conducted via an online communication platform. In this way, the co-creation's organizers were able to gain a better understanding of the participants' expectations, get to know them, get a sense of their behaviour, and learn more about their prior experience and challenges in the defined field, as well as their knowledge and skills. This conversation is also an opportunity to provide an accurate assessment of each participant's role in the process so that both the entrepreneur and the researcher are aware of the resources they will need to invest such as knowledge, time, etc.

Following the round of exploratory interviews, two prospective participants - a business and a researcher, voluntarily withdrew from the process. The business was unable to contribute as much time to the co-creation, and the researcher refused to participate for free. Every participant signed an undertaking agreement. Its primary objective was to ensure the active participation of participants at all stages of the co-creation process, including providing feedback to the organizers in order to prepare guidelines and improve the future course of such co-creation laboratories, as well as compliance with the General Data Protection Regulation and the requirements for intellectual property rights.

Although the co-creation process is based on dialogue and the unrestricted flow of ideas, it must be structured and managed intelligently to ensure a productive, constructive process and result. To organize a successful innovation co-creation, each participant's roles and responsibilities must be explicitly defined. In this experiment, seven individuals moderated the process. Twenty individuals, including the event's moderator and assistants, were defined as participants in the experiment to determine the optimal coordination of an online event. Figure 3.6 depicts the complete list of innovation co-creation laboratory participants.

Fig. 3.6. Participants of the pilot-test “Innovation Co-creation Laboratory” [Created by the author].

A week before the bridging stage of the innovation co-creation, each participant received a packet containing a detailed description of the Innovation Co-creation Laboratory, the programme of the bridging phase and the preparatory worksheets, an energy drink recipe and a treat, and various promotional and useful items for the co-creation process. The provision of such materials demonstrates the thoughtfulness of the organizers and enables the participants to come to the co-creation prepared and with a positive attitude.

A few days prior to the bridging co-creation event, an online meeting was conducted during which participants had the opportunity to become acquainted with one another, receive a tutorial on how to use the digital tools, and try audio and video communications. Such a meeting is a very important precondition in order for all participants to feel secure and learn how to use the fundamental functions of the digital tools on the day of the co-creation event. Due to the fact that not all participants could attend, the meeting was recorded and made available for later review.

Given the cross-disciplinary and cross-sectoral nature of the group of experiment participants, prior to the innovation co-creation stage the moderator provided training for assistant moderators This involves discussing in detail and introducing the intended objectives of the group work, the event's flow, and the knowledge transfer practices being employed. As stressed many times throughout the thesis, for group work to be successful, there must be meticulous planning, trust in the group, continuous monitoring of group dynamics, and adaptability with regard to the process and the outcome. It is crucial that, during the preparatory phase, the innovation process moderator discusses with the assistants' essential aspects, such as group dynamics, communication, and conflict resolution strategies, and provides advice on how to handle various situations. The number of assistants – moderators can vary depending on the circumstances in which the co-creation process is conducted and the size of the group. As the Innovation Co-creation Laboratory experiment was carried out completely online and the participants worked in three breakout rooms in parallel, the number of assistants was larger.

Key performance indicators and values achieved in stage 2:

→ Knowledge domain coverage – 100%, based on self-assessment
→ Participant engagement score – 95%
→ Stakeholder engagement score – 100%
→ Diversity of the group of participants in terms of demographic and professional backgrounds – 100%
→ Timely delivery of material kits to participants - Yes
→ Number of briefed participants – 100%
→ Level of preparedness of assistants - moderators – 80%, based on self-assessment
→ Level of preparedness of the co-creation process – 90%, based on self-assessment
→ Rate of homework completion by participants – 50%

Stage 3: Innovation co-creation

The innovation co-creation stage consisted of three phases: 1. Bridging co-creation; 2. Unsupervised participants' communication; and 3. Experimental co-creation.

The bridging co-creation aimed to build relationship between researchers and entrepreneurs; to get acquainted with the latest scientific insights, inventions, and technological solutions of relevance for sustainable food packaging; to get a deeper understanding of the problems related to the development of sustainable food packaging; and to select problems for further innovation co-creation. The bridging co-creation lasted nearly an entire working day and was held online in the Zoom platform. Nevertheless, the agenda was planned similarly to that of a face-to-face event, including engaging ice-breaking activities and brief lectures, short breaks every 40 to 60 minutes encourage participants to move around and stretch. This phases also comprised work in smaller groups, thus creating a space for dialogue to develop. The participants were asked to turn on video cameras to ensure a sense of presence and letting the process moderators to be able to capture and respond to the participants' behaviour and emotions.

The bridging co-creation phase concluded with a more in-depth understanding of the industry problems and list of challenges to be addressed in the experimental co-creation (figure 3.7). The task of the moderator and group work assistants is to periodically remind the participants that the next phase of co-creation will be devoted to the search for solutions, as it is highly likely that they will attempt to think more about solutions during this phase.

Fig. 3.7. Problem areas defined in the field of sustainable food packaging as a result of the bridging co-creation [Created by the author].

Due to the unpredictability of the outcome of the bridging co-creation stage, it is highly probable that one of the participants will wish to withdraw or that additional specialists from the absent areas of expertise will be required. During this experiment, for instance, one packaging manufacturer and the waste management company were involved in the next phase of co-creation as it became clear that the participants would gain additional information which would be relevant when considering innovative solutions for sustainable food packaging. To facilitate the complete participation of each participant in the co-creation-process, four multi-disciplinary working groups of three to five individuals were formed, including the group moderator. That required the reduction of the number of problems to be addressed during the subsequent phase of the co-creation process. To maintain high motivation until the end of co-creation stage, the participates were allowed to choose their own problems. Using Google Forms, the organizers designed an online polling questionnaire in which experiment participants could rank their top three areas of focus. The organizers then divided the participants into distinct groups, taking into consideration the participants' ballots and their knowledge of each participant's professional experience and requirements. The bridging co-creation phase concluded with the immediate assessment based on the Mentimeter poll (figure 3.8) and Google Forms questionnaire.

Fig. 3.8. Participants' assessment of the bridging co-creation phase in the Latvian language [Mentimeter].

The second phase of the innovation co-creation stage was introduced during the planning stage of the Innovation Co-creation Laboratory. During the exploratory interviews, it became evident that entrepreneurs lacked knowledge of the research competences and infrastructure available in Latvia. Some business owners acknowledged that they did not know where to search for such information or how to get started. Consequently, the phase "unsupervised participants' communication" was incorporated. It took place between the bridging co-creation and experimental co-creation phases. The process was entirely voluntary, and according to the information available to the experiment organizers, both the

entrepreneurs and the researchers took advantage of the opportunity to establish or maintain relationships with their peers.

The "experimental co-creation" was the concluding phase of the innovation co-creation stage. It aimed to generate solutions – concepts and prototypes to the selected problems, and to evaluate the possibilities for developing these solutions further. As with the preceding phases, the experimental co-creation was conducted online through the Zoom platform, which limited opportunities to implement a rapid prototyping process using laboratory-scale equipment, prototyping materials and tools, and readily movable furniture. Instead, innovative solutions to the problems were created primarily at the level of descriptions or illustrations. The process of generating solutions to problems is incremental and structured, therefore, experimental stage of innovation co-creation was based on the key elements of the design thinking method. Due to the limited time and the online format, the participants in the experimental co-creation went through three stages of design thinking, namely, empathising, defining, and ideating.

Already after the bridging co-creation phase, it became clear that the problems selected would be very different, some connected with food products and manufacturing technologies, whereas others requiring the shift in public thinking and behaviour. Many of those problems were admitted being suitable for further development in the co-creation process. Therefore, at the end of the experimental co-creation phase the participants received information about the various locally and internationally available support instruments for further elaboration of innovative ideas, such as funding sources, innovation brokerage network, EIT Food programmes and the Latvian Food Bioeconomy Cluster. As before, the experimental co-creation concluded with the completion of detailed assessment questionnaire by mid-night of the same date.

Key performance indicators and values achieved in stage 3:

<u>Bridging co-creation</u>

→ Communication effectiveness: the level of engagement and participation, and quality of discussions – 95%, based on self-assessment and participants' feedback
→ Misunderstanding rate – not measured
→ Co-creation process output (clearly defined problems for further work) – 4 out of 10
→ Satisfaction and turnover of the team members – 95%, based on participants' feedback
→ Feedback of the team members – 100%, response rate to the questionnaire

<u>Unsupervised participants' communication</u>

→ Number of bilateral or multi-lateral meetings conducted – 5, as reported by participants
→ Participants feedback on quality of meetings and future outlook – 100% positive.

Experimental co-creation

→ Communication effectiveness: the level of engagement and participation, and quality of co-working – 65%, based on self-assessment and participants' feedback
→ Misunderstanding rate – not measured
→ Conflict resolutions – 100%, based on self-assessment
→ Co-creation process output: 1 tested approach for research-industry innovation co-creation, 4 concepts of innovative solutions for further development, 6 challenges available for further exploration.
→ Participant satisfaction with the results achieved – 68%, based on participants' feedback.

Knowledge transfer boundaries encountered during the pilot-testing and the boundaries spanning practices applied

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 (Appendix 7). 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.

Appendix 8 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.

Stage 4: Evaluation and dissemination

The logic underlying the evaluation of the author's proposed methodological framework was derived from the validation approach established by Pedersen, K., et al. (2000), figure 3.9.

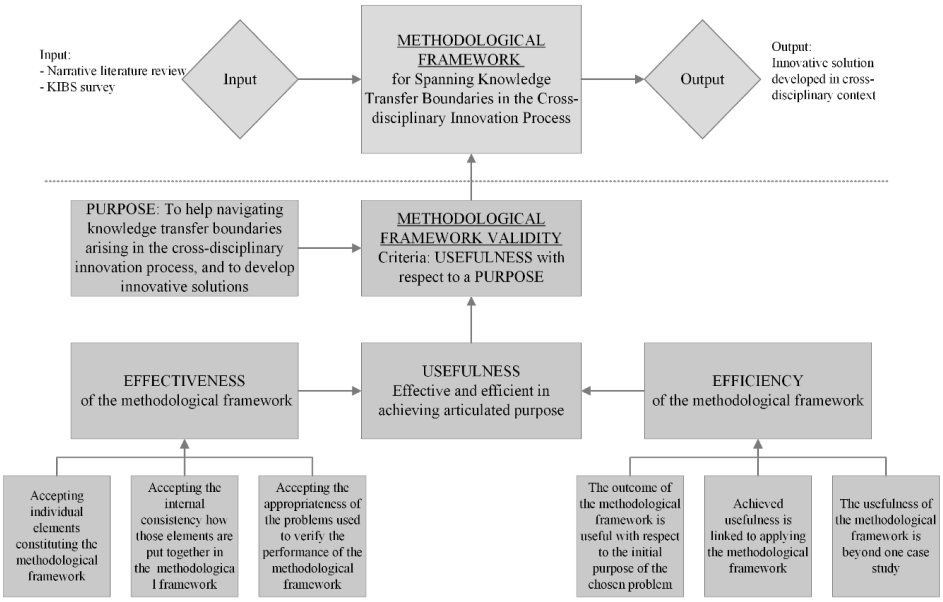


Fig. 3.9. Validation framework [Created by the author based on Pedersen, K., et al., 2000].

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, first, its effectiveness and second, its efficiency.

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

1. The individual elements constituting the methodological framework has to 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 with respect to the initial purpose of the chosen problem.
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. narrative literature review; 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 regional development management organisation representatives with a 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 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 was comprised of four Vidzeme Planning Region specialists, including the Head of 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 the implementation of the Innovation Co-creation Laboratory as trainers and moderators. The questions of the focus group discussion are given in Appendix 9.
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 of the researchers and entrepreneurs who participated in the experiment. To structure the conversation, interview questions were sent to the participants in advance (Appendix 10). As social distancing requirements remained in effect, the interviews were conducted online via the Zoom platform, and the average interview lasted 45 minutes. There was a total of 13 interviews conducted, including seven with SMEs and six with researchers. The answers of researchers and entrepreneurs were analysed with the help of content analysis and are summarized in the table 3.4.

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 narrative literature review, the online survey of KIBS companies and the author's professional experience in

managing cross-disciplinary innovation development processes. Second, as depicted in Figure 3.4, 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, as well as which knowledge transfer practices were utilized. Throughout the pilot-test appearing of various knowledge transfer boundaries was tracked. The focus group participants concluded that the methodological framework's elements are assembled in a logical and consistent manner.

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. The implementation of the Innovation Co-creation Laboratory experiment proved that the methodological framework serves as the effective tool for the management of cross-disciplinary innovation development project (table 3.1).

Table 3.1

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 an 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 of 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 is highly evaluated by the experiment participants (table 3.3). The third criterion for measuring the effectiveness of the proposed methodological framework was not met (table 3.2), because it has been tested only in one instance and in one country. More empirical tests are needed to prove its usefulness.

Table 3.2

Efficiency of the methodological framework [Created by the author].

Efficiency indicators	**Yes / No**
The outcome of the methodological framework is useful with respect to 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 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 various 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 spanning multiple boundaries.

Table 3.3

Evaluation of the Innovation Co-Creation Laboratory by companies and researchers [Created by the author].

Assessed aspects of the Innovation Co-creation Laboratory	**Participants**			
	Entrepreneurs		**Researchers**	
	Strength	**Space for improvement**	**Strength**	**Space for improvement**
Benefits	→ New contacts → New knowledge and ideas → Opportunity to reflect on your company's operations from another perspective → Opportunity to learn to collaborate and listen → Opportunity to generate new ideas in a diverse environment → Opportunity to experience the process of reaching a certain level of result in a limited time	→ To hold a follow-up meeting in 40 days to share experience about how far everyone has reached and what they have tried/learnt/changed/started	→ New experience because innovation co-creation is a new, unprecedented format → New knowledge → New contacts	→ Researchers should be renumerated for their work as experts and compensated for their direct costs → Concluding a contract with university or research institute for the participation of a researcher
Process	→ Well-structured, without unnecessary information, without technical glitches → Professionally moderated → Constructive group work, because due to the online format there is time limit and less redundancy → Opportunity to work in groups → Design thinking process	→ Allow time for company presentations, thus, giving participants a chance to learn more about each other and identify opportunities for cooperation → In the experimental co-creation, it was difficult for the group to narrow down the initially defined problem, so several of the proposed solutions remained at a very general level → Allocate more time for discussions and Q&A sessions	→ Moderator's work → The process is suitable for making contacts → The process is suitable for starting a creativity process → Problem analysis process	→ The problems solved were too vague, thus, some of the solutions remained superficial → Each participant speaks as if in their own language, so sometimes it's difficult to understand each other → Group work moderators need to be skilled process managers → Two days online is too much → The format and process may remain, but it shall take place face-to-face

Table 3.3 (continued)

Composition of participants	→ A diverse and professional team → Exceeded expectations as all the participants were ready to get involved and experience co-creation	→ It would be worthwhile to involve representatives of the main stages of the food packaging value chain	→ It's positive that the organiser of cocreation is an organisation from the region → Companies from the region → Very different participants with different views on the problem → Involvement of packaging manufacturers	→ Other colleagues from the research community could be involved → In addition to SMEs, medium and large-size companies should be involved, as they have more experience, knowledge, and resources → Co-creation is an appropriate format for start-ups
Communication with the other party	→ The researchers were open and focused on finding solutions	→ At some moments, it was difficult to understand what researchers said because they spoke competently but very scientifically. Without an interpreter, it is difficult to talk to researchers.	→ Contacts with specific companies have been gained → Information on the needs of producers has been obtained	→ It was not always possible to understand the needs of the entrepreneurs
Prospects for innovation co-creation laboratory	→ Innovation co-creation is a good format for entrepreneurs to get to know each other and researchers	→ It is necessary to focus on narrower goals and objectives and to define clearer problems	→ Co-creation laboratory should definitely be continued → A great opportunity to network	→ A challenge of finding time to take part in events of this format → Co-creation laboratory should take place fact-to-face
Engagement of other participants	→ Very positive, because you could get a different perspective		→ Co-creation laboratory could involve participants from other countries	→ Consideration should be given to participants coming from countries at a similar stage of develop
Willingness to pay for co-creation as a service	→ If there is a clear goal and a solution, companies would be willing to pay the participation fee			

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 service industry which plays a crucial role in the innovation development, and whose significance is expected to grow in the 21st century.

1.1. The narrative literature review confirms that employees, with their specialised skills and competences, 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 artifact 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 types of professional expertise to produce the result. Networking with a variety of actors is critical for KIBS enterprises to successfully manage service production.

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 concluding 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 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 environment 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 reached an agreement that innovation development is complex and multidimensional process that involves significant improvements or new

advancements. It requires the 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 the transfer of knowledge 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 the majority of 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 concluding that knowledge transfer is challenging in the cross-disciplinary innovation process due to several reasons. Knowledge that is embodied in a person and a specific context is more difficult to share with others than codified knowledge. Various types of boundaries appear when people of heterogenous 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 organisation, and knowledge hiding.

Thesis #3: Although a variety of 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 collaborate. Despite this, the results of the survey 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 higher levels of innovation to be achieved in the innovation project, a wider 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 often are not aware of or trained to recognize the various potential obstacles to knowledge transfer that might arise from interactions between disciplines and organisations. 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 a comprehensive and integrated picture of the many stages of the innovation process, the various barriers that emerge, and the appropriate strategies to overcome them.

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

4.1. Based on the narrative literature review, 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, incorporates "cause-effect" logic, iterative, and useful to the purpose it was created.

4.2. The methodological framework consists of 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 experiment "Innovation Co-creation Laboratory". 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 to 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 – with respect to 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 with the development of 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 growth and long-term operation of 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 this 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 author's methodological framework in a variety of 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 analysis of the knowledge network, 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. 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 policy makers

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 breaking 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 various innovation projects and initiatives of cross-disciplinary characters.

For educational institutions at different levels of education

9. Promote cross-disciplinary education by creating programs and courses that encourage students to work across different fields. This will help them develop cross-disciplinary communication and collaboration skills and knowledge that is essential for innovation development.
10. Use problem-based and project-based learning to facilitate cross-disciplinary innovation development skills. Pay particular attention to the development of 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, as well using 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 top and middle-level managers of public and private sector organizations about knowledge transfer and cross-disciplinary innovation management, supervising master thesis of Riga Technical University Faculty of Engineering Economics and Management students, and leading various development projects and initiatives in her capacity as Vice-mayor of Cēsis municipality.

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Inese Suija – Markova
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APPENDICES

Appendix 1

Definitions of KIBS in chronological order based on literature review [Created by the author].

Source	KIBS definition	Shared elements		
		Knowledge intensive	Another organisation as a customer	Service as the main product / activity
(Alvesson, 1993)	"Knowledge-intensive business services offer products and services to other organisations so that these conform to the institutionalised expectations of their environments" (p.1004)	x	x	x
(Miles et al., 1995)	"Services that involve economic activities which are intended to result in creation, accumulation or dissemination of knowledge." (p.18)	x		x
(Den Hertog, 2000)	"Private companies or organisations who rely heavily on professional knowledge, i.e., knowledge or expertise related to a specific (technical) discipline or (technical) functional – domain to supply intermediate products and services that are knowledge based." (p.505)	x		x
(Alvesson, 2000)	"Companies where most work can be said to be of an intellectual nature and where well-educated employees form a major part of the workforce." (p.1101)	x		
(Muller & Zenker, 2001)	"Firms performing, mainly for other firms, services encompassing a high intellectual value-added." (p.1502)	x	x	x
(Bettencourt et al., 2002)	"Enterprises whose primary value-added activities consist of the accumulation, creation and dissemination of knowledge for the purpose of developing a customized service or product solution to satisfy the client's needs." (pp.100 – 101)	x		x
(Toivonen, 2004)	"Expert companies that provide services to other companies and organisations." (p.2)		x	x
(Miozzo & Grimshaw, 2005)	"Business services that are knowledge based, both based on social and institutional knowledge or more technological knowledge."	x		x
(Leiponen, 2006)	"Knowledge-intensive business services, such as engineering, management consulting and R&D services, almost exclusively consist of transferring knowledge and skills to client organizations." (p.444)	x	x	X
(Muller & Doloreux, 2009)	"Service firms that are characterised by high knowledge-intensity and services to other firms and organisations, services that are predominantly non-routine." (p.65)	x	x	X

Source	KIBS definition	Shared elements		
		Knowledge intensive	Another organisation as a customer	Service as the main product / activity
(Consoli & Elche-Hortelano, 2010)	"Intermediary firms specialised in knowledge screening, assessment and evaluation, and trading of professional consultancy services." (p.1303)	x		x
(Amara, D'Este, Landry, & Doloreux, 2016)	"Knowledge-intensive business services (KIBS) provide services based on professional knowledge. In that industry, transactions consist of knowledge and outputs that are often intangible." (p.4066)	x		x
(Figueiredo & de Matos Ferreira, 2020)	"Firms that provide knowledge-intensive services in the service sector and aim to create or transfer knowledge to companies in other sectors, either through a professional or a technological approach, generating innovation and consequently increasing competitiveness." (p.1322)	x	x	x

Appendix 2

KIBS competitiveness dimensions, indicators, and measures based on the literature review [Created by the author].

Competitiveness dimension	Indicator	Measures	Source
Competitive performance	Overall business performance	Market share and its growth, profit and its growth, sales growth, return on sales, turnover growth, profitability, profit on share capital, return on investments, return on assets, cash-flow from market operations, export-ratio.	(Bumberová & Milichovský, 2019) (Kohtamäki & Partanen, 2016) (Santos-Vijande et al., 2013) (Santos-Vijande, González-Mieres, et al., 2013) (Santos-Vijande, Lopez-Sanchez & Gonzalez-Mieres, 2012) (Lara, Palacios-Marques, & Devece, 2012) (Muller & Doloreux, 2009) (Teece, 2007) (Menguc, 2006) (Bolisani et al., 2014)
	Innovation performance	Sales, market share, profit, patent counts	(Yam, Lo, Tang, & Lau, 2011) (Santos-Vijande, Lopez-Sanchez, & Gonzalez-Mieres, 2012) (Tseng, Pai, & Hung, 2011) (Santos-Vijande, Lopez-Sanchez, & Rudd, 2016) (Abreu, Grinevich, Kitson, & Savona, 2010)
	Brand performance	Well-established brand reputation	(Bumberová & Milichovský, 2019) (Lara, Palacios-Marques, & Devece, 2012) (Corrocher, Cusmano, & Lenzi, 2013)
Competitive potential	Creation of customer value and impact on customer business performance	Customer satisfaction, customer loyalty and retention, value added perception, the level of communication achieved with customers, the reduction in customer complaints, improved customer perception of the firm's image, the competitive leadership of the customer firm	(Santos-Vijande, Lopez-Sanchez, & Gonzalez-Mieres, 2012) (Bumberová & Milichovský, 2019), (Bustinza, Gomes, Vendrell-herrero, & Baines, 2017), (Santos-Vijande et al., 2016)

Competitiveness dimension	**Indicator**	**Measures**	**Source**
Competitive potential		in the market as a result of the new service, adjustment to the changeable needs of the customers and other stakeholders, customer's business performance (profit level, profit level change, increased profitability), sales volume, market share, firm growth (sales and employment)	(Santos-Vijande, González-Mieres, et al., 2013) (Kohtamäki & Partanen, 2016) (Abreu et al., 2010) (Lara, Palacios-Marques, & Devece, 2012) (Belso-Martínez et al., 2011) (O'Cass & Sok, 2013)
	Productivity	Income per head	(Bumberová & Milichovský, 2019) (Tether, Li, & Mina, 2012) (Lara, Palacios-Marques, & Devece, 2012)
	Internal processes	Coordination of internal processes, organisation of personnel's task, use of advanced technologies	(Bumberová & Milichovský, 2019) (Corrocher, Cusmano, & Lenzi, 2013)
	Quality	Quality of services, speed of service delivery, range of services offered	(Bumberová & Milichovský, 2019) (Corrocher, Cusmano, & Lenzi, 2013)
	Human relations	Internal communication, employees' motivation, labour absenteeism, employees' satisfaction	(Bumberová & Milichovský, 2019) (Santos-Vijande et al., 2016) (Lara, Palacios-Marques, & Devece, 2012)
	Skills	KIBS employees' skills in English	(Wyszkowska-Kuna, 2017)
	Collaboration	Collaboration with other firms	(Corrocher, Cusmano, & Lenzi, 2013)
	Intellectual capital	Development and management of intellectual capital	(Teece, 2007)
External factors	Talent	Availability and access to global talent	(Javalgi et al., 2011)
	ICT infrastructure	Advances in satellite communications and access to and cost of broad-band internet connectivity	(Javalgi et al., 2011) (Wyszkowska-Kuna, 2017)
	Off-shoring	Off-shoring of knowledge-based services to emerging markets due to low-cost advantages	(Javalgi et al., 2011) (Wyszkowska-Kuna, 2017); (Huggins, 2011)
	Distribution channels	Availability and location of distribution channels	(Corrocher, Cusmano, & Lenzi, 2013)

Appendix 3

Framework of the online survey [Created by the author].

Researcher:	Inese Suija - Markova, PhD student at Faculty of Engineering Economics and Management, Riga Technical University
Purpose:	The survey is part of a PhD project on strategies for confronting different types of knowledge boundaries during the innovation process.
Research questions:	**What type of boundaries emerge in innovation process? What tools and approaches are used to cross these boundaries?**
Confidentiality:	All information collected about you during the course of this project will be kept without any personal identifiers
Please complete the questionnaire by clicking the buttons and filling the text fields. At the end just hit the SUBMIT button to hand in your answers (it may be necessary to confirm the submission).	
Don't close the browser window before you have submitted your answers, otherwise the data will be lost! The survey takes approximately 25 minutes to complete.	

Part I: Innovation development

No.	Questions	Dropdown menu				
		1	2	3	4	5
1	During the three years 2019 - 2021, did your organisation work on the development of new or improved products (goods and/or services)? If the answer is "no", please proceed with question no. 6 (1 - Yes; 2 - No)					
2	Who were the customers of these innovations? (1 - Your own enterprise; 2 - private business enterprise; 3 - public sector organisation; 4 - non-governmental organisation; 5 - individuals or households)					
3	Who developed these innovations? (1 - only your own organisation; 2 - other organisation; 3 - your own organisation together with other organisations and actors)					
4	If these innovations were co-created, who participated in the innovation co-creation process? If they were not co-created, please proceed with the next question. (1- private business enterprises; 2 - research organisations, universities or other higher education institutions; 3 - public sector organisations (e.g., local or regional municipalities, governmental agencies, ministries); 4 - non-governmental organisations; 5 - individuals (e.g., individual experts, end-users)					
5	What type of knowledge was required to develop these innovations? (1 - knowledge from one field of expertise and/or speciality; 2 - knowledge from a variety of predefined fields of expertise and/or specialities; 3 - any type of knowledge from any type of expertise and/or speciality was useful)					

Part II: Knowledge boundaries

Theoretical base (Information invisible to respondents)	No/Questions	Scale				
		1	2	3	4	5
		never	rarely	sometimes	often	always
	6 To what extent have you experienced the below-listed behaviours during the development of these innovations?					
Syntactic (Carlile, 2002)	Different individuals found it difficult to understand each other because they were using different language / lexicon (e.g., different terminology, professional jargon)					

Semantic (Carlile, 2002)	The same words / terminology were interpreted and understood differently by individuals from different fields of expertise and specialities					
Semantic (Rau, 2016), fuziness boundary	Individuals from one field of expertise found it difficult to explain the meaning of terminology to help other individuals from other fields of expertise to understand					
Semantic (Rau, 2016), terminology boundary	Individuals recognized that they lacked understanding of specific terms but avoided clarification, as they were embarrassed to do so					
Semantic (Rau, 2016), unbalanced mental model	Individuals held false assumptions about their counterparts' work practices, corresponding timelines, and resources					
Semantic (Carlile, 2002)	Some individuals had a different understanding of the innovation project goal than others					
Semantic (Carlile, 2002)	Some individuals had a different perception of a solution to a problem than others					
Pragmatic (Carlile, 2002)	If somebody presented a possible solution that required some individuals to change their views, these people found it difficult					
Pragmatic (Carlile, 2002)	If there was no agreement achieved, the individuals were generally not willing to change their position					
Pragmatic (Carlile, 2002)	Some individuals had different and/or competing interests and agendas during the innovation project					
Pragmatic (Rau, 2016), trajectory boundary	Some individuals were looking for ways to torpedo the project					
Pragmatic (Rau, 2016), trajectory boundary	Some individuals engaged alone in the innovation project and hoped that by doing so they would convince the others of their ideas and proposals					
Pragmatic (Rau, 2016), everybody is an innovator	Some individuals did not want to share their knowledge during the innovation project					
Pragmatic (Rau, 2016), everybody is an innovator	Some individuals did not respond to emails, did not answer the phone or simply did not show up at meetings					
Pragmatic (Rau, 2016), everybody is an innovator	Some individuals thought it was not their responsibility to share knowledge					

Part III: Knowledge boundaries crossing practices

Theoretical base (Information invisible to respondents	No/Questions	Respondent's answer
Syntactic (Carlile, 2002)	7. In what ways, if any, does your organisation usually develop a common lexicon / terminology in multi-disciplinary innovation teams?	
Semantic (Carlile, 2002)	8. In what ways, if any, does your organisation usually secure knowledge translation (e.g., translation of terms used by biologists to economists) and common meaning development in multi-disciplinary innovation teams?	
Pragmatic (Carlile, 2002)	9. In what ways, if any, does your organisation usually build common interests in multi-disciplinary innovation team?	
Pragmatic (Carlile, 2002)	10. In what ways, if any, does your organisation usually secure open knowledge sharing among specialists from different fields of expertise and specialities?	

Part IV: Contextual boundaries

Theoretical base (Information invisible to respondents	No/Questions	Respondent's answer
Contextual boundaries (Edmondson 2018; Filstad, 2018)	11. What other types of boundaries / barriers (e.g., working environment, tasks, timeframe, leadership, power, hierarchy, and others) have you experienced that individuals working on the development of innovations are faced with? Please name up to 5 boundaries.	

Part V: Boundary crossing practices (tools and approaches)

No/Questions	Respondent's answer
12. For an effective knowledge sharing during the innovation process, what tools and / or approaches has your organisation employed, if any?	

Part VI: General information

Question	NACE	Sectors	Industries
13. What is the main economic activity of your enterprise? Please, select.	B.	Primary and secondary sectors	Mining and quarrying
	C.	Primary and secondary sectors	Manufacturing
	D.	Primary and secondary sectors	Electricity, gas, steam and air conditioning supply
	E.	Primary and secondary sectors	Water supply, sewerage, waste management and remediation activities
	F.	Primary and secondary sectors	Construction
	H.	Primary and secondary sectors	Transport and storage
	58.	Knowledge intensive services	Publishing activities

	61.	Knowledge intensive services	Telecommunication
	62.	Knowledge intensive services	Computer programming, consultancy and related activities
	63.	Knowledge intensive services	Information service activities
	K.	Knowledge intensive services	Financial and insurance activities
	69.1.	P-KIBS	Legal services
	69.2.	P-KIBS	Accounting, book-keeping and tax consultancy services
	70.21.	P-KIBS	Management consultancy services (PR, strategic, organisation, Human Resources and financial planning)
	71.11.	T-KIBS	Architectural activities, building design and drafting, town and city planning and landscape architecture
	71.12.	T-KIBS	Engineering activities and related technical consultancy
	71.2.	T-KIBS	Technical testing and analysis
	72.1.	T-KIBS	Scientific research and development services in natural sciences and engineering
	72.2.	T-KIBS	Scientific research and development services in social sciences and the humanities
	73.1.	C-KIBS	Advertising
	73.2.	C-KIBS	Market research and public opinion polls
	74.1.	C-KIBS	Specialised design activities
	74.2.	C-KIBS	Architectural and engineering activities and related technical consultancy
	O.	Knowledge intensive services	Public administration and defence, compulsory social security
	P.	Knowledge intensive services	Education
	Q.	Knowledge intensive services	Human health and social work activities
	R.	Knowledge intensive services	Arts, entertainment, and recreation
	A	Primary and secondary sectors	Agriculture and forestry

No.	Questions	Dropdown menu			
14	Which sector does your enterprise belong to? Please, select. 1 - Private business enterprise; 2 - Public sector organisation; 3 - Public - private sector partnership; 4 - non-governmental organisation.	1	2	3	4
15	Which country is your organisation located in?	Name of the country			
16	What is the number of employees of your enterprise? (1- fewer than 10 persons; 2 - 10 to 49 persons; 3 - 50 to 249 persons; 4 - 25 or more persons)	1	2	3	4
17	What is the age of your organisation?	Years			
18	What is your position at the enterprise? (1 - top-level management; 2 - middle-level management; 3 - team-leader; 4 - staff)	1	2	3	4
19	If you are willing to learn about the survey results, please leave your e-mail address.	e-mail address			
20	If you are willing to participate in a focus group discussion or an expert interview, please leave your e-mail address.	e-mail address			

Appendix 4

Boundaries encountered by KIBS in the innovation process based on the conceptual content analysis [Created by the author].

Category	Definition	Unit	Frequency	Example
Collaborative communication boundary	Boundary that prevents people from working together to achieve a common goal by sharing resources, knowledge, insights and learning to build a consensus	Insufficient multi- and inter-disciplinary, and multi-stakeholder collaboration skills, lack of open and trustful communication, weak knowledge sharing skills, work in silos	27	"Some good experts are narrow focused in a specific field and are not skilled and/or do not want to make any effort in "translation of their messages" to the group. Some experts are not team players, they lack communication skills", "working in silos or only with colleagues from their own field", "older scientists neglective attitude towards cooperation", "temptation to hide competences", "lack of open and trustful communication", "lack of trust between science and industry"
Temporal boundary	Boundary associated with time allocated for a task or a project implementation	Unreal timeframe or deadlines	26	"Unreal time-frames", "too short deadlines", "time-frame set in projects is too short to create innovation"
Financial boundary	Boundary related to insufficient financial means for innovations	Insufficient financial resources, budgetary restrictions	23	"Insufficient financial resources assigned to the project", "budget restrictions", "insufficient budget as tech development can be very expensive", "limited financial support"
Hierarchy of authority	Boundary related to how hierarchy of authority functions in the organization, including division of labor, delegation of authority, chains of commands, positional roles, and functions	Excessive hierarchy, lack of clear hierarchy, unclear roles, lack of delegation of authority, decision-making deficiency	21	"Unclear who is in charge", "unclear roles", "insufficient hierarchy, especially in the project beginning", "lack of authority to decide", "too much hierarchy", "delayed decision-making"
Conflicting agendas	Boundary pertaining to contradictory insights, agendas, and goals (individual vs. team; team vs. organization; organization vs. organization; sectors vs. sector)	Conflicting agendas, hidden agendas, contradictory interests / goals	18	"Personal innovation or research goals not aligning with the goals of the company or commercial feasibility", "different - partly conflicting - interests (public vs. private actors)", "hidden agendas", "scientists don't want to participate if they can't publish the results"

Appendix 4 (continued)

Category	Definition	Unit	Frequency	Example
Leadership	Boundary related to lack of or insufficient direction of people towards accomplishment of a goal	Leadership, lack of leadership	16	“Insufficient leadership”, “absence of leadership, “low involvement from top management”, “leadership changes”, “bad leadership”
Lack of domain expertise	Boundary connected with insufficient knowledge and understanding of essential elements of a domain or specific field of inquiry	Qualification, state-of-the-art knowledge, experience, skills	13	“Lack of experienced professionals”, “knowledge about the topic”, “lack of understanding of the topic being discussed”, “unknown / new developed field so far for all involved parts, as well as terms and common goals and solutions are new or not even set for now”, “lack of specific skills”
Individual differences	Boundary related to life experiences, emotions, attitudes, and behavior	Incompatibility of personalities, passivity, motivation, sense of responsibility	12	““Personal chemistry" between individuals don't match. They don't like to work together”, “low self-efficacy”, “lack of motivation”, “laziness to take on new responsibilities”, “irresponsibility”, “stagnation”
Multitasking	Boundary associated with the ability to complete multiple task goals in the same general time-period by switching between individual tasks frequently	Multi-tasking, multiple commitments	10	“Time that must be found in addition to daily tasks and activities”, “multiple commitments”, “multitasking”, “extreme occupation of really good experts”
Deficient process	Boundary caused by deficiencies in the innovation management processes	Delays, lack of control, inappropriate tools, inefficiency	9	“Delayed decision-making process”, “delayed procurement”, “inappropriate delivery model (not agile)”, “inefficient processes wasting time”, “task prioritization, especially in collaborative projects”, “lack of quality control”, “not defined process of ideas review”
Cultural differences	Boundary pertaining to differences in behaviors, beliefs, customs, traditions, language that are characteristic to a group of people of a particular organization, sector, or domain origin	Different work culture, different historical experience, cultural differences, different perception, cultural boundaries	9	“Different working culture”, “different working styles”, “attitude towards work varies from country to country”, “different working conditions in the cross-organizational teams”, “different perception of time and speed of process”, “lack of understanding of the other cultures involved”

Category	Definition	Unit	Frequency	Example
Fear	Boundary related to unpleasant emotions caused by anticipation or awareness of danger, evil, or pain	Fear, being afraid, concerns	7	"People are afraid to come up with some crazy ideas if they feel that hierarchically higher person thinks differently", "concern of exposing the lack of knowledge on the subject of matter", "people are afraid to take risks", "fear of unknown"
Legal and regulatory framework	Boundary related to a rule, law, or policy that makes it difficult or impossible for innovation process to happen or innovation to be achieved	Legislation, bureaucratic restrictions, bureaucratic requirements, procedures	7	"Legislation", "bureaucratic restrictions and formal requirements, "procedural requirements", "it is required that you describe the solution to get funded by e.g., EU funds, however by innovating we could not foresee the final solution before the project, and we ended up doing something different than planned".
Changes and uncertainty	Boundary pertaining to changing circumstances and a degree of certainty during the innovation project implementation	Changes, shifts, uncertainty	7	"Changing objectives", "strategy shift during the innovation project implementation", "shifts in priorities", "lack of continuity in idea development", "speed of changes in external environment"
Language boundary	Boundary connected to linguistic obstacles to communication; the difficulties in communication experienced by people or groups originally speaking different languages	Language skills, language issues, language barriers	5	"Language issues", "language skills", "three different languages have been used daily", "language barriers appear if someone involved in a project must cooperate with a company from a different nation"
Established patterns and habits	Boundary associated with sticking to established patterns and habits	Established concepts, replication, repeating, stagnation	5	"Experts and organizers stick too strong to the established concepts", "medical society is very keen to think strongly within the box, any other areas are refused in majority cases. Even plain digitalization takes a lot of time, rejection, and confusion", "it's in human nature to replicate and repeat"
Geographical distance and different time zones	Boundary related to working in different geographical locations and time zones	Time zones, geographical distance	3	"Time zone can be a boundary", "geographical distance", "working in different time zones", "time zones"
Online working environment	Boundary connected with innovating in online working environment	Online working environment	2	"Online working environment inhibits trust building", "online meetings (due to coronavirus) are not that efficient"

Gender equality and stereotypes	Boundary pertaining to 1. the state in which access to rights or opportunities is unaffected by gender; 2. an overgeneralization of characteristics, differences and attributes of a certain group based on their gender	Gender, inequality, gender stereotypes	2	“Gender inequality”, “gender inequalities”

APPENDIX 5

Content analysis of definitions of the term "knowledge transfer" [Created by the author].

Source	Definition	Dimensions					
		Process	Stage-based	Dyadic	Levels	Boundaries	Absorptive capacity
(Gilbert, Cordey-hayes, 1996)	The process of knowledge transfer is not a static one, it is dynamic, and is part of a process of continuous learning	x					
(Albino, Garavelli, Schiuma, 1998)	The knowledge transfer between two or more actors (individuals or organizations) can be defined as the process by which the knowledge of one actor is acquired by another. From an operational point of view, the knowledge transfer is a communication process with information processing activities.	x		x	x		
(Empson, 2001)	Knowledge transfer is above all an inter-personal process (..) where knowledge is constructed, disseminated and legitimated through an ongoing process of inter-action among individuals.	x			x		
(Carlile, Rebentisch, 2003)	The transfer of knowledge from an "expert" site to a "novice" site. (..). Some researchers in the knowledge transfer domain have focused on knowledge transfer as a repeated process.	x		x	x		
(Cummings, Teng, 2003)	(..) the objective of any knowledge transfer project is to transfer source knowledge successfully to a recipient			x			
(Minbaeva, Pedersen, Björkman, Fey, Park, 2003)	We define knowledge transfer between organizational units as a process that covers several stages starting from identifying the knowledge over the actual process of transferring the knowledge to its final utilization by the receiving unit.	x	x				x
(Argote, McEvily, Reagans, 2003)	Knowledge management outcomes (knowledge creation, retention, and transfer). (…) Knowledge transfer is evident when experience acquired in one unit affects another			x			x
(Szulanski, Cappetta, Jensen, 2004)	Knowledge transfer is often undertaken to reproduce superior results observed elsewhere within the organization. (..) Knowledge transfer, in this sense, is the replication of routines across geographical space				x		x

Source	Definition	Dimensions					
		Process	Stage-based	Dyadic	Levels	Boundaries	Absorptive capacity
(Wang, Tong, Koh, 2004)	Knowledge transfer is a process of systematically organized exchange of information and skills between entities. (…) Knowledge transfer in this study refers to successful knowledge transfer such that the recipient unit accumulates and assimilates new knowledge	x		x			
(Majchrzak, Cooper, Neece, 2014)	Knowledge transfer is the process through which knowledge acquired in one situation is applied to another	x		x			
(Kane, Argote, Levine, 2005)	Knowledge transfer is the process by which one unit of an organization, such as a group or department, is affected by the experience of another (Argote & Ingram, 2000).	x		x	x		
(Ko, Kirsch, King, 2005)	Knowledge transfer is "dyadic exchanges of organizational knowledge between a source and a recipient unit in which the identity of the recipient matters" (Szulanski 1996, p. 28). (...) Knowledge transfer can be seen as "the process through which one unit (e.g., group, department, or division) is affected by the experience of another" (Argote and Ingram 2000, p. 151). (...) Darr and Kurtzberg (2000) go further by arguing that knowledge transfer occurs "when a contributor shares knowledge that is used by an adopter" (p. 29). (...) This study captures both of these ideas by defining knowledge transfer as the communication of knowledge from a source so that it is learned and applied by a recipient.	x		x	x		x
(Tiwana, McLean, 2005)	Knowledge transfer refers to transmission of knowledge from one individual to another. Ideally, at the end of such a knowledge transfer process, the transferee should possess the transferred knowledge of the transferor in its entirety.	x		x			x
(Oshri, Van Fenema, Kotlarsky, 2008)	Knowledge transfer is a process through which one organization (or unit) identifies and learns specific knowledge that resides in another organization (or unit), and reapplies this knowledge in other contexts (Hansen et al,1999). On the individual level, Cutler (1989) has previously observed that knowledge transfer is indeed a process by which the knowledge of one actor is acquired and is reapplied by another.	x		x	x		x

Source	Definition	Dimensions					
		Process	Stage-based	Dyadic	Levels	Boundaries	Absorptive capacity
(Bramwell, Wolfe, 2008)	(…) knowledge transfer from universities to industry is a fluid, complex and iterative process involving many different actors. (…) knowledge transfers are mainly person-embodied	x	x	x			
(Ward, House, Hamer, 2009)	knowledge transfer as the process of transferring knowledge into action where knowledge included tacit knowledge, new ideas or innovations as well as research and other evidence.	x					
(Liyanage, Elhag, Ballal, Li, 2009)	It is the conveyance of knowledge from one place, person or ownership to another. Successful knowledge transfer means that transfer results in the receiving unit accumulating or assimilating new knowledge. (..) Knowledge transfer is an area of knowledge management concerned with the movement of knowledge across the boundaries created by specialised knowledge domains. (..)It includes transfer of knowledge at higher levels such as group, product line, department, or division.			x	x	x	x
(Ambos, Ambos 2009)	The key element in knowledge transfer is not the underlying (original) knowledge, but rather the extent to which the receiver acquires potentially useful knowledge and uses this knowledge in own operations"						x
(Argote, Miron-Spektor, 2011)	When knowledge is developed from the experience of another unit, we term the learning subprocess as knowledge transfer. Knowledge transfer typically occurs across a boundary. The boundary could be between occupational groups (Bechky 2003), between organizational units (Darr et al. 1995,) or between geographic areas (Tallman and Phene 2007).	x		x	x	x	
(Maurer, Bartsch, Ebers, 2011)	Knowledge transfer commonly denotes the processes through which one organizational unit shares its knowledge with another; it manifests itself through changes in the knowledge base of the recipient unit and, if the acquired knowledge is used, its performance outcomes	x		x			x
(Blome, Schoenherr, Eckstein, 2014)	We define internal knowledge transfer as the firm's ability to share information internally with other functions (..) External knowledge transfer is defined as the firm's ability to utilize external expertise for the benefit of the firm's products and processes.			x			

Source	Definition	Dimensions					
		Process	Stage-based	Dyadic	Levels	Boundaries	Absorptive capacity
(Mileva - Boshkoska, Liu, Chen, 2018)	Exploring the boundaries that occur in knowledge transfer, regarded as knowledge boundaries (Tell, Berggren, Brusoni, & Van de Ven, 2017), identify five major categories: individual, domain-specific, task-oriented, spatial and temporal.					x	
(Valkering, Beumer, Carijn De Kraker, Ruelle, 2013)	In the knowledge transfer process, knowledge boundaries may arise between science, policy, and society, between academic disciplines, government departments, companies' internal functions, and between actor groups with different language and cultural back- ground (Carlile, 2002; Hegger et al., 2012; Wenger, 1998)	x				x	

APPENDIX 6

Matrix of the methodological framework [Created by the author].

Innovation process stages	Innovation objectives	Innovation activities	Key performance indicators*	Knowledge transfer practices (methods, tools, strategies, concepts)**
1. Internal / external innovation opportunity exploration	Identify innovation opportunities	→ Identify market opportunities → Identify problems in current processes → Identify unfulfilled needs of current customers → Select the problem to be addressed	→ Number of ideas generated → Quality of ideas generated → Idea conversion rate (%) → Time to market → Customer feedback	→ Establish a process for systematic innovation opportunity exploration → Gather ideas through different events and channels (e.g., conferences, trade fairs, literature reviews, customer needs research, policy analysis, etc.) → Document and manage ideas in the digital platform
2. Strategy selection	Define the problem and its scope	→ Define the initial problem that the innovation aims to solve → Define the scope of the innovation project → Determine the novelty of expected innovative solution	→ Clarity of the problem and scope → Completeness of the scope → Feasibility of the scope, given the resources available → Relevance of the problem and scope → Alignment with stakeholder expectations	→ Use root-cause analysis tools (e.g., IFD, affinity diagram, fault tree analysis) → Use Altshuller's levels of invention to determine the novelty level of expected innovative solution
	Identify the relevant stakeholders and knowledge domains involved	→ Identify stakeholders who are affected by the problem and who can contribute to the innovation solution → Determining the type of knowledge required to develop the innovative solution	→ Stakeholder engagement score → Knowledge domain coverage → Accuracy score	→ Use Altshuller's levels of invention to determine the type of knowledge and knowledge domain required to solve a problem → Use stakeholder identification tools (e.g., stakeholder mapping matrix, stakeholder triage)
	Build a diverse team and establish common grounds	→ Identify stakeholders who are affected by the problem and who can contribute to the innovation solution → Determining the type of knowledge required to develop the innovative solution	→ Diversity of the team in terms of demographic and professional backgrounds → Satisfaction and turnover of the team members → Conflict resolution: the number and severity of conflicts	→ Build cross-disciplinary and cross-functional taskforce → Organise alignment meetings → Organise team trainings → Engage translators and moderators → Use written documentation → Develop document depositories

Innovation process stages	Innovation objectives	Innovation activities	Key performance indicators*	Knowledge transfer practices (methods, tools, strategies, concepts)**
3. Idea generation and solution development	Foster a culture of openness and trust	→ Develop a safe and respectful environment that allows stakeholders to share their ideas, opinions, and concerns	→ Satisfaction and turnover of the team members → Feedback of the team members → Conflict resolution → Communication effectiveness: the level of engagement and participation, and quality of discussions	→ Celebrate successes and failures as a learning opportunity → Establish guidelines for respectful communication and behaviour → Lead by example → Use tools and platforms for sharing ideas and feedback
	Synchronize the languages and terminologies	→ Develop and maintain a shared language by defining key concepts and using common frameworks and standards	→ Terminology alignment rate → Misunderstanding rate → Communication efficiency → Consistency in language and terminology use	→Develop a glossary or a terminology database → Standardize terminology across all communication channels → Conduct training and awareness sessions → Use translation and interpretation services
	Design a collaborative process	→ Establish a process that integrates different perspectives, expertise, and resources of the stakeholders	→ Collaboration effectiveness → Diversity and inclusiveness → Innovation process output → Resource utilisation rate → Team satisfaction	→ Use tools and platforms (e.g., Miro, Confluence, Asana, Notion, etc.) → Use collaborative approaches (e.g., Design Thinking, Co-creation, Rapid prototyping, sprints, etc.) → Use creative thinking techniques → Organise events for team collaboration (e.g., workshops, event storming, hackathons, failure Fridays)
	Manage the innovation project	→ Use appropriate project management tools and methods	→ Resource utilisation → Budget adherence → Time to completion → Quality of deliverables → Risk management → Team collaboration	→ Establish a clear innovation team structure and role division → Establish a project documentation system → Establish a project management process and use project management tools and platforms → Working meetings to track progress, resolve issues and gather feedback

Innovation process stages	Innovation objectives	Innovation activities	Key performance indicators*	Knowledge transfer practices (methods, tools, strategies, concepts)**
4. Evaluation and full-scale implementation	Evaluate and disseminate	→ Evaluate the innovation solution based on its outcomes and impacts → Disseminate the solution and / or finding to relevant stakeholders	→ Innovation adoption rate → Return on investment → Time to market → Innovation effectiveness → Innovation efficiency → Intellectual property protection → Market share → Customer satisfaction	→ Prototype testing → User testing → Pilot testing → Benchmarking → Expert review → Disseminate through social media, traditional media, influencers → Publish white papers, case-studies → Host webinars or virtual events → Reach out to relevent organisations

Possible Knowledge Transfer Boundaries

Individual boundaries: → Language difficulties and inability to develop common lexicon or syntax → Collaborative communication boundary → Lack of domain expertise → Individual differences → Fear

Inter(organisational) boundaries: → Hierarchy of authority → Leadership → Deficient processes → Conflicting agendas → Regulatory framework → Multitasking → Established patterns and habits → Cultural differences

Boundaries related to scarce resources: → Temporal boundary → Financial boundary

Boundaries deriving from external environment: → Changes and uncertainty → Legislative boundary → Gender inequality and stereotypes

Boundaries related to specific working conditions: → Geographical distances and different time zones → Online working environment

As you progress through the innovation process, regularly trace hints for knowledge transfer boundaries, evaluate your progress and iterate on your knowledge transfer practices as needed

Notes:

* Specific key performance indicators that are most relevant will depend on the organization and the nature of the innovation opportunity being explored

** Specific innovation practices will depend on the organization and the nature of the innovation opportunity being explored

APPENDIX 7

Self-assessment questions for identifying knowledge transfer boundaries in the cross-disciplinary innovation process [Created by the author].

The goal of these self-assessment questions is to assist innovation process managers, facilitators, or moderators in becoming 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.

Self-assessment questions	Yes	No
Individual boundaries		
1. Did different individuals find it difficult to understand each other because they were using different language / lexicon (e.g., different terminology, professional jargon)?	o	o
2. Were the same words / terminology interpreted and understood differently by individuals from different fields of expertise and specialities?	o	o
3. Did individuals from one field of expertise find it difficult to explain the meaning of terminology to help other individuals from other fields of expertise to understand	o	o
4. Did individuals recognize that they lack understanding of specific terms but avoid clarification, as they are embarrassed to do so?	o	o
5. Did individuals hold false assumptions about their counterparts' work practices, corresponding timelines, and resources?	o	o
6. Did some individuals have a different understanding of the innovation project goal than others?	o	o
7. Did some individuals have a different perception of a solution to a problem than others?	o	o
8. If somebody presented a possible solution that required some individuals to change their views, did these people find it difficult?	o	o
9. If there was no agreement achieved, were the individuals generally not willing to change their position?	o	o
10. Did any individuals have different and/or competing interests and agendas during the innovation project?	o	o
11. Was any individual looking for ways to torpedo the project?	o	o
12. Did any individual engage in the innovation project and hope that by doing so he/she would convince the others of their ideas and proposals?	o	o
13. Did any individual not want to share his/her knowledge during the innovation project?	o	o
14. Did any individual not show up at the innovation project events / meetings?	o	o
15. Did any individual think that it was not his/her responsibility to share knowledge?	o	o
Inter(organizational) boundaries		
16. Did the team members have a clear understanding of their roles and responsibilities?	o	o
17. Does the project have a clear chain of command and decision-making process in place?	o	o
18. Are team members encouraged to express their opinions and ideas?	o	o
19. Are the team members allowed to make decisions within their area of expertise?	o	o

20. Is there feedback provided to team members in the constructive and timely manner?	o	o
21. Did you face any issues related to the lack of trust and respect among team members?	o	o
22. Have team members been given authority to carry out their work?	o	o
23. Have team members been involved in setting goals and objectives for the project?	o	o
24. Are team members able to challenge the authority without fear of negative consequences?	o	o
25. Have you spotted any issues related to cultural differences among organizations involved in the project (in case of a cross-sectoral and cross-organizational projects)?	o	o
26. During the innovation project, have you identified any issues relating to organizational routines, traditions, or habits that impede the innovation process (in case of a cross-sectoral and cross-organizational projects)?	o	o
Boundaries related to scarce resources		
27. Does the innovation project have a clear timeline and budget?	o	o
28. Have individuals been able to allocate sufficient time for the innovation project?	o	o
29. Did you have to reduce the frequency and length of activities due to individuals facing time constraints?	o	o
30. Did you have to limit the scope of the project due to resource constraints (budget, time, human resources)?	o	o
Boundaries deriving from external environment		
31. Have individuals mentioned any legal or regulatory constraints that could impact the innovation project or its outcome?	o	o
32. Have individuals mentioned any market forces that could impact the success of the project?	o	o
33. Have you observed any cultural or societal factors that could impact the reception of the project?	o	o
34. Have you observed any technological limitations that could impact the innovation project?	o	o
35. Have you observed any economic factors that could impact the funding or viability of the innovation project?	o	o
Boundaries related to specific working conditions		
36. Do individuals have the necessary equipment and tools to carry out their work?	o	o
37. Have you observed any issues with the innovation project as a result of working conditions?	o	o
38. Have you observed any issues with the innovation process as a consequence of geographically dispersed participants?	o	o

APPENDIX 8

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 and encouraging entrepreneurs to ask questions and asking clarifying questions by moderators themselves
Struggle to explain the idea	Participants struggle to explain their ideas so that others can understand	Encouraging to give idea clarifying examples
Collaborative communication boundary	The entrepreneur admitted that he did not know how and where to find relevant knowledge, and the researcher suggested him to read scientific articles	Explaining by moderators that it is not a common practice for entrepreneurs to read scientific articles and asking 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	Analysing encountered difficulties after the event
Lack of skills to use digital tools	Some moderators struggled to use Miro during the group work in the experimental co-creation phase	Analysing 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 the 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

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	Allocating 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 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 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

APPENDIX 9

Questions for the focus group discussion to evaluate the validity of the methodological framework for spanning knowledge transfer boundaries in the cross-disciplinary innovation process [Created by the author].

1. The effectiveness of the methodological framework
1. What are your first thoughts when looking back at the Innovation Co-creation Laboratory experiment?
2. How do you assess the whole experiment: the overall design, the various stages, the methods, tools, and approaches applied? What worked? What did not work? Please provide specific examples or instances that support your perspective.
3. How do you perceive the internal consistency of the methodological framework used for the experiment in terms of how its elements are put together? Please provide specific examples or instances that support your perspective.
4. What would you change the next time around?
5. How did the experiment's overall design address the need to test innovation co-creation as a tool for industry-research collaboration? Please provide specific examples or instances that support your perspective.
2.The efficiency of the methodological framework
6. In your opinion, how did the methodological framework help cross-disciplinary innovation development?
7. To what extent did the methodological framework help identifying and addressing of various boundaries appearing during the experiment? What worked? What did not work? Please provide specific examples or instances that support your perspective.
8. Would you suggest using the methodological framework in other projects and initiatives? Please provide support for your position

APPENDIX 10

Question of in-depth interviews of the participants of Innovation Co-Creation Laboratory [Created by the author].

1. Questions to entrepreneurs
9. What are the first thoughts that come to your mind when looking back on your participation in the Innovation Co-Creation Laboratory (ICL)?
10. How do you assess the organisational process of the ICL: division of the ICL into stages, time allocated for collaboration, chosen methods and techniques of the co-creation (World Cafe, Problem Selection Process, Design Thinking)?
11. How do you assess the composition of the ICL participants?
12. How do you assess the contact with the researchers involved in the ICL? What was successful and what failed? Why?
13. What prospects do you see for such a format of cooperation between science and business?
14. How would you assess the process of the ICL if international participants with similar challenges also took part in it – what would be the challenges and benefits of this process?
15. Would you be willing to pay for participation in the ICL?
2. Questions to researchers
1. What are the first thoughts that come to your mind when looking back on your participation in the Innovation Co-Creation Laboratory (ICL)?
2. How do you assess the organisational process of the ICL: division of the ICL into stages, time allocated for collaboration, chosen methods and techniques of the co-creation (World Cafe, Problem Selection Process, Design Thinking)?
3. How do you assess the composition of the ICL participants?
4. How do you assess the contact with the entrepreneurs involved in the ICL? What was successful and what failed? Why?
5. What prospects do you see for such a format of cooperation between science and business?
6. How would you assess the process of the ICL if international participants with a similar research profile also took part in it – what would be the challenges and benefits of this process?
7. Would you be willing to participate in the ICL in the future and under what conditions?

Inese Suija-Markova was born in 1978 in Cēsis. In 2000, she received a Bachelor's degree in communication and public relations from Vidzeme University College. She obtained her Master of Business Administration (MBA) degree in 2006 after graduating with distinction from the joint Norwegian–Latvian International Master Program in Innovation and Entrepreneurship. For 16 years, she has been the Managing Director of the Institute for Environmental Solutions, a private research and innovation organisation. Since 2009, she has been a Council Member of Cēsis Municipality. Since 1 September 2022, she has been a Deputy Mayor of Cēsis Municipality and a Deputy Chairman of Vidzeme Planning Region Development Board. She leads the Innovation Transfer Working Group of the Baltic Sea States Subregional Cooperation. Inese has been granted the USA State Department and Government of Canada scholarships and a UNESCO Bank Fellowship Program scholarship for individual research at the European Adult Education Association in Brussels, Belgium. She is also a trainer in project management, innovation technologies, and creativity. She has been a participant, a speaker, and a moderator at many international conferences and workshops.