BUSINESS
FINLAND

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MID-TERM EVALUATION OF **THE LEADING COMPANY INITIATIVE** (LCI) PARTNERSHIPS FINAL REPORT

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BUSINESS FINLAND
We believe in the power of ideas. That's why we fund and help Finnish companies grow quicker and develop their innovations to become global success stories.

EXECUTIVE SUMMARY

The evaluation of Business Finland's Leading Company Initiative (LCI) highlights significant advancements in fostering collaboration between businesses and research organizations. The initiative, launched in 2020, aims to tackle future challenges, boost R&D investments, create jobs, and positively impact Finnish society. By June 2024, 23 LCIs have been selected, each eligible for substantial funding. The ecosystems have succeeded in mobilising significant resources for research and innovation, and well under way in achieving their main targets, though the challenged in the operative environment have been significant and have in some cases slowed down the impact (e.g. in mobilising more SMEs).

The evaluation focused on the impact of cooperation within these ecosystems, developing new methodologies for analysing ecosystem impacts, particularly through NLP and advanced text analytics. The evaluation of the LCI partnerships demonstrates the initiative's success in fostering collaboration, generating knowledge spillovers, and contributing to Finland's strategic goals, and the findings provide insights for future development and utilisation of the LCI instrument to achieve national and international objectives. The findings indicate that the LCI has successfully generated knowledge spillovers and other externalities beyond the ecosystems, contributing to Finland's strategic goals. Main value added identified in the evaluation include:

1. **Significance of Collaboration:** The collaboration between companies and research organizations has been crucial in achieving the goals of the LCI. The partnerships have led to the development of new technologies, solutions, and business models, enhancing the global competitiveness of Finnish companies.
2. **Knowledge Spillovers and Externalities:** The LCI has generated significant knowledge spillovers and externalities, benefiting not only the participating organizations but also the broader Finnish economy and society. These include increased R&D investments, job creation, and advancements in sustainability.
3. **Additionality of LCI Activities:** The LCI activities have shown substantial additionality, particularly in terms of input additionality (increased investments and cooperation), behavioural additionality (changes in behaviour of firms and research organizations, e.g. more innovation-friendly and actively international SMEs with a stronger growth mind set), and output additionality (tangible results and synergies, e.g. business growth, patenting, exports).

4. **Impacts on Finnish Economy and Society:** The LCI has had a positive impact on the Finnish economy and society, contributing to sustainable development and addressing environmental themes. The initiative has significant potential for helping Finland achieve its 4% R&D targets, as well as employment targets in the participating companies. Significant differences exist between the various types of companies, and whilst both large and small companies benefit from knowledge spillovers and externalities generated through ecosystem cooperation, the impact may be more substantial for smaller companies, as they gain access to new knowledge, technologies, and best practices that can drive their growth and development. Smaller companies benefit from accessing larger research networks and partnering with more established firms and research institutions.
5. **Future Directions:** As Finland aims to increase R&D funding to 4% of GDP by 2030, the lessons learned from the LCI collaboration will be crucial in mobilizing resources and solidifying close collaboration between businesses and research organizations. A more mission-driven approach to LCI collaboration has been clearly visible and could be further fostered within the LCI ecosystems and between them.

FOREWORD

The basis of Finnish wellbeing stems from the wealth and jobs created by the success of Finnish companies in the global market. The role of Business Finland is to promote the prosperity of Finland by stimulating the emergence of new and innovative initiatives and by supporting the internalization of the Finnish industry.

Business ecosystems flourish when different stakeholders and industries meet, collaborate and create value together. Business Finland has taken an active role in enabling networks that have the potential to grow into business ecosystems, and in supporting the most promising ecosystems to grow into international success stories that renew, grow and improve the competitiveness of the Finnish economy.

The Leading Company Initiative was launched in 2020 as a challenge competition for leading companies. The aims of the Leading Company Initiative is to incentivize R&D investments, mobilize networks and ecosystems to address global challenges and market opportunities, and thereby boost Finnish employment, competitiveness and growth.

Company-research organization collaboration is a key part of these business ecosystems' activities also as a facilitator for knowledge spillovers. Company-research collaboration encourages partnerships for a range of other partners as well, such as start-ups, SMEs, and large enterprises for even broader societal impacts. In addition to examining company-research organization collaboration, Business Finland hopes that this evaluation will help us understand these broader societal impacts of the Leading Company Initiative. In addition, the evaluation has intendedly taken an exploratory and new approaches to impact assessments by using advanced text analytics, natural language processing, and large language models. We are also grateful for the participation of Academy of Finland in the steering group and hope that we can deepen our cooperation on evaluations in the future.

Business Finland thanks the evaluators (VTT Oy and MDI) and the steering group for the good work and discussions. It is important to note that the partnership, networks and ecosystems that the Leading Company Initiative has generated are diverse and at different stages of their life cycle, making it challenging to provide a comprehensive coverage of their impact. It is also important to gain a deeper understanding of the impacts of the initiative on the leading companies themselves. However, this mid-term evaluation creates valuable basis for further analysis of the impacts of the Leading Company Initiative on the Finnish economy and society.

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1. INTRODUCTION: THE EVALUATION TASK AND ITS IMPLEMENTATION

Business Finland's ***Leading Company Initiative*** (LCI), launched in 2020, challenges global leaders to tackle future challenges, boost R&D investments, create jobs, and have a positive impact on the Finnish society. The initiative fosters collaboration across industries, aiming to build high-value business ecosystems with international success and align with Finland's strategic goals. By June 2024, 23 LCIs have been selected, each eligible for up to 20 million euros in funding over 3–5 years, and Challenger Veturi 10 million and 20 million EUR for the ecosystem.

The mid-term evaluation of the Ecosystem funding instrument reported here focuses on the LCI partnerships ("LCI Veturi kumppanuudet" in Finnish) and assesses the extent and impact of the cooperation between business and research organisations within these ecosystems.

The evaluation project has also sought to develop new methodologies for analysing ecosystem impacts, in particular through the development and testing of NLP methodologies and analyses.

The evaluation report at hand answers these evaluation questions:

1. **What has been the significance of company-research organization collaboration?**
2. **To what extent has Business Finland's LCI also generated knowledge spillovers and other externalities beyond these ecosystems?**
3. **What has been the additionality of LCI activities** (in particular effects, impacts and externalities, in particular input additionality and cooperation in LCI ecosystems compared to investments, cooperation with SMEs, as well as behavioural additionality, i.e. assessing the changes in the behaviour of firms and research organisations involved, as a result of the LCI programme).
4. **What have been the impacts to the Finnish Economy and Society**, e.g. what kind of wider externalities (economic effects/external effects) has the LCI achieved through ecosystem cooperation, how have these arisen, and what have been the examples? What has been the importance of business-research cooperation to these external effects? How to measure impacts of LCI on sustainability (SDGs or other measures)? To what extent are the external effects also related to wider societal effects and sustainable development, e.g. environmental themes?
5. **How to continue**? As Finland aims to raise by R&D funding to 4 percent of the GDP by 2030, what lessons can be drawn from LCI collaboration for mobilizing the resources and solidifying the close collaboration?

The impact logic of engine programmes has been identified as presented below, with inputs in the form of financing and services, investments in human capital and collaborative efforts, value-creating networks and partnerships within the ecosystems provided by the LCI, as well as the new business models and lessons learnt within the partnerships.

The prior evaluation of Business Finland's ecosystem operations, titled "Evaluation of Ecosystem Funding Instruments and Partnership Model," was completed in 2022, where LCI was one of the instruments assessed. This current evaluation, however, focuses exclusively on LCI and its role in fostering business-research cooperation. Our objective with the new methodology enhanced with LLMs is to propose a comprehensive variable structure and novel indicator sets that will effectively capture the impacts and address Business Finland's key evaluation questions.

Specifically, this evaluation has sought to measure input additionality by assessing the effectiveness of business-research cooperation, the involvement of various research organizations, and the integration of SMEs within LCI ecosystems. Additionally, we have explored behavioural additionality by evaluating the significance of common roadmaps, the emergence of societal impacts, and the growth of SMEs as a result of LCI participation. Furthermore, our analysis has covered output additionality, focusing on the tangible results, knowledge spillovers, and the creation of synergies between Business Finland and other initiatives, such as the Academy of Finland's Flagships. Finally, we have assessed the broader impacts on the Finnish economy and society, including the externalities generated through ecosystem cooperation, sustainability impacts, and the overall contribution to societal development. This comprehensive approach and multi-method approach was utilised in order to measure the success of the LC, and to provide insights into how LCI instrument can be better utilised and further developed and leveraged to achieve national and international objectives.

Impact develops gradually, starting with early signs and building up over time. The most significant impact and the initial steps towards achieving this, happen throughout the long-term trust-building and collaboration process, in particular when companies work together amongst themselves and with research partners, with funds allocated to actual tasks. The impact criteria and relating data and methodology have not yet been fully leveraged for detecting early signals of impacts during the ecosystems. At the beginning of this evaluation project a customised (and future oriented) impact model was created for the systematic analysis of LCI impacts. The starting point for the framework was Business Finland's ecosystem impact framework, LCI's intervention logic and additionality thinking of Business Finland. The core idea therefore was to outline the logical impact paths that may have interdependencies and/or causalities connecting inputs with actions and measures, outputs, outcomes, and impacts.

In the previous impact analysis of the Nokia's Engine[1] project, a new methodological approach was piloted. This method focused on activities within the project's duration, emphasising company reporting on their actions with the funding and their final and quarterly reports, both as individuals and as part of the consortium reports ("loppuraportti"). Enhanced with advanced text analytics, natural language processing (NLP), and large language models (LLM) methods, over 40 new variables to analyse were identified in this pilot study. The variables mainly focused on LCI and business-research cooperation and their core activities during the project, providing strong evidence for future, more substantial impacts that could stimulate co-innovation, EU-level projects, job creation, and significant increases in R&D spending in Finland. This gave a starting point and tested methodology to be implemented further in this mid-term evaluation stage of LCI, providing a rich dataset for responding to the key question of

1 Impact Brief 2/2024 Ekosysteemit uudistumisen ja kasvun vauhdittajina – case Nokia Engine - Business Finland

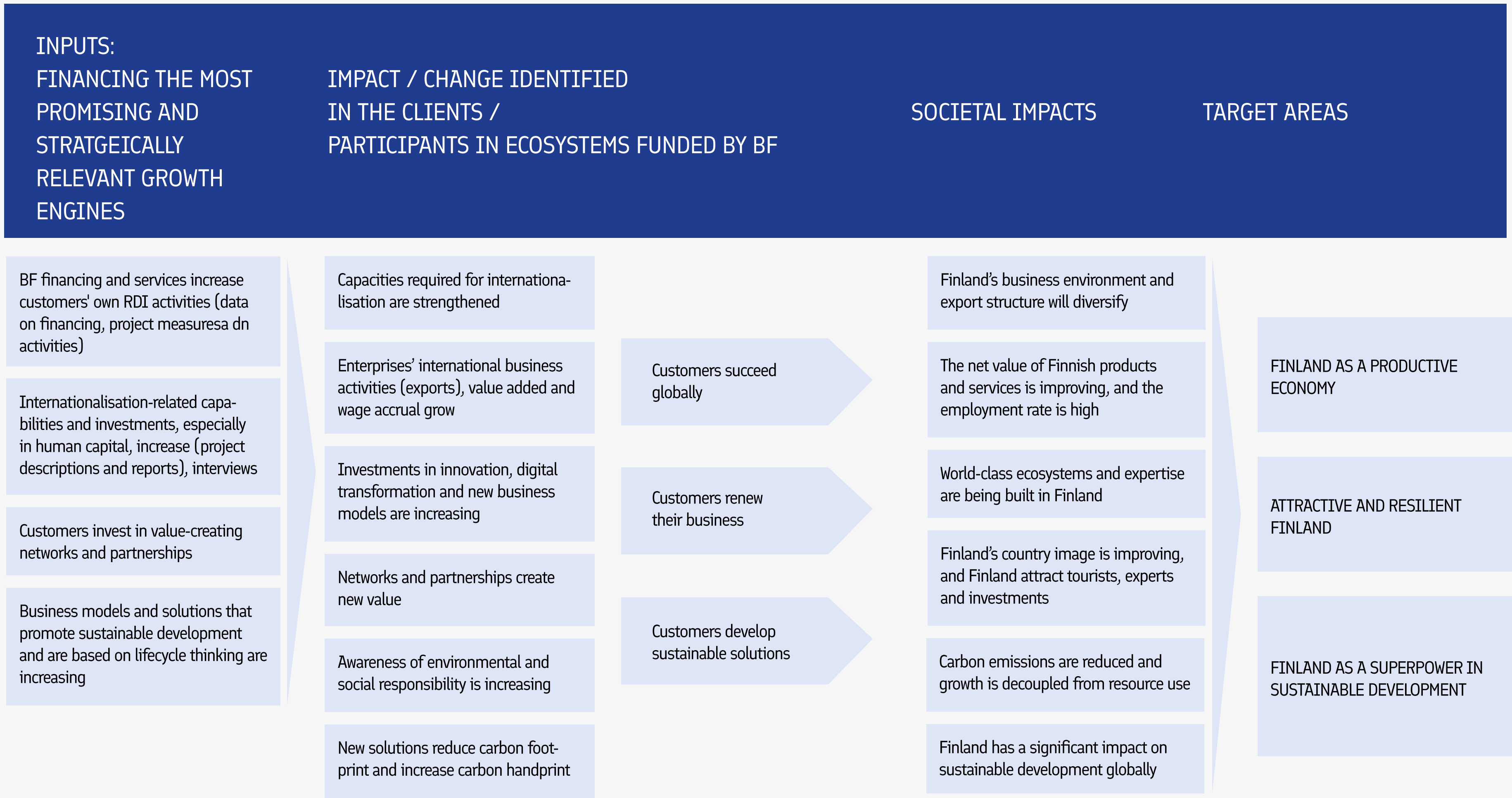
what kind of impacts has Business Finland's LCI had on the development and growth of these ecosystems. Through comparing the performance between companies within the ecosystem and similar companies outside it, tangible benefits can be identified and analysed.

Besides the traditional metrics, additional metrics were introduced, e.g. value-added, R&D investments, and product and service exports to provide a comprehensive understanding of the impacts of ecosystem participation. Additionally, we have measured the knowledge spillovers and externalities beyond these ecosystems through a detailed background text analysis from open web and companies' disclosures. In this final report we demonstrate this method and implement the analysis through case studies and comprehensive over-all analysis of the LCIs.

Cases selected for closer inspection included V_Fortum&Metsä: The "ExpandFibre" ecosystem focusing on bio-based materials; V_Meyer: Meyer's ecosystem, NEcOLEAP, dedicated to climate-neutral cruise ships; V_Borealis: ecosystem aiming at transforming the plastics industry towards sustainability, significant disruptive potential; V_Wärtsilä: The "Zero Emission Marine" ecosystem focuses on zero-emission solutions for the marine industry. Valio Engine has also been explored, being the only food industry Engine currently in operation.

FIGURE 1: LCI IMPACT FRAMEWORK

HOW DO THE ENGINE PROGRAMMES REALISE THE 6 IMPACT GOALS OF BF



ADAPTED FROM MDI&VTT COLLABORATION ON DEVELOPING BF IMPACT MONITORING & EVALUATION MODEL, 2023/24

2. EVALUATION RESULTS

This chapter describes the fundings and results of the evaluation per task.

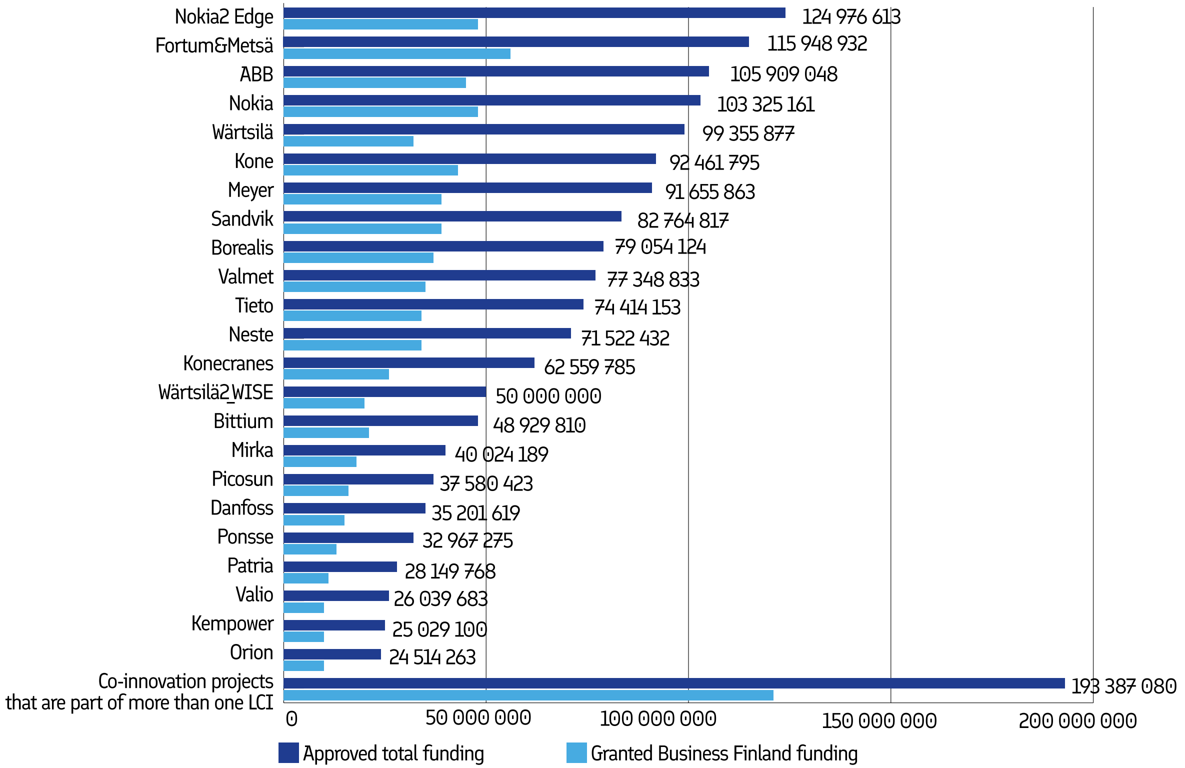
2.1 PROGRAMME IMPLEMENTATION: GOALS, OBJECTIVES AND THEIR ATTAINMENT

There are currently 23 Leading Company Initiatives in operation, funded by Business Finland. They aim to drive significant advancements in research, development, and innovation (RDI) within Finland, with the objective of increasing and catalysing RDI Investments and boosting cumulative RDI investments in Finland by nearly €1.5 billion, by implementing Technology Roadmap identified in the early stages of the activity, and by focusing on solving significant future challenges and contributing to Finland's RDI and employment targets.

By fostering innovation, these initiatives aim to enhance the global competitiveness of Finnish companies in the global market, by achieving new cutting-edge innovation and by solving shared missions and challenges. A novelty of the concept is, that If the RDI increases and ecosystem project-targets of the LCI-company are not met, the payments for the Veturi company will be dramatically reduced.

Amongst the operational principles are an ecosystem approach to work, i.e. leading companies form ecosystems that include various partners such as SMEs and research organizations, seeking to create synergy and win-win situations for collaboration. Emphasis is placed on joint projects between companies and research organizations to foster co-innovation. Business Finland provides substantial funding to the LCIs, with up to €20 million for leading companies and €50 million for their ecosystems, as well as 10 and 20 MEUR for challengers.

FIGURE 2. APPROVED TOTAL FUNDING AND GRANTED BUSINESS FINLAND FUNDING FOR DIFFERENT LCI'S.



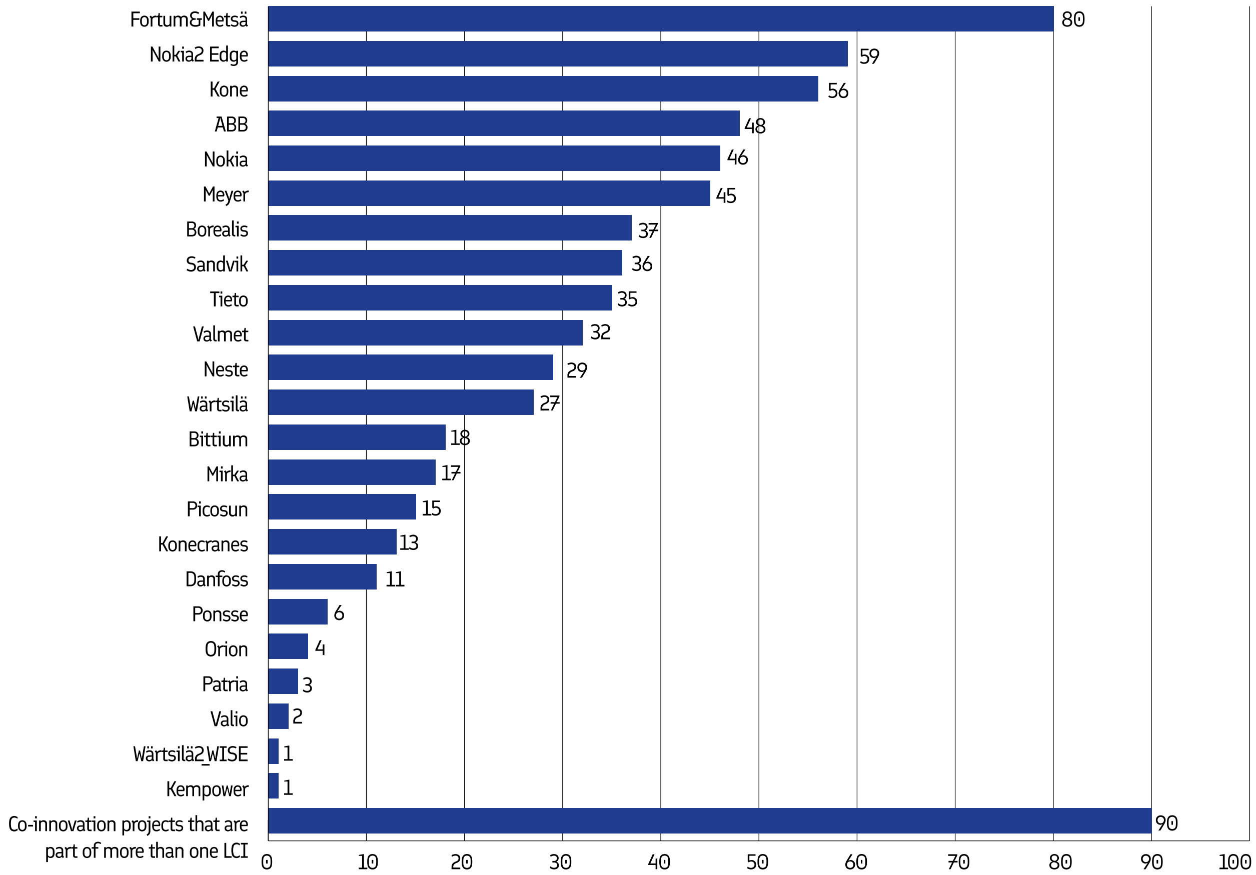
Main activities range from research and development, focusing on extensive R&D activities to develop new technologies and solutions, innovation projects, undertaking innovation projects that combine insightful product and service ideas with growth markets, as well as export promotion, i.e. significant efforts made to increase exports, particularly in high-value-added products and services. These initiatives are designed to create sustainable growth and new business opportunities, ultimately contributing to Finland's economic development and technological leadership.

BASIC INFORMATION OF LCI FUNDING AND PROJECTS

As a whole, 792 million euros of project funding has thus far been allocated to different LCI's (by October 2024). Correspondingly, approved total funding of the projects, including Business Finland funding and other funding, was 1 723 million EUR. These numbers also include the basic LCI project funding for LCI leader organisations. In the longer-running LCI's, total project funding has already risen to more than 100 million EUR and Business Finland funding almost 50 million EUR. In co-innovation projects, which have been implemented as part of several LCI's, total funding has been almost 200 million EUR.

Altogether 711 projects have been implemented in the 24 LCI's programmes. In terms of number of projects, in Fortum& Neste Expand Fibre LCI most projects have been

FIGURE 3. NUMBER OF PROJECTS IN DIFFERENT LCI'S.

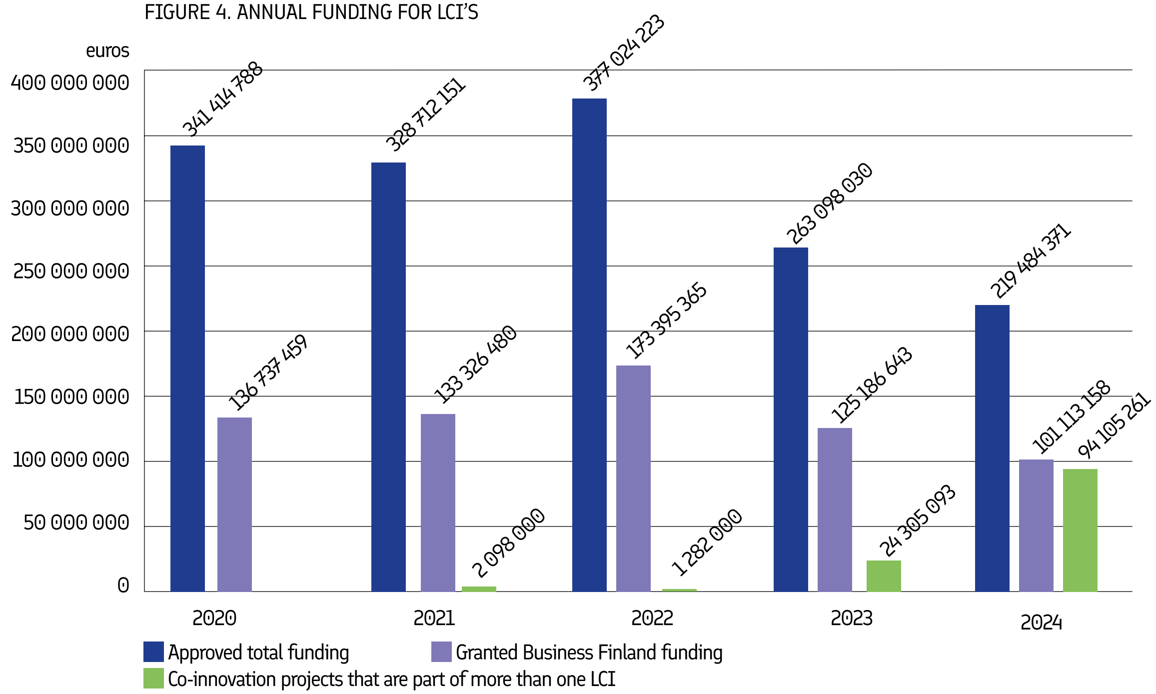


implemented (80 projects). On average, several dozen projects are shown to be implemented in the older LCI's projects. There have also been 90 Co-innovation projects, which have been implemented as part of several LCIs. In LCI's there has been a wide range of projects underway, with the number of projects continuing to increase in the future.

Annually the Business Finland funding volume of LCI's has been 125–177 million euros, while the approved total funding in projects has been 263–377 million euros. On top of this comes funding for co-innovation projects in more than one LCI. The number of Co innovation projects, that are part of several LCI, has started to increase during the last years. Overall funding in LCI's has decreased in 2023, being 287 million euros, because new smaller challenger Veturis were introduced (both Veturis and their ecosystems smaller).

Different Business Finland funding instruments have been used by LCI partnerships projects (or programmes). The most important has been Research, development ja piloting funding instrument. Altogether 393 million euros and about 50 % of all Business Finland funding has been granted to LCI projects from this instrument during 2020–2024. 345 million euros have been allocated to various co-innovation instruments. Their funding share is a total of 44% in the years 2020–2024. Co-innovation projects that are part of more than one LCI have received 122 million euros of Business Finland funding, whereas

FIGURE 4. ANNUAL FUNDING FOR LCI'S



Co-Innovation projects for research participants have received 118 million euros and Co-Innovation projects for company participant 105 million euros. The funding volume of Co-Creation and Co-Research is 54 million euros. Co-Creation projects were funded only in 2021.

FIGURE 5. ANNUAL FUNDING FOR LCI'S FROM DIFFERENT FUNDING INSTRUMENTS.

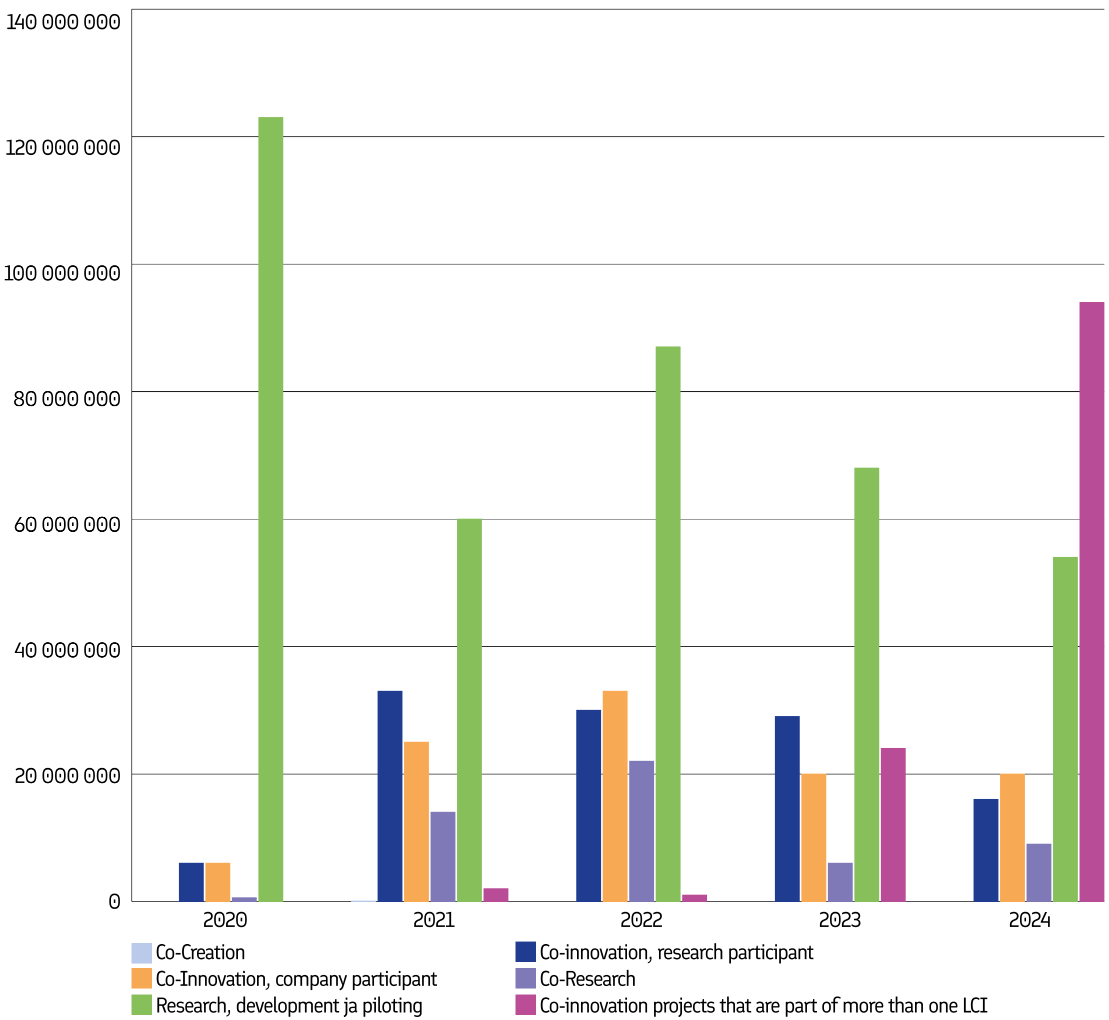
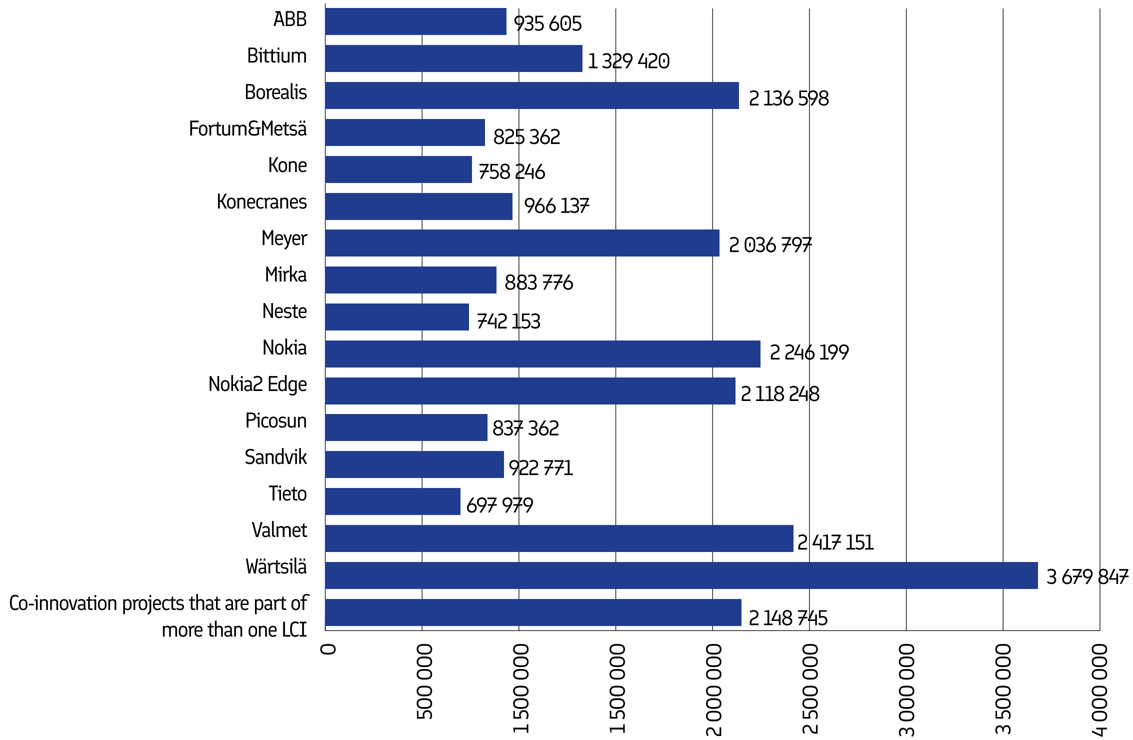


FIGURE 6. AVERAGE PROJECT FUNDING[2]



2 Only LCI's with more than 20 projects included, data doesn't include the basic LCI funding.

The average funding volume (approved total funding) of projects financed in different LCI partnerships / programmes has varied between 700 000 to 3 800 000 million euros. The projects are on average quite large in volume, as they are cooperation projects that bring together several actors. In this way, financial and other resources can also be gathered in larger volumes for projects. The average volume of all LCI projects is 1 460 000 euros.

In total, there have been several hundreds of organisations leading individual LCI project activities and 326 different project implementers in all LCI's. In both Nokia Edge and Fortum & Metsä Expand Fibre LCI's over 50 organizations have implemented projects. In general, the different LCIs that have been in operation for longer have had several dozen main project implementers.

Most of the Business Finland funding to LCI projects has been targeted to projects led by companies. Altogether, 67 % of the funding has been targeted to companies, and 33 % of funding to universities and research organisations. There are some differences in the share of universities and research organizations between LCI's, depending for instance on the stage of maturity and characteristics of the LCI.

FIGURE 7. NUMBER OF PROJECT IMPLEMENTERS IN DIFFERENT LCI'S.

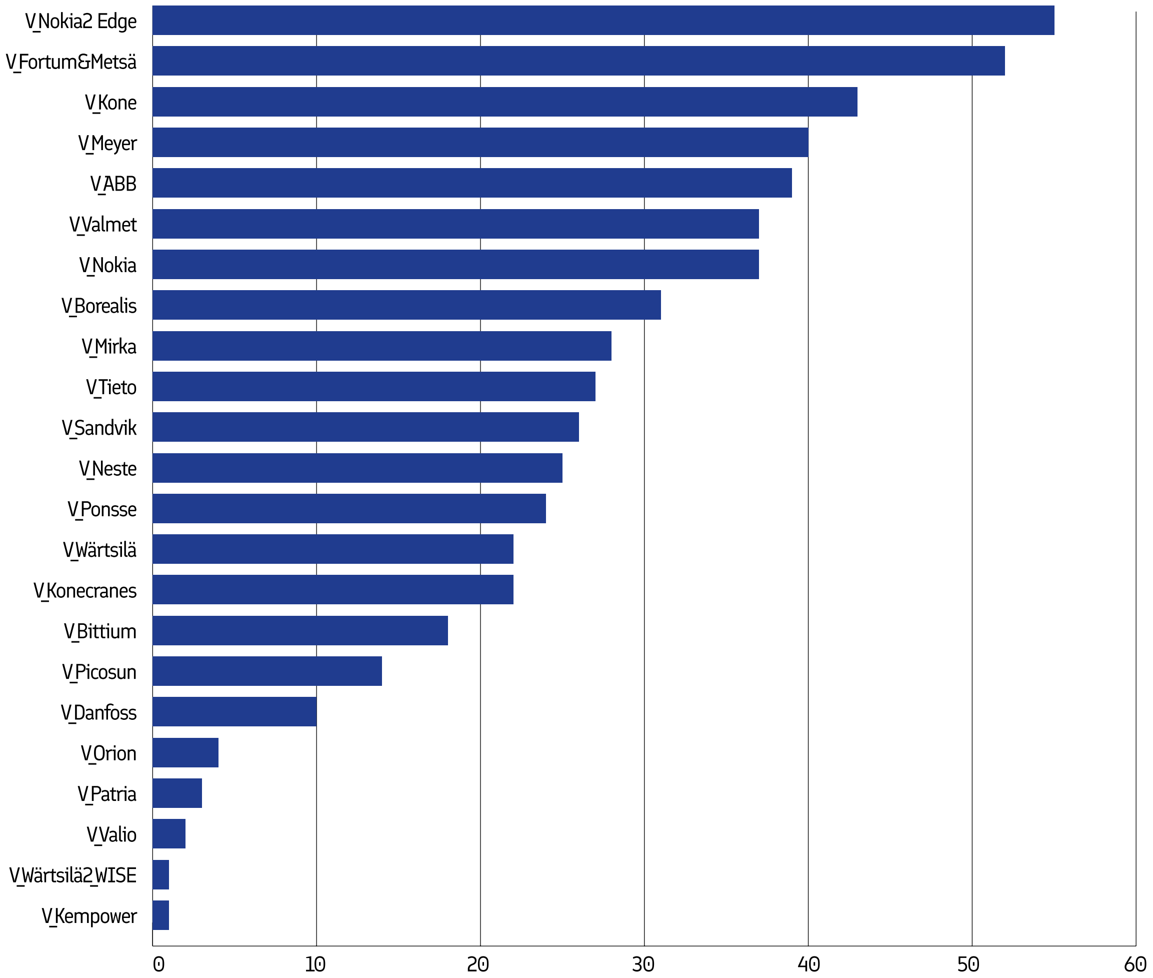
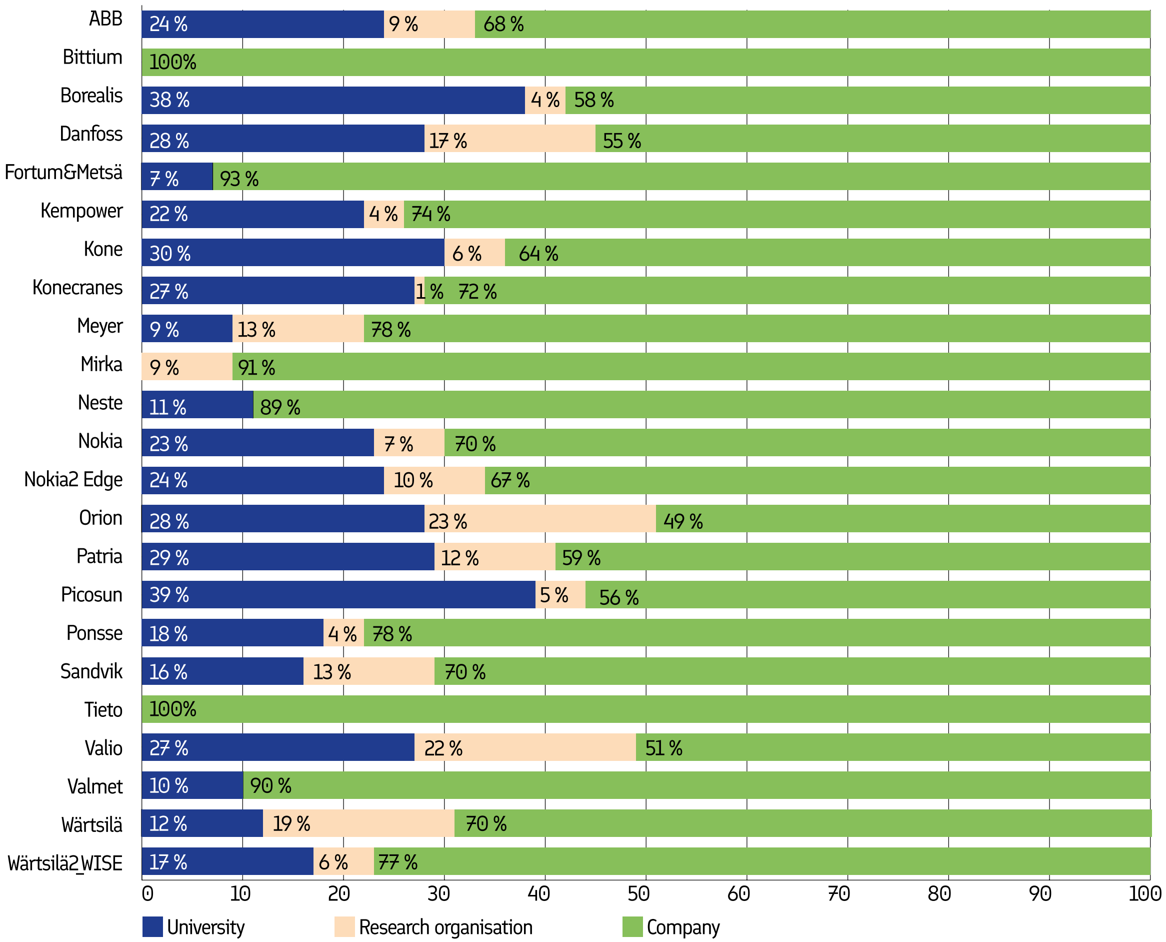


FIGURE 8. SHARE OF GRANTED BUSINESS FINLAND FUNDING RECEIVED BY DIFFERENT ORGANISATION TYPES.



2.2. TEXT ANALYSIS AND ADVANCED NATURAL LANGUAGE PROCESSING APPROACH

In the analysis of project reports, we utilised a wealth of information from company documents, including both interim and final reports. These documents, structured according to a standardized template, provide valuable insights into the companies' progress relative to their project objectives. They contain essential information, including key achievements, activities, challenges, and lessons learned. To systematically process and analyse this data, we developed a robust pipeline employing Natural

FIGURE 9. DATA RETRIEVAL AND HARMONIZATION PROCESS SAMPLE (HAJIKHANI 2020)

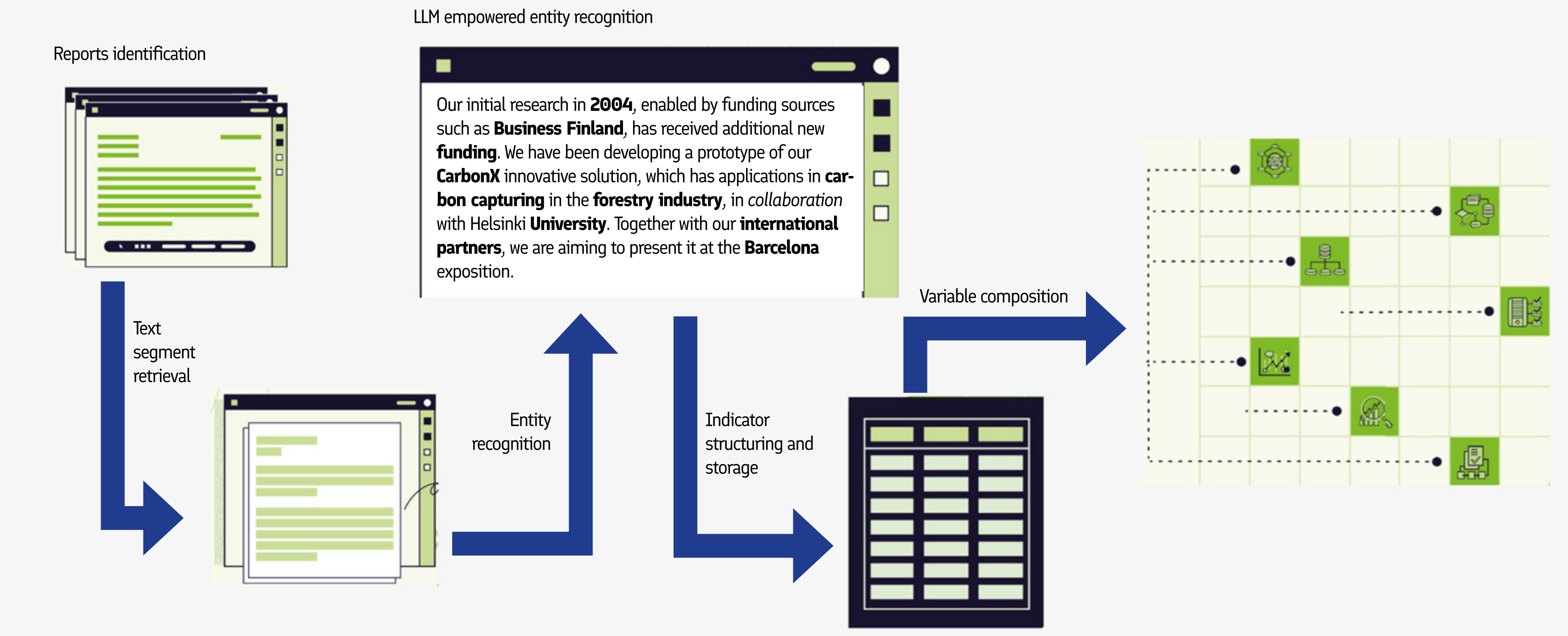
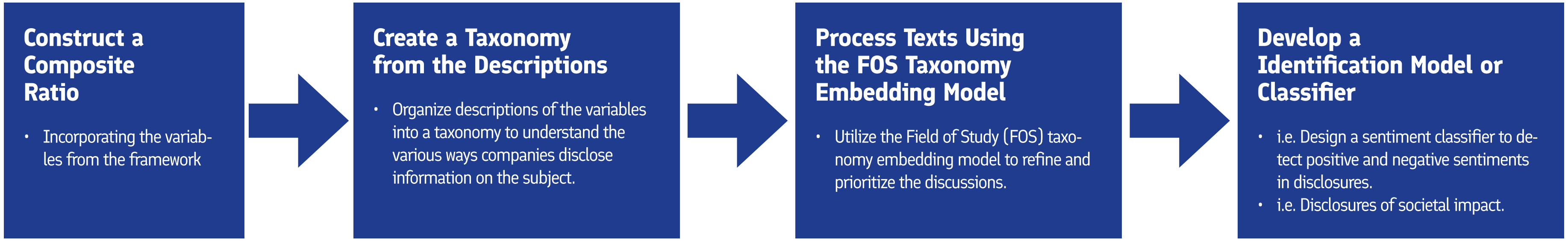


FIGURE 10 NATURAL LANGUAGE PROCESSING PIPELINE VISUALIZATION



Language Processing (NLP) techniques. The holistic process of information retrieval and harmonization is illustrated in Figure 1. This begins with text segmentation applied to the unstructured content of the reports, followed by entity recognition to identify relevant terms and entities. Finally, indicator structuring and storage are conducted, transforming the unstructured text into meaningful, structured variables that facilitate further analysis.

As previously published (Hajikhani et al. 2020), our pipelines have been fine-tuned to process textual data and extract specific entities of interest. In this instance, we applied our modified pipeline to capture key information, including project alignment with the ecosystem-defined scope, collaboration intensity, and the perceived financial and market performance of the company sample. A visual representation of this pipeline is provided in Figure 10 below.

The interim report data for the LCI projects (2020–2024) includes a comprehensive analysis of 4,200 pages of text collected from 288 unique companies across 19 projects. The combined dataset consists of 1,271,145 words, with an average text length of 162.93 words per row, a median length of 102 words, a maximum of 669 words, and a minimum of 7 words. This scale underscores the substantial volume of textual information analysed.

The reports cover key thematic areas, including:

- **Changes in company and infrastructure operations** (ID 210),

- **Customer assessments of project implementation** (ID 211),
- **Summaries of knowledge and skills generated in relation to business goals** (ID 212),
- **Evaluations of infrastructure's impact on the operating environment**, such as innovation activities, market effects, and technological advancements (ID 213), and
- **Funding group assessments** to evaluate research programme advancement (ID 214) and project success, implementation, and outcomes (ID 216).

These reports provide both quantitative and qualitative insights into the projects, offering a detailed understanding of their progress, results, and broader impacts. The template structure for the text collected during the reporting period is outlined in Table 1.

Figure 11 illustrates the iterative process of topic modelling applied to the reports' textual data to identify the most representative topics and their distributions. Topic modelling, a cornerstone method in Natural Language Processing (NLP), is built on probabilistic principles such as **Latent Dirichlet Allocation (LDA)**. It enables the

TABLE 1. REPORTING DATA

TEXT FIELDS	LOPPURAPORTTI	VÄLIRAPORTTI	GRAND TOTAL
Rahoitusryhmän arvio projektin etenemisestä, toteutumisesta ja onnistumisesta	98		98
Rahoitusryhmän arvio tutkimusohjelman edistymisestä		1771	1771
Kerro lyhyesti mitä projektissa tehtiin ja vertaa toteutusta hyväksyttyyn suunnitel-maan.	126	1944	2070
Mitä uutta tietoa ja osaamista yritykselle on syntynyt liittyen tavoiteltavaan liiketoi-mintaan?	67	1361	1428
Mitä infrastruktuurin hyödyntämisnäkymiin vaikuttavaa kehitystä on tapahtunut toi-mintaympäristössä, esimerkiksi innovaatioaktiivisuudessa, potentiaalisten infrastruktuu-rin käyttäjien määrässä, markkinoissa, teknologioissa tai yhteistyöverkostoissa?	67	1361	1428
Yrityksen tai infrastruktuuritoiminnan tilassa tapahtuneet muutokset raportointijakson aikana	64	943	1007
Grand Total	**422**	**7380**	**7802**

FIGURE 11. TOPIC MODELLING ITERATION

extraction of latent topics from large text collections by analysing word co-occurrences and patterns. Each dot in the plots represents a document cluster (or a text segment), with its position reflecting its similarity to other documents based on topic composition. The size of each dot may represent additional attributes, such as document length or word count. The three visualizations demonstrate different stages of the iterative refinement process. By systematically clustering and validating the topics, this analysis ensures that the extracted themes are both statistically robust and highly interpretable. This process provides meaningful insights into the underlying structure and content of the reports, enhancing the understanding of key thematic patterns and relationships.

The outcome of the iterative topic modelling process resulted in a robust and well-structured identification of variables within the interim report data. The final output is an organized framework comprising **10 main categories**, **22 subcategories**, and a total of **71 variables**, effectively capturing the diverse themes and dimensions embedded in the textual data. Through the iterative modelling process, the data was systematically clustered into meaningful and representative topics, balancing granularity with interpretability. Each iteration refined the topic structure—starting from broad, loosely defined clusters and progressively homing in on detailed, cohesive categories. This ensured the extraction of the most relevant variables while preserving their relationships and distinctions.

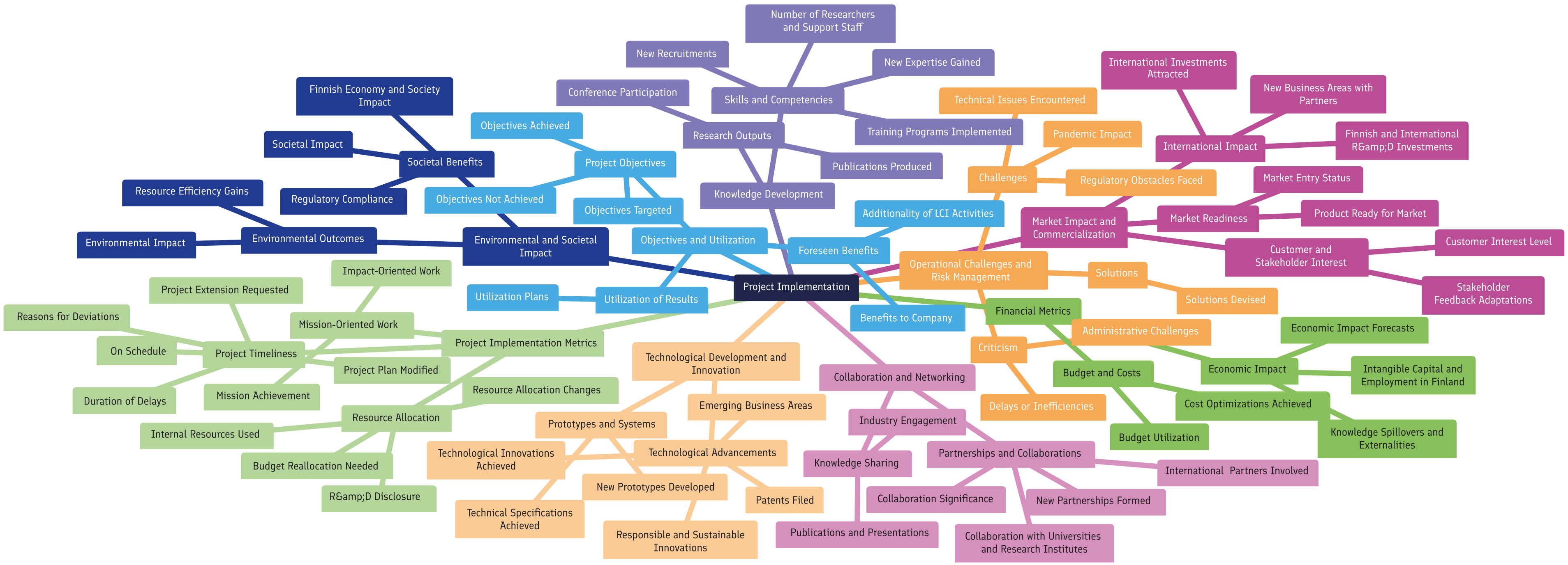
The final structure, as illustrated in **Figure 4**, presents a clear and logical breakdown of key concepts such as Utilisation of funding, impact and social benefits of funding and objectives met or unmet in the project among them.

I the table 2 the comprehensive list of variables and indicators is provided.

We refined our methodology into a structured process for analysing interim report data. This included creating a composite ratio for standardizing variable evaluation, developing a taxonomy to categorize variables clearly, and applying a text model with lexical queries to organize and quantify variable disclosures. The analysis focused on the following variables:

- **5.1.4. Collaboration Significance (Qualitative):** Evaluates the importance and outcomes of collaborations between companies and research organizations.
- **6.1.1. Environmental Impact (Qualitative):** Details sustainability improvements.

FIGURE 12. INTERIM REPORT-BASED VARIABLES



- **6.2.3. Finnish Economy and Society Impact (Qualitative):** Evaluates the specific contributions and benefits of the project to the Finnish economy and society.
- **10.1.2. Objectives Achieved (Qualitative):** Identifies which objectives were achieved and the reasons if disclosed.
- **10.1.3. Objectives Not Achieved (Qualitative):** Identifies which objectives were not achieved and the reasons if disclosed.
- **10.2.1. Utilisation Plans (Qualitative):** Describes how the results will be utilised or plans for utilisation.
- **10.3.1. Benefits to Company (Qualitative):** Details the benefits the company foresees on business areas, company level, or other dimensions.
- **10.3.2. Additionality of LCI Activities (Qualitative):** Assesses the added value and unique benefits generated by LCI activities in achieving project objectives.

PROGRAMME IMPLEMENTATION, GOALS, OBJECTIVES AND THEIR ATTAINMENT

The following analysis incorporates the variables we focused on and extracted, along with additional variables such as **company size**, **funding instrument type**, and the **ratio of Business Finland subsidy to the company's turnover** for the same year.

Company Size:

- A **micro enterprise** is defined as a company with fewer than **10 employees** and either an annual turnover (total revenue generated in a year) or balance sheet total (a statement of assets and liabilities) below **€2 million**.
- A **small enterprise** has fewer than **50 employees** and either an annual turnover or balance sheet total below **€10 million**.
- A **medium-sized enterprise** is characterized by having fewer than **250 employees** and either an annual turnover below **€50 million** or a balance sheet total below **€43 million**.
- If a company is owned by a larger company, its classification aligns with the size category of the parent company.

- **Subsidy Calculation**:
  Subsidy refers to financial aid provided by **Business Finland** during a specific year. It is calculated as the **subsidy amount divided by the company's turnover** for the same year.
- **Business Finland Loans**:
  Although loans from Business Finland were also reviewed, they were minimal and primarily granted to companies that had already received significant direct subsidies.

TABLE 2 IMPACT INDICATORS AND COMPOSITE VARIABLES

Project Implementation Metrics

Project Timeliness

1.1.1. On Schedule (Yes/No): Indicates whether the project is progressing according to the original timeline.
1.1.2. Duration of Delays (in months): Quantifies the length of project delays, if any.
1.1.3. Reasons for Deviations (Categorical: Technical, Financial, Commercial, Other): Captures reasons for delays or changes in the plan.
1.1.4. Project Plan Modified (Yes/No): Indicates whether the original project plan was altered.
1.1.5. Project Extension Requested (Yes/No): Shows whether additional time was requested.

Mission-Oriented Work

1.2.1. Mission Achievement (Yes/No): Indicates whether the project achieved the goals or mission it was originally set to accomplish.
1.2.2. Impact-Oriented Work (Qualitative): Describes how the project aligns with its intended impact or purpose.

Resource Allocation

1.3.1. Resource Allocation Changes (Categorical): Tracks significant shifts in resource distribution.
1.3.2. Budget Reallocation Needed (Yes/No): Identifies if budget allocations were adjusted.
1.3.3. Internal Resources Used (Increased/Decreased): Indicates changes in the reliance on internal resources.
1.3.4. R&D Disclosure (Yes/No): Indicates whether R&D activities were disclosed, and to what extent.

Technological Development and Innovation

Prototypes and Systems

2.1.1. New Prototypes Developed (Number): Counts prototypes or systems created.
2.1.2. Technical Specifications Achieved (Qualitative): Specific milestones such as performance metrics or design optimizations.

Technological Advancements

2.2.1. Technological Innovations Achieved (Yes/No): Indicates whether the project achieved notable technological advancements.
2.2.2. Patents Filed (Number): Number of patent applications resulting from the project.
2.2.3. Emerging Business Areas (Qualitative): Identifies new business areas developed as a result of the project.
2.2.4. Responsible and Sustainable Innovations (Qualitative): Tracks how innovation aligns with sustainability and responsibility goals.

Knowledge Development

Research Outputs

3.1.1. Publications Produced (Number): Counts scientific articles published.
3.1.2. Conference Participation (Number): Tracks conferences attended, and presentations delivered.

Skills and Competencies

3.2.1. New Expertise Gained (Qualitative): Describes knowledge or skills acquired.
3.2.2. Number of Researchers and Support Staff (Number): Includes researchers and assistants contributing to the project.
3.2.3. Training Programmes Implemented (Yes/No): Indicates if training sessions were conducted.
3.2.4. New Recruitments (Number): Tracks whether new staff members were recruited.

Market Impact and Commercialization

Market Readiness

4.1.1. Product Ready for Market (Yes/No): Indicates market readiness of the product/service.
4.1.2. Market Entry Status (Categorical: Planned/Initiated/Achieved): Tracks progress toward market entry.

Customer and Stakeholder Interest

4.2.1. Customer Interest Level (High/Medium/Low): Assesses market demand.
4.2.2. Stakeholder Feedback Adaptations (Yes/No): Indicates adjustments based on feedback.

International Impact

4.3.1. International Investments Attracted (Qualitative): Tracks attraction of foreign investments.
4.3.2. New Business Areas with Partners (Qualitative): Identifies collaborative business ventures initiated with partners.
4.3.3. Finnish and International R&D Investments (Categorical): Specifies whether R&D investments were focused on Finland or elsewhere.

Collaboration and Networking

Partnerships and Collaborations
5.1.1. New Partnerships Formed (Number): Tracks the number of new collaborations.
5.1.2. International Partners Involved (Yes/No): Indicates international collaborations.
5.1.3. Collaboration with Universities and Research Institutes (Number): Counts partnerships with academic and research institutions.
5.1.4. Collaboration Significance (Qualitative): Evaluates the importance and outcomes of collaborations between companies and research organizations.

Knowledge Sharing
5.2.1. Publications and Presentations (Number): Highlights dissemination activities.
5.2.2. Industry Engagement (Qualitative): Includes participation in workshops and seminars.

Environmental and Societal Impact

Environmental Outcomes
6.1.1. Environmental Impact (Qualitative): Details sustainability improvements.
6.1.2. Resource Efficiency Gains (Quantitative): Tracks efficiency metrics.

Societal Benefits
6.2.1. Societal Impact (Qualitative): Describes benefits to communities or industries.
6.2.2. Regulatory Compliance (Yes/No): Indicates adherence to regulatory standards.
6.2.3. Finnish Economy and Society Impact (Qualitative): Evaluates the specific contributions and benefits of the project to the Finnish economy and society.

Operational Challenges and Risk Management

Challenges
7.1.1. Technical Issues Encountered (Yes/No): Notes any technical difficulties.
7.1.2. Regulatory Obstacles Faced (Yes/No): Tracks barriers due to regulations.
7.1.3. Pandemic Impact (Qualitative): Describes how the COVID-19 pandemic influenced the project.

Criticism
7.2.1. Administrative Challenges (Qualitative): Captures criticism related to administration or decision-making.
7.2.2. Delays or Inefficiencies (Qualitative): Highlights any reported inefficiencies.

Solutions
7.3.1. Solutions Devised (Qualitative): Describes corrective actions taken.

Financial Metrics

Budget and Costs
8.1.1. Budget Utilisation (Qualitative): Details funding allocation and deviations.
8.1.2. Cost Optimizations Achieved (Quantitative): Tracks cost-saving measures.

Economic Impact
8.2.1. Economic Impact Forecasts (Qualitative): Projects financial benefits.
8.2.2. Intangible Capital and Employment in Finland (Quantitative): Measures human and intangible capital.
8.2.3. Knowledge Spillovers and Externalities (Qualitative): Describes the extent to which funding has contributed to knowledge spillovers and created externalities beyond the ecosystem projects.

Objectives and Utilisation

10.1. Project Objectives
10.1.1. Objectives Targeted (Qualitative): Describes what objectives were targeted by the project.
10.1.2. Objectives Achieved (Qualitative): Identifies which objectives were achieved and the reasons if disclosed.
10.1.3. Objectives Not Achieved (Qualitative): Identifies which objectives were not achieved and the reasons if disclosed.

10.2. Utilisation of Results
10.2.1. Utilisation Plans (Qualitative): Describes how the results will be utilised or plans for utilisation.

10.3. Foreseen Benefits
10.3.1. Benefits to Company (Qualitative): Details the benefits the company foresees on business areas, company level, or other dimensions.
10.3.2. Additionality of LCI Activities (Qualitative): Assesses the added value and unique benefits generated by LCI activities in achieving project objectives.

PROJECT TYPES AND THEIR UTILISATION PLANS – SUMMARY OF OUR ANALYSIS

The analysis of company project reporting reveals distinct patterns in utilisation plans across different project types, company sizes, and subsidy/turnover ratios. These patterns demonstrate how Co-Innovation, Co-Research, and Development and Piloting projects each exhibit unique characteristics in their utilisation approaches, reflecting varied objectives and innovation strategies. In co-innovation projects, which represent the largest category, there is a clear focus on immediate commercial applications and market-ready solutions. Large companies with 0–1% subsidy/turnover ratios demonstrate three primary approaches: 1) ecosystem-level collaboration involving multiple stakeholders, 2) integration of results into existing product development pipelines, with 94.6% planning direct commercialization paths, and 3) technology platformisation aimed at international market expansion. These projects typically target commercialization for 2025–2026, with implementation following a structured path including phased implementation, rapid prototyping, and continuous customer feedback integration. Mid-sized companies in co-innovation projects show more varied utilisation approaches, particularly evident in the split between 0–1% (57.5%) and 1–5% (42.5%) subsidy/turnover ratios. Their plans typically encompass: 1) near-term commercialization of specific technologies, 2) integration of research results into existing product lines, especially in AI and digitalization sectors, and 3) strategic collaboration with research institutions for solution scaling.

Co-research and development projects demonstrate distinctly different patterns, focusing on building fundamental knowledge and capabilities. The key characteristics include: 1) stronger focus on collaboration with universities and research centres, particularly among companies with 1–5% subsidy/turnover ratios, 2) emphasis on knowledge creation and capability building rather than immediate commercialization, and 3) higher frequency of international collaboration mentions, especially in standardization efforts. Implementation typically follows systematic research methodology, knowledge sharing initiatives, and industry-wide standardization efforts. Development and piloting projects demonstrate more immediate practical applications across company sizes. The utilisation plans in this category show: 1) clear focus on specific technical solutions with shorter implementation timelines, 2) strong emphasis on customer testing and validation, particularly among SMEs, and 3) higher proportion of direct commercialization plans with clear paths from piloting to market implementation.

Key distinctions between project types emerge in several aspects: 1) Timeline Perspective - Co-Innovation focuses on short to medium-term commercialization while Research & Development targets long-term advancement, 2) Implementation Focus - Co-Innovation emphasizes specific product development while Research & Development pursues broad technology advancement, and 3) Partnership Strategy - Co-Innovation prioritizes commercial partnerships while Research & Development focuses on research and ecosystem collaborations. Cross-cutting themes emerge across all categories and company sizes: 1) environmental sustainability drives many utilisation plans, particularly in energy efficiency and renewable technology projects, 2) digital transformation and AI integration appear frequently regardless of company size or project type, 3) companies with higher subsidy/turnover ratios (>5%) tend to have more experimental and research-intensive utilisation plans, and 4) increasing emphasis on ecosystem development and attention to market trends.

The interaction between project type, company size, and subsidy/turnover ratio creates distinct patterns in utilisation planning. The most successful approaches appear to be: 1) systematic integration of project results into existing business operations, particularly evident in large companies' co-innovation projects, 2) balanced focus on both immediate commercialization and long-term capability building, especially in mid-sized companies, and 3) flexible adaptation to market needs while maintaining clear commercialization paths, most commonly seen in successful SME projects across all categories.

PROJECT DISCLOSED BENEFITS ANALYSIS SUMMARY

The analysis of project disclosed benefits in the reporting data reveals comprehensive patterns across different project types, company sizes, and subsidy/turnover ratios, demonstrating both immediate impacts and long-term strategic advantages in the Finnish innovation ecosystem.

Co-innovation projects, particularly among large companies with low subsidy/turnover ratios (0–1%), demonstrate immediate and tangible business impacts with three primary benefit categories: 1) significant revenue growth ranging from 20–60%, 2) direct enhancement of existing product portfolios through new technological capabilities, and 3) strengthened ecosystem partnerships leading to new business opportunities. These benefits materialize through operational improvements including: 1) development of new product portfolios, 2) enhanced technological capabilities, and 3) improved operational efficiency through integration of advanced technologies like AI and robotics. Mid-sized companies in co-innovation projects show a balanced distribution of benefits: 1) immediate technical capabilities enhancement, particularly in AI and digitalization, 2) strengthened market position through new product features, and 3) expanded partnership networks leading to new business opportunities. Strategic business development benefits encompass: 1) creation of new business models, 2) strengthened market competitiveness, and 3) improved customer relationship management.

Co-research and development projects generate more fundamental and long-term benefits focused on foundational capabilities and industry advancement. Key benefits include: 1) enhanced R&D capabilities and knowledge base development, 2) new technological expertise and intellectual property creation, and 3) strengthened industry position through participation in standardization efforts. Sustainability and future readiness benefits show: 1) development of sustainable solutions, 2) improved environmental performance, and 3) enhanced capability for green transition. Development and piloting projects demonstrate rapid benefit realization across company sizes, with three main categories: 1) immediate technical solution validation and improvement, 2) accelerated market entry through customer validation, and 3) reduced development risks through pilot-phase learning. Industry leadership benefits comprise: 1) strengthened position in industry ecosystems, 2) enhanced international collaboration, and 3) development of industry standards.

Cross-cutting benefits emerge across all categories: 1) enhanced sustainability credentials and capabilities, particularly in environmental performance and carbon footprint reduction, 2) improved digital capabilities and AI integration readiness, 3) strengthened ecosystem positions and partnership networks, and 4) increased organizational learning and innovation capabilities. The interaction between project type, company size, and subsidy/turnover ratio reveals optimal benefit patterns: 1) large companies benefit most from systemic innovation capabilities and ecosystem leadership, showing significant revenue growth and market expansion, 2) mid-sized companies show optimal benefits from balanced technology and market development, and 3) smaller companies achieve most value through focused innovation and rapid market validation.

This comprehensive benefit pattern supports the Finnish innovation ecosystem by, 1) ensuring immediate competitiveness improvements for participating companies through enhanced technological capabilities, 2) building long-term innovation capabilities across industry sectors, particularly in sustainability and digitalization, and 3) strengthening collaboration networks that support ongoing innovation. The varied benefit patterns across project types and company sizes contribute to a robust national innovation system that successfully balances immediate market impact with long-term capability development and industry advancement. Market development benefits are particularly notable across all project types, including: 1) enhanced competitive positioning in both domestic and international markets, 2) improved market understanding and customer relationships, and 3) successful international market expansion. These benefits, combined with strengthened innovation capacities and sustainability improvements, demonstrate the comprehensive value creation achieved through the different project types and company collaborations.

PROJECT OBJECTIVES ACHIEVEMENT ANALYSIS - SYNTHESIZED OVERVIEW

The analysis of project's reporting on achievements reveals distinctive patterns across different project types, company sizes, and subsidy/turnover ratios. Co-Innovation projects demonstrate particularly strong achievement rates across multiple dimensions, with clear evidence of both technical and business success.

In co-innovation projects, large companies with 0–1% subsidy/turnover ratios report significant achievements in three main areas: 1) successful technological development and implementation, with many reporting completion rates of 80–100%, particularly in AI and robotics, 2) strong financial performance, with several companies reporting revenue growth of 20–60%, and 3) successful development of new platforms and products, especially in simulation environments and automation systems. Notable examples include successful pilot programme completions and international market expansion achievements. Mid-sized companies in co-innovation projects show more varied achievement patterns, with a notable split between technological and business objectives: 1) high success rates in specific technical developments, particularly in digital solutions and automation, 2) strong progress in pilot implementations and customer validations, and 3) successful achievement of research and development milestones, especially in companies with 1–5% subsidy/turnover ratios.

Co-research and development projects demonstrate distinct achievement patterns focusing on fundamental capabilities: 1) strong progress in fundamental research goals and technical studies, 2) successful completion of technical validation activities and pilot programmes, and 3) effective development of new methodologies and sustainable technologies. These projects show particular strength in foundational research and capability development, though their outcomes may be less immediately measurable than those of co-innovation projects. Development and piloting projects demonstrate strong achievement rates in practical implementation: 1) successful completion of pilot programmes across various scales, 2) high achievement rates in technical validation objectives, and 3) effective progress in sustainable technology development. These projects show particular success in bridging research outcomes with practical applications.

Cross-cutting achievements emerge across all categories, showing strong performance in timeline and planning: 1) most projects achieving objectives according to schedule, despite some facing delays, 2) successful development and implementation of digital solutions, especially in AI and automation, and 3) strong achievement rates in ecosystem development and partnership building. Projects demonstrate remarkable ability to adjust to changing circumstances while maintaining focus on core objectives. The interaction between project type and company size reveals distinct achievement patterns: 1) large companies in co-innovation projects show high achievement rates in systematic development and implementation, 2) mid-sized companies demonstrate balanced achievement across technical and business objectives, and 3) smaller companies show strong achievement in specific technical and market objectives.

Timeline perspectives on achievements show interesting patterns: 1) larger companies report more sustained and systematic achievement of objectives over longer periods, 2) smaller companies demonstrate more immediate and focused achievement of specific objectives, and 3) companies with higher subsidy/turnover ratios show more experimental and research-oriented achievements.

This comprehensive achievement pattern supports the Finnish innovation ecosystem by demonstrating success across different project types and company sizes. While co-innovation projects tend to show more immediate, measurable outcomes, research and development projects demonstrate stronger achievement in foundational research and capability development. Both project types maintain high achievement rates while contributing differently to the innovation landscape, creating a robust system that effectively balances immediate project success with long-term capability building.

PROJECT OBJECTIVES NON-ACHIEVEMENT ANALYSIS - SYNTHESISED OVERVIEW

The analysis of non-achieved objectives reveals distinct patterns across project types, company sizes, and subsidy/turnover ratios. These patterns demonstrate systematic challenges in the Finnish innovation ecosystem, with varying impacts across different project categories.

Co-Innovation projects show several patterns in unachieved objectives, particularly among large companies with 0–1% subsidy/turnover ratios: 1) delays in software and hardware development, especially in complex systems like SoC and autonomous solutions, 2) difficulties in achieving targeted cost reductions, with several projects not meeting their 50% reduction goals, and 3) market-related challenges, with companies reporting difficulties in customer acquisition and market expansion. Technical integration issues are particularly prominent in multi-partner projects. Mid-sized companies in co-innovation projects face different challenges: 1) technical implementation difficulties, particularly in AI and advanced technology integration, 2) resource constraints affecting development timelines, especially evident in companies with 1–5% subsidy/turnover ratios, and 3) missed revenue targets due to market conditions and delayed commercialisation of new technologies. Resource-related challenges emerge through staffing difficulties and partner dependencies.

Co-research and development projects demonstrate distinct patterns of non-achievement: 1) technical difficulties in achieving desired product quality standards, 2) delays in regulatory approvals and compliance processes, and 3) slower than expected progress in process optimization. These projects also show challenges in meeting timeline objectives for research validation and testing, particularly in projects with higher subsidy/turnover ratios.

Small and micro companies show specific patterns of non-achievement: 1) business development challenges, particularly in revenue growth and market expansion, 2) technical development delays due to resource constraints and partner dependencies, and 3) difficulties in achieving international growth objectives. Companies with 6–10% subsidy/turnover ratios show particular sensitivity to these challenges.

TABLE 3: SUMMARY OF FINDINGS ON PROJECT TYPES, UTILISATION PLANS, BENEFITS, ACHIEVEMENTS, AND CHALLENGES

ASPECT	KEY INSIGHTS	DETAILS
Project Types	Co-Innovation, Co-Research, Development & Piloting each exhibit unique characteristics and strategies.	• **Co-Innovation**: Focus on commercialization (ecosystem collaboration, product pipeline integration). • **Co-Research**: Knowledge creation, university collaborations. • **Development & Piloting**: Short timelines, customer validation, rapid commercialization.
Utilisation Patterns	Clear distinctions based on project types, company sizes, and subsidy/turnover ratios.	• Large companies (Co-Innovation): Systematic integration, phased commercialization. • SMEs (Piloting): Focused technical solutions, customer feedback. • Higher subsidies (>5%): Experimental plans.
Cross-Cutting Themes	Shared priorities across all project types and sizes.	• Sustainability (energy efficiency, renewable tech). • Digital transformation (AI integration). • Ecosystem development and market trends emphasized.
Disclosed Benefits	Projects show both immediate impacts and long-term strategic advantages.	• **Co-Innovation**: Revenue growth (20-60%), enhanced tech capabilities, ecosystem partnerships. • **Co-Research**: R&D advancements, sustainable solutions, IP creation. • **Piloting**: Rapid technical validation, reduced risks, market entry.

Achievements	High achievement rates across project types, with clear distinctions by size and subsidy ratios.	• Large companies: Systematic outcomes (AI, robotics, market expansion). • Mid-sized companies: Balanced achievements (tech and business). • SMEs: Rapid validation, focused achievements.
Challenges	Distinct patterns of non-achievement reveal systematic obstacles by project type, size, and subsidy ratios.	• Large companies: Complex integration issues, market challenges. • Mid-sized companies: Resource constraints, technical delays. • SMEs: Revenue and market growth struggles.
Key Recommendations	Address challenges with targeted strategies to enhance overall success.	• Flexible resource allocation mechanisms. • Enhanced technical support for complex systems. • Stronger market development assistance (especially for SMEs).
Impact on Ecosystem	Balanced success across immediate and long-term objectives ensures ecosystem resilience.	• Immediate competitiveness through enhanced technologies. • Long-term capabilities in sustainability and digitalization. • Stronger collaboration networks.
Patterns by Company Size	Clear utilization and benefit patterns emerge for large, mid-sized, and small companies.	• Large companies: Systematic innovation, ecosystem leadership. • Mid-sized companies: Balanced focus on tech and market development. • SMEs: Rapid innovation, market testing.

Cross-cutting patterns emerge across all categories: 1) timeline management issues, with many projects experiencing delays in key deliverables, 2) resource allocation challenges, particularly in multi-stakeholder projects, and 3) technical complexity management difficulties, especially in innovative technology development. External factors such as market conditions, regulatory changes, and cost increases have impacted all project types.

The interaction between project type and company size reveals distinct patterns: 1) larger companies tend to face challenges in complex system integration and market expansion, 2) mid-sized companies struggle more with resource allocation and technical implementation, and 3) smaller companies face greater challenges in achieving business development objectives. Co-Innovation projects appear more sensitive to immediate market conditions, while Research and Development projects show more resilience to short-term market fluctuations but greater sensitivity to regulatory and technical barriers.

This comprehensive analysis suggests that while the Finnish innovation ecosystem is robust, it faces specific challenges based on project type and company size. The patterns indicate the need for: 1) more flexible resource allocation mechanisms, 2) enhanced support for technical implementation, particularly for complex systems, and 3) stronger market development support, especially for smaller companies. The findings highlight the importance of understanding these challenges for future programme design and support mechanisms. They demonstrate that while both project types maintain high overall success rates, they face distinct obstacles that require targeted support approaches. This understanding can help ensure that different types of companies receive appropriate assistance in overcoming their specific obstacles while maintaining the overall effectiveness of the innovation ecosystem.

2.3 R&D INVESTMENTS AND OTHER KEY FACTORS IN THE OPERATIONAL ENVIRONMENT

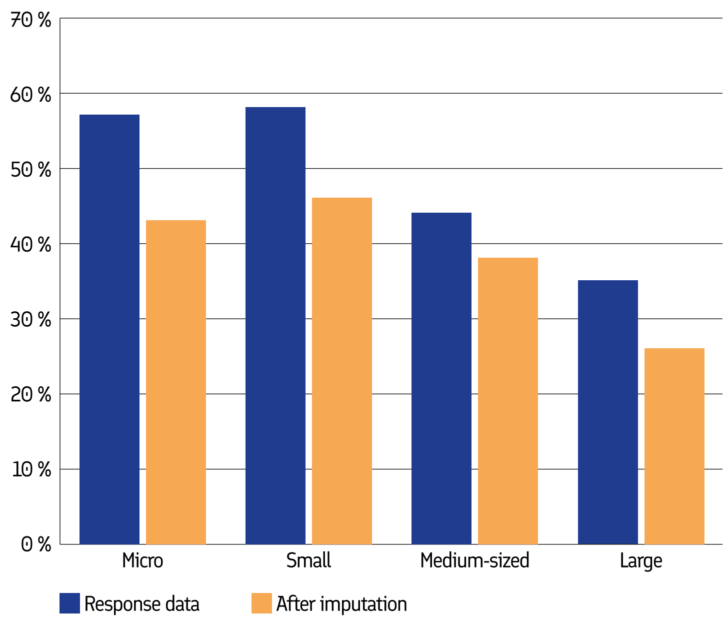
ANALYSIS OF R&D INVESTMENTS IN COMPANIES PARTICIPATING IN THE LCI PROGRAMME

This analysis investigates the impact of the LCI Programme on the R&D investments, both monetary and intangible, of participating companies. The focus is on corporations that received funding in 2020 and 2021, with a total of 85 companies included in the study. These companies were grouped by size, with large corporations representing most of the participants. More precisely, there were 18 micro, 12 small, 13 medium-sized, and 42 large companies in the sample.

DATA COLLECTION AND CHALLENGES

A primary challenge in evaluating the changes in R&D investments stems from the reliance on survey-based data in national R&D statistics. Companies' responses to these surveys are voluntary, leading to significant gaps, particularly among small and micro-sized enterprises. For the companies in this study over half of the small and micro-sized companies either did not respond or were not surveyed. While larger corporations provided more consistent data, the overall response rate was limited, complicating a more comprehensive analysis.

FIGURE 13. INFORMATION ON R&D INVESTMENTS IS LACKING 2020–2023.



Statistics Finland addresses these gaps through data imputation. For instance, if a company reported R&D investments of €100 million in 2020 and €120 million in 2022, the 2021 value might be imputed as €110 million. Despite this approach, substantial data gaps remain, particularly for smaller companies, which diminishes the reliability of the dataset.

For national statistics, responses from surveyed companies are further adjusted to represent their respective industries and size categories. This process multiplies available data to estimate broader trends.

The analysis reveals that while imputation and scaling techniques help to address missing data, they do not fully resolve the challenges posed by low response rates. This is particularly evident among smaller companies, where gaps in data hinder the ability to accurately evaluate changes in R&D investments.

ANALYSIS OF R&D INVESTMENTS USING EMPLOYEE CATEGORIZATION AND STATISTICAL MODELS

We addressed the challenge in micro-level R&D data by examining the relationship between companies' R&D investments and their workforce composition, focusing on firms participating in the LCI Programme. The study employs a novel categorization of employee roles to explore how workforce characteristics correlate with reported R&D investments. Data spanning 2010 to 2023 was utilised, alongside inputs from Statistics Finland.

APPROACH AND METHODOLOGY

The analysis categorized company personnel into five groups to assess their potential influence on R&D activity:

- **R&D Personnel** – Directly involved in research and development.
- **ICT Personnel** – Supporting technological capabilities.

- **Management Personnel** – Representing organizational capital.
- **Other Skilled Employees** – Higher education professionals, including engineers without advanced degrees.
- **Other Employees** – Lower-educated or less-skilled workers.

The categorization drew from job titles, educational background, and income registry data. While comprehensive, some data gaps existed: Educational data was available up to 2023. Job titles were sourced from income and work history records, but these were partially incomplete for the years 2022 and 2023.

Two models were employed to explain R&D investment levels: (1) a Statistics Finland data-based model using reported R&D and assisting personnel numbers; and (2) a categorization-based model incorporating the five employee categories, focusing on the four skilled categories. Explanatory variables included the amount of funding received from Business Finland; company size (micro, small, medium, large); industry classification (manufacturing, knowledge-intensive business services3, other industries) and temporal factors, such as the year of operation. The models aimed to estimate variability in R&D investments and compare their effectiveness against exact reported values.

RESULTS

The models performed well, explaining approximately 70% of the variability in R&D investments across companies from 2010 to 2023. Key findings include:

Both models aligned closely with actual reported figures for R&D investments, particularly at the aggregate level and across size and industry categories.

The categorization-based model (blue line) closely matched reported R&D figures (orange line), indicating that workforce composition effectively predicts R&D activity.

Discrepancies arose in the latest year (2023) due to missing data and imputation challenges. When imputed values were used, deviations increased, likely due to double-counting during calculations.

At the aggregate level, the study found that these firms contributed significantly to national R&D investments, with reported values nearing €5 billion. This aligns well with Statistics Finland's 2023 estimate of €8.4 billion, considering multipliers used in national projections.

IMPLICATIONS AND IMPACT OF THE LCI FUNDING

The results suggest that employee composition, particularly in skilled categories, serves as a reliable proxy for estimating R&D investments. The findings underscore the value of integrating workforce data into models for evaluating innovation activities. However, discrepancies in the latest year highlight the need for improved data collection and imputation practices.

FIGURE 14. MODEL STATISTICS: STATISTICS FINLAND DATA-BASED MODEL ON THE LEFT; CATEGORIZATION-BASED MODEL ON THE RIGHT.

Source	DF	Mean Square	F Value	Pr > F
Model	21	6,4E+11	3018,29	<.0001
Error	27500	2,12E+08		
Corrected Total	27521			

R-Square	Root MSE	YSYHT Mean
0,697417	14566,79	2 323 386

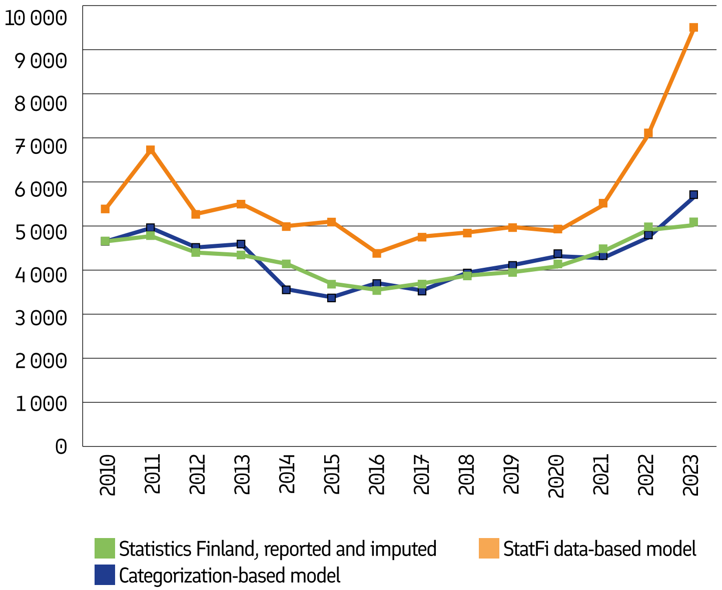
Parameter		Estimate	"Standard Error"	t Value	Pr > |t|
Intercept		2 197 386	4 660 919	4,71	<.0001
tutlkm		1 916 312	1 063 199	180,24	<.0001
mtklkm		4 519 171	4 503 618	10,03	<.0001
maksettuSumma		0,011723	0,0003	39,06	<.0001
vuosi	2010	-2327,32	5 089 885	-4,57	<.0001
vuosi	2011	-1758,09	5 097 149	-3,45	0,0006
vuosi	2012	-2291,27	5 051 574	-4,54	<.0001
vuosi	2013	-2134,16	5 013 019	-4,26	<.0001
vuosi	2014	-2158,18	5 046 133	-4,28	<.0001
vuosi	2015	-2053,37	5 057 489	-4,06	<.0001
vuosi	2016	-2254,35	5 132 709	-4,39	<.0001
vuosi	2017	-2014,25	516,52	-3,9	<.0001
vuosi	2018	-2178,31	5 282 457	-4,12	<.0001
vuosi	2019	-2257,53	5 325 647	-4,24	<.0001
vuosi	2020	-2495,19	5 260 088	-4,74	<.0001
vuosi	2021	-2232,18	5 254 506	-4,25	<.0001
vuosi	2022	-1394,5	5 299 157	-2,63	0,0085
vuosi	2023	0	.	.	.
luokka	KIBS	-485 982	2 189 816	-2,22	0,0265
luokka	Muu	1 348 095	2 585 159	0,52	0,602
luokka	Valmistus	0	.	.	.
PKSLuokitusEU 1		-806 178	267 973	-3,01	0,0026
PKSLuokitusEU 2		-1156,12	2 635 739	-4,39	<.0001
PKSLuokitusEU 3		-871 306	2 758 751	-3,16	0,0016
PKSLuokitusEU 4		0	.	.	.

Source	DF	Mean Square	F Value	Pr > F
Model	23	6,12E+11	3238,08	<.0001
Error	27498	1,89E+08		
Corrected Total	27521			

R-Square	Root MSE	YSYHT Mean
0,730343	13751,91	2 323 386

Parameter		Estimate	"Standard Error"	t Value	Pr > |t|
Intercept		-4195,11	4 501 987	-9,32	<.0001
grp_0 (skilled)		-919 478	1 454 299	-63,22	<.0001
grp_1 (T&K)		7 093 579	0,813675	87,18	<.0001
grp_2 (johto)		1 890 035	257 954	73,27	<.0001
grp_3 (ICT)		1 219 899	1 077 977	113,17	<.0001
maksettuSumma		0,011086	0,000284	39,03	<.0001
vuosi	2010	-214 532	4 817 025	-0,45	0,6561
vuosi	2011	1 553 073	4 823 295	0	0,9974
vuosi	2012	-127 674	4 779 214	-0,27	0,7894
vuosi	2013	6 911 936	4 742 892	0,15	0,8841
vuosi	2014	7 573 041	4 772 895	0,16	0,8739
vuosi	2015	2 113 844	4 784 052	0,04	0,9648
vuosi	2016	2 850 152	4 855 571	0,59	0,5572
vuosi	2017	309 004	4 885 964	0,63	0,5271
vuosi	2018	6 737 405	4 996 458	1,35	0,1775
vuosi	2019	3 528 849	5 036 235	0,7	0,4835
vuosi	2020	4 436 112	4 975 226	0,89	0,3726
vuosi	2021	5 080 489	4 969 832	1,02	0,3067
vuosi	2022	-500 327	5 003 528	-1	0,3173
vuosi	2023	0	.	.	.
luokka	KIBS	-2157,1	2 072 758	-10,41	<.0001
luokka	Muu	-616 108	2 452 552	-2,51	0,012
luokka	Valmistus	0	.	.	.
PKSLuokitusEU 1		5 205 103	2 646 761	19,67	<.0001
PKSLuokitusEU 2		4 881 893	2 600 767	18,77	<.0001
PKSLuokitusEU 3		4 227 543	2 685 386	15,74	<.0001
PKSLuokitusEU 4		0	.	.	.

FIGURE 15. COMPARISON BETWEEN THE REPORTED AND IMPUTED R&D INVESTMENT DATA (M€).



The analysis demonstrates that categorizing workforce roles enhances our understanding of R&D investment dynamics. Further refinements in data availability and processing could bolster the accuracy of such models, aiding policymakers and funding bodies in assessing the impact of investment programmes on innovation ecosystems.

On the basis of the analysis above, we can conclude with an analysis of R&D investment trends and workforce dynamics among companies involved in the LCI funding programme. Using both model-based estimations and data reported to Statistics Finland, the findings reveal significant growth in R&D activities and personnel numbers over recent years.

SUMMARISING THE KEY FINDINGS ON R&D INVESTMENTS

From 2020 to 2023, R&D investments among these companies increased significantly: Statistics Finland's imputed data indicates a rise of approximately €400 million. The model-based estimates suggest an even larger increase of €800 million, although this higher figure warrants cautious interpretation. A balanced estimate likely falls around an increase of €600 million.

The discrepancy between the imputed figures (orange line) and the model-based estimates (grey line) in Figure 4 stems from two key differences:

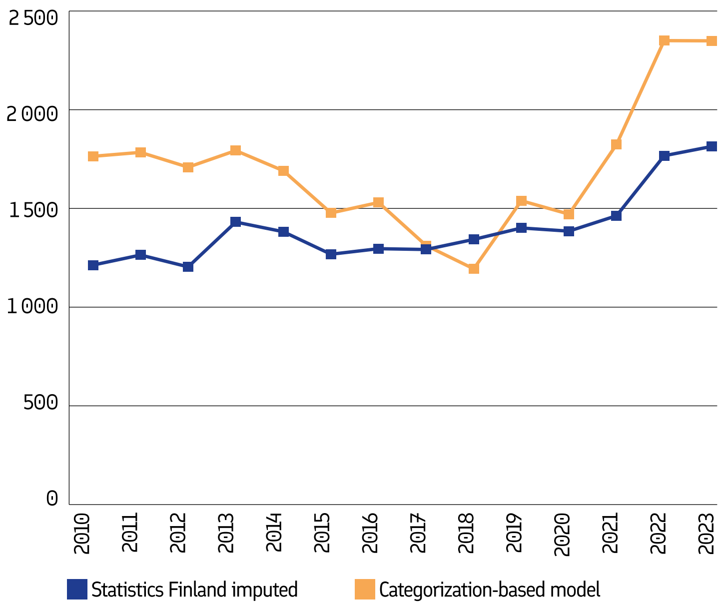
- **Data Coverage**: The imputed figures are based on 31 company responses, whereas the model covers all 42 companies in the sample.
- **Timing of Growth**: Imputed data attributes the increase primarily to 2021 onward, whereas the model indicates growth beginning earlier, around 2020.

INSIGHTS FROM CASE STUDIES

To validate the model, selected company cases were reviewed in more detail, comparing reported values from Statistics Finland, model estimates, and annual report data:

- **Kone and Stora Enso**: The model's R&D investment estimates closely matched figures disclosed in their annual reports.
- **Neste**: The model significantly overestimated R&D investments, likely due to the high valuation of R&D personnel in the estimation approach. Neste's annual report indicated a more modest figure than both the model and Statistics Finland's survey.

FIGURE 16. DEVELOPMENT OF R&D INVESTMENTS IN LCI PROGRAMME COMPANIES 2010–2023 (M€).



These case studies highlight the uncertainty surrounding R&D investment estimates, especially when relying on imputed or modelled data.

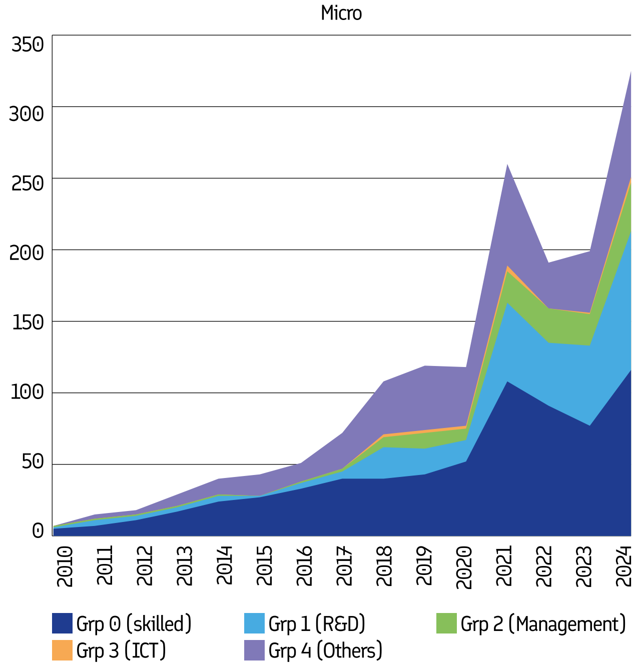
WORKFORCE TRENDS

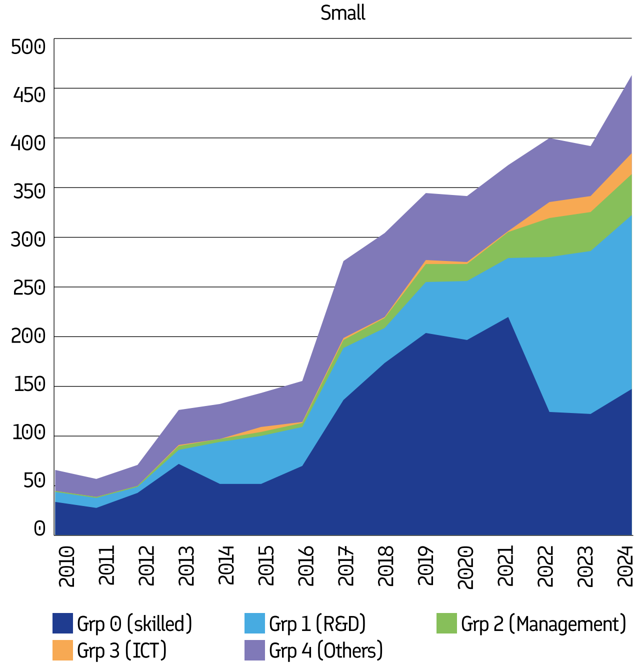
A clearer and more robust trend emerged in workforce dynamics. From 2020 to 2023, the number of R&D, ICT, and other skilled personnel increased by approximately 5,000 employees across the companies studied—representing a 20% growth. Notably, the proportion of skilled employees (R&D, ICT, and other skilled personnel) rose from 54% to 62% of the workforce. We can expect that this growth in intangible capital reflects companies' increasing focus on innovation and capability building. Preliminary data from 2024 suggests that this positive development in workforce composition is continuing.

CONCLUDING ON RDI INVESTMENTS IN PARTICIPATING COMPANIES

While uncertainties exist in precise monetary R&D investment estimates, particularly for smaller companies, the analysis strongly indicates substantial growth in both R&D investments and skilled workforce numbers among LCI Programme participants. These trends highlight the programme's positive impact on fostering innovation and enhancing intangible capital, contributing significantly to Finland's R&D ecosystem. Future research should prioritize

FIGURE 17. DEVELOPMENT OF THE NUMBER OF EMPLOYEES IN THE FIVE EMPLOYEE GROUPS 2010 – 2024.



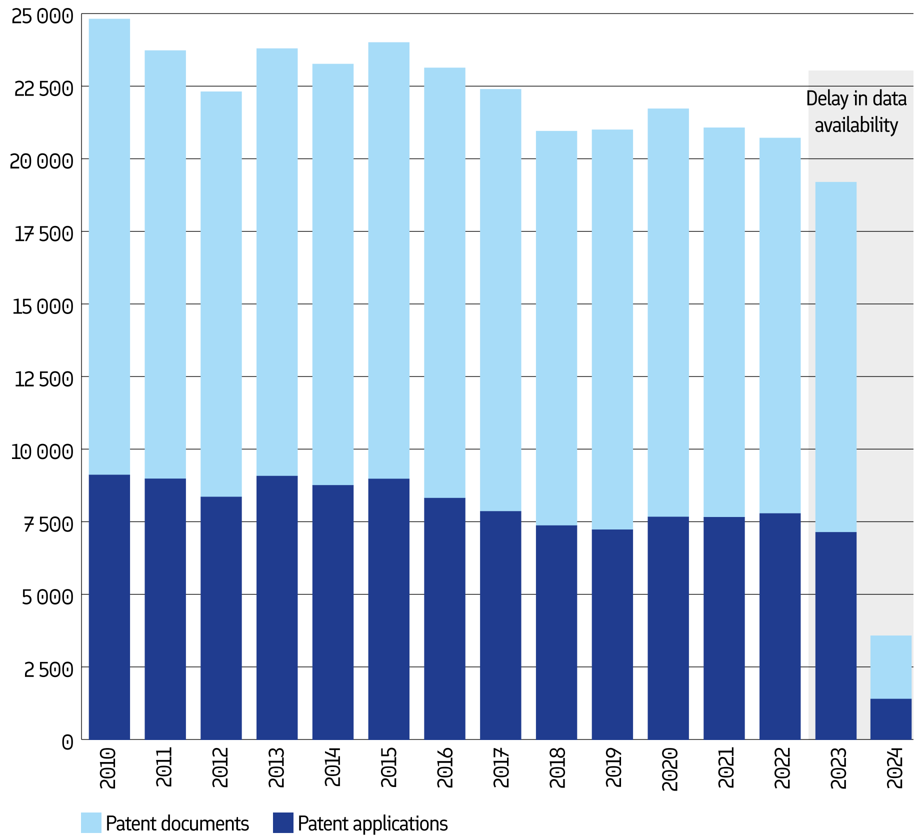


improved data collection and imputation methods, particularly for SMEs, to enhance the accuracy and reliability of R&D investment estimations. The model's reliance on employee counts is more reliable for larger companies, but less so for smaller ones, where small numerical changes result in large percentage variations. Despite these limitations, the positive trends observed in smaller companies based on available Statistics Finland data remain noteworthy.

2.4 MAIN RESULTS OF THE IPR-DATA ANALYSIS

As part of the evaluation, a descriptive statistical analysis was conducted on the IPR activity of companies participating in the LCI instrument. The analysis did not aim to perform a statistical impact or comparative analysis using a matched control group, as finding a suitable control group is challenging and comparing ecosystems directly is not strictly relevant. The IPR data was used to examine whether changes in the IPR activity and activity level of the LCI companies can be identified based on the analysis.

FIGURE 18. NATIONAL TOTALS OF PATENT DOCUMENTS AND APPLICATIONS (DARK BLUE) BY PUBLICATION YEAR BETWEEN 2010–2024. SOURCE: XAMK, IPR-FINLAND



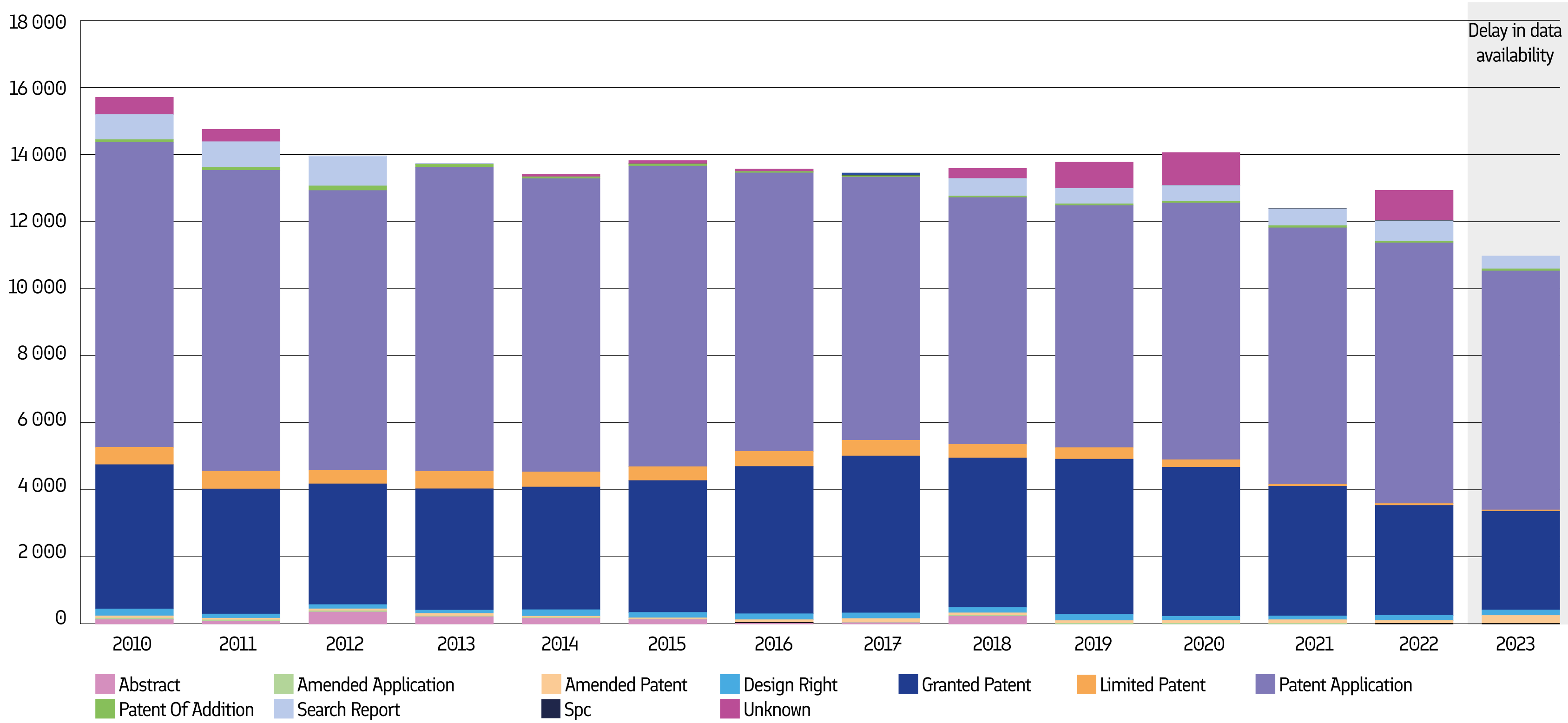
The analysis began with a brief examination of the national trends in patenting activity, with a specific focus on the development of patent applications over time. Following this, the analysis delved deeper into the patenting activity of companies funded through the LCI instrument, covering a longer timeframe from the 2010s to the 2020s. Particular attention was paid to developments in the 2020s in comparison to earlier periods. Finally, the analysis incorporated project-level reporting from LCI-funded initiatives. This allowed for a parallel evaluation of general trends in patent applications within the ecosystems and the patenting activity reported in specific projects. This comparative approach provided insights into the alignment between observed patenting trends and self-reported activity by ecosystem participants.

The analysis utilised the IPR Finland database, which is an open database developed by XAMK. It can be used to study the activities of different companies and industries in protecting intellectual property rights and their development activities. IPR Finland contains information on patents, trademarks, design rights and public R&D support and funding. The data mainly covers the years 2010–2024, and updates are added as new information is published. It is important to note that there is a significant inaccuracy (about 1–1.5 years) towards the end of the registration data range, as the data is updated and becomes public. Also, patents of foreign companies are not (usually) registered to a Finnish subsidiary. The analysis here examines all patent documents, but especially patent applications of LCI companies (see the explanations in the appendices for more details).

The figure 18 shows the national totals of published patent documents and applications from 2010 to 2024, categorized by publication year. The dark blue bars represent the trend in patent applications, illustrating changes in patenting activity over this period. From 2010 to 2024, there is an observable decline in published patent activities. However, the dark blue bars, which indicate patent applications, show a slightly increasing trend in the number of patent filings in recent years.

The figure 19 below shows a similar overview of patent documents but by filing year, which provides insight into when companies initiated the patent process. The number

FIGURE 19. NATIONAL TOTALS OF PATENT DOCUMENTS (FILING YEAR) BETWEEN 2010–2023. SOURCE: XAMK, IPR-FINLAND



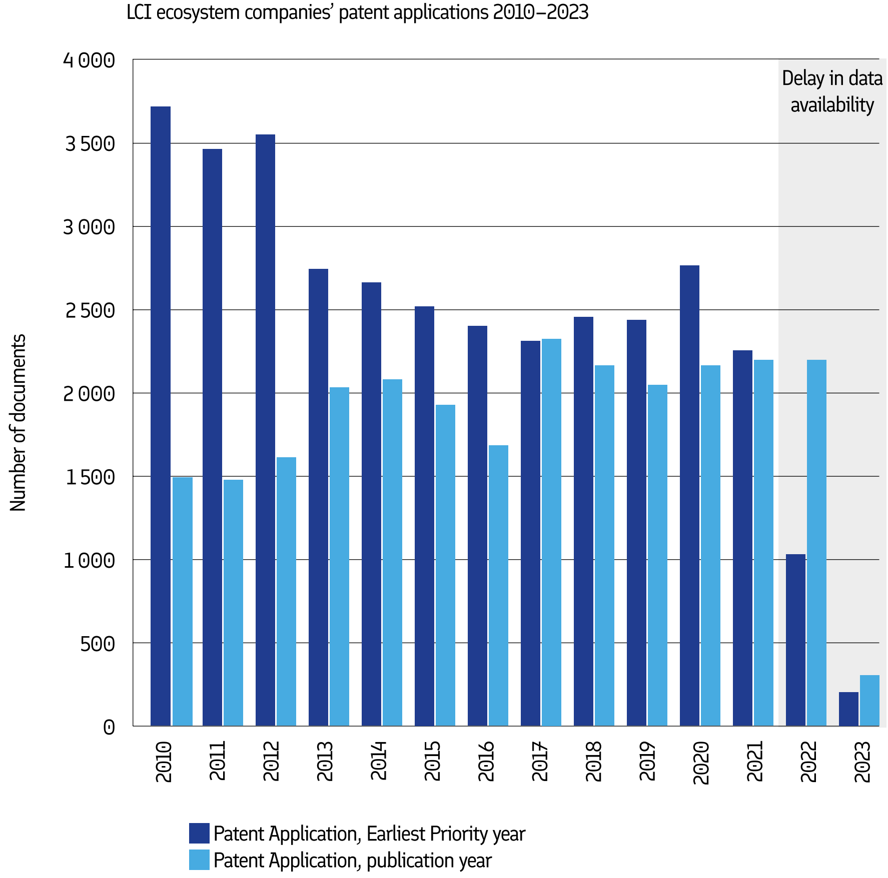
of patent applications have slightly grown in 2020–2022 compared to previous years in 2010's.

MAIN RESULTS OF PATENTING PER ECOSYSTEM

The next figure (Figure 20) shows the patent documents of LCI companies by both earliest priority year and publication year. The distribution of patent application numbers by priority and publication year shows that the number of published applications follows the priority applications with a lag of a few years, which is expected. The trends in patent activity are quite the same than the national average. The patenting activity of companies funded through the LCI instrument has changed significantly during the period 2010–2023. In the early years (2010–2013), the number of patent applications was notably high, especially when examining the earliest priority year of applications. After 2014, the number of patent applications started to decline. This is particularly visible in the applications' earliest priority years. From 2018 onwards, the numbers stabilized at a relatively consistent but lower level compared to the early 2010s. There is a slight increase in patent applications and granted patents in 2020's if we look at the publication year. However there has been no significant growth in patenting in recent years in average. The delay in data availability after 2022 is evident, as the figures for these years are still incomplete.

The table 3 below provides a snapshot of the varying levels of patenting activity among different Veturi ecosystems. The data represents 23 ecosystems involved in the LCI instrument. Each ecosystem comprises a mix of higher education institutions (HEIs), research institutions (RIs), and companies. The ecosystems consist of a broad collaboration from 19 higher education institutions, 8 research institutions, and 299 companies. Within the period 142 companies have at least one documented patent, which accounts for 47% of all companies in the ecosystems. A total of 77 companies have actively filed patent applications in recent years, representing 26% of all companies. This indicates that while many companies hold patents, fewer are actively pursuing new applications in the most recent timeframe. Ecosystems like Fortum&Metsä, Neste, Nokia2 Edge, and Sandvik are consistently active in patenting, both overall and in the 2020s. Some ecosystems, such as Valmet, exhibit increased focus on recent patent applications.

FIGURE 20. LCI ECOSYSTEM COMPANIES' PATENT APPLICATIONS AND GRANTED PATENS BETWEEN 2010-2023
(earliest priority year & publication year).



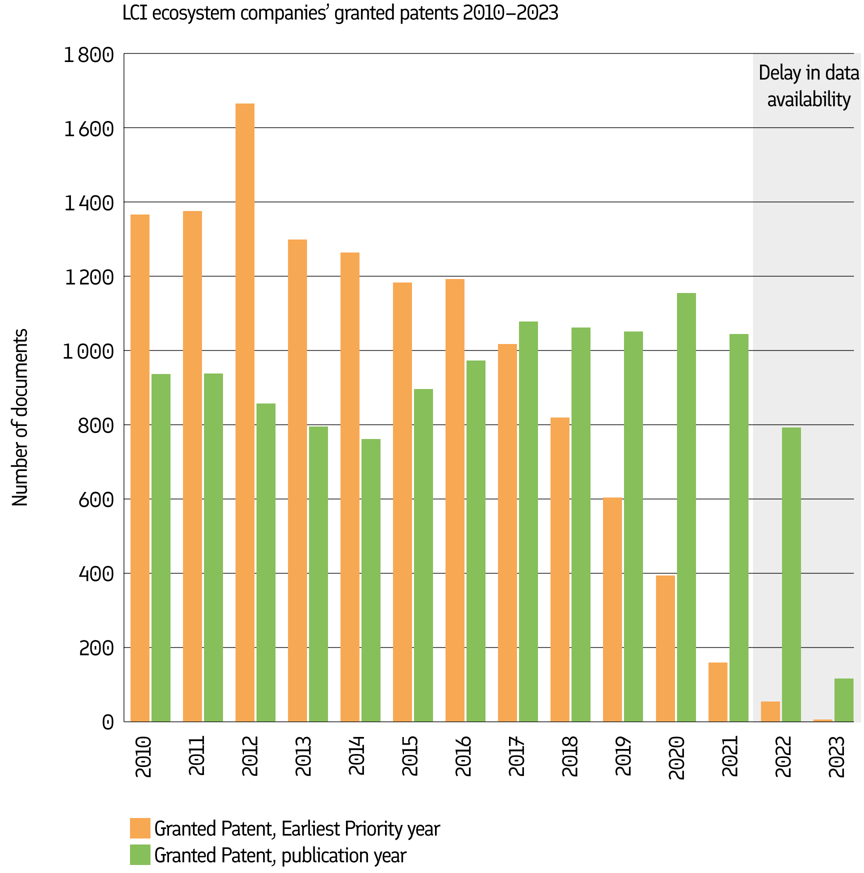


TABLE 4. PATENTING ACTIVITY BY ECOSYSTEM.

ECOSYSTEM	HIGHER EDUCATION INSTITUTIONS	RESEARCH INSTITUTIONS	COMPANIES	COMPANIES WITH PATENT DOCUMENTS 2010–2024	%	COMPANIES WITH PATENT APPLICATIONS 2020–2024	%
ABB	9	1	29	12	41 %	6	21 %
Bittium	4	1	13	8	62 %	4	31 %
Borealis	9	4	19	9	47 %	4	21 %
Danfoss	2		8	5	63 %	4	50 %
Fortum&Metsä	12	2	38	26	68 %	15	39 %
Kempower			1	1	100 %	1	100 %
Kone	7	4	32	11	34 %	9	28 %
Konecranes	5	1	16	6	38 %	3	19 %
Meyer	11	1	28	8	29 %	3	11 %
Mirka	8	3	17	13	76 %	6	35 %
Neste	11	4	10	7	70 %	7	70 %
Nokia	6	1	30	15	50 %	8	27 %
Nokia2 Edge	11	2	42	21	50 %	10	24 %
Orion	3		1	1	100 %	1	100 %
Patria		1	2	1	50 %		
Picosun	2	2	10	6	60 %	3	30 %
Ponsse	4	1	19	12	63 %	3	16 %
Sandvik	6	2	18	13	72 %	10	56 %
Tieto	7	2	19	4	21 %		
Valio	1		1	1	100 %	1	100 %
Valmet	12	3	22	10	45 %	9	41 %
Wärtsilä	7	1	14	5	36 %	5	36 %
Wärtsilä_WISE			1	1	100 %	1	
23 ecosystems	19 HEI's	8 RI's	299 Companies	142 Companies with patent documents 2010–2024	47 %	77 Companies with patent applications 2020–2024	26 %

Table 4 below shows Nokia2 Edge has the highest number of total patent documents (16,915) and applications (12,040) from 2010–2024. Fortum&Metsä follows closely with 12,011 patent documents and 7,621 patent applications. Nokia and Kone also exhibit significant patenting activity. Ecosystems like Nokia2 Edge and Nokia are particularly active in the 2020s, with 1,826 and 1,848 patent documents, respectively, contributing to 11%–12% of their total patent documents. Similarly, their 2020s patent applications contribute 14%–15% of their total applications, showing sustained patenting activity. Larger ecosystems such as Nokia and Nokia2 Edge maintain significant patent volumes, with the 2020s contributing a meaningful share of their activity, reflecting ongoing leadership in innovation. Ecosystems like ABB and Fortum&Metsä have smaller shares of their total patent activity in the 2020s (e.g., 7%–8% for patent documents and applications). While the larger ecosystems dominate patenting numbers, smaller ecosystems like Sandvik, Bittium, and Ponsse show focused activity in specialized sectors. Their innovation strategies may rely less on high patent volumes and more on niche expertise or partnerships. Companies like Kempower stand out with an overwhelming majority of their patent applications originating in the 2020s, showcasing a sharp focus on recent innovations. Konecranes and Bittium also exhibit notable shares of 2020s activity, emphasizing their strategic focus on new technologies.

MAIN RESULTS OF PATENTING PER LCI PROJECTS

In addition to the IPR statistical data, LCI organisations' own reporting on patenting was also examined. Altogether 39 companies and 9 higher education institutions and research institutions reported patenting in LCI projects. Table 5 show if the ecosystems have themselves reported patenting in LCI projects. According to the LCI report, 13 out of 23 ecosystems and 13% of the LCI companies have reported on patenting (39/299 LCI companies have reported patent activities in their projects; as a comparison 77 companies have patent applications 2020–2024). Patenting-related work seems to be an important part of activities for many ecosystems. This is especially important in the Fortum&Metsä ecosystem. But as we can see, patenting it is still not at the center of a large proportion of projects and ecosystems.

Looking closer to the content of the reported patent activity there is a significant focus on environmentally friendly innovations, such as biobased materials, sustainable polymers, and methods for biomass utilisation. Patents often address novel material formulations aimed at improving performance or sustainability in industrial processes. Also, the integration of artificial iurasurement methods have also been key targets for patent filings.

TABLE 5. PATENTING ACTIVITY BY ECOSYSTEM – COMPARISON BETWEEN 2010-2024 AND 2020-2024.

ECOSYSTEM	SUM OF PATENT DOCUMENTS 2010-2024	SUM OF PATENT APPLICATIONS 2010-2024	%	SUM OF PATENT DOCUMENTS 2020-2024	SUM OF PATENT APPLICATIONS 2020-2024	SHARE OF 20'S PATENT DOCUMENTS OF TOTAL TIME PERIOD 2010-2024	SHARE OF 20'S PATENT APPLICATIONS OF TOTAL TIME PERIOD 2010-2024
Fortum&Metsä	12 011	7 621	63 %	800	577	7 %	**8 %**
Nokia2 Edge	16 915	12 040	71 %	1 826	1 670	11 %	**14 %**
Kone	5 868	3 781	64 %	361	338	6 %	**9 %**
Nokia	15 887	11 329	71 %	1 848	1 667	12 %	**15 %**
ABB	4 123	2 357	57 %	295	200	7 %	**8 %**
Valmet	8 689	5 419	62 %	692	501	8 %	**9 %**
Borealis	3 253	2 165	67 %	108	84	3 %	**4 %**
Meyer	144	89	62 %	19	12	13 %	**13 %**
Sandvik	2 591	1 697	65 %	246	213	9 %	**13 %**
Konecranes	39	29	74 %	12	10	31 %	**34 %**
Tieto	74	33	45 %	1	0	1 %	**0 %**
Wärtsilä	2 706	1 945	72 %	92	80	3 %	**4 %**
Neste	6 219	3 894	63 %	363	276	6 %	**7 %**
Wärtsilä_WISE	2 015	1 519	75 %	30	29	1 %	**2 %**
Ponsse	670	401	60 %	32	20	5 %	**5 %**
Mirka	6 360	4 121	65 %	414	320	7 %	**8 %**
Bittium	1 412	865	61 %	166	157	12 %	**18 %**
Danfoss	426	255	60 %	31	30	7 %	**12 %**
Picosun	661	354	54 %	56	35	8 %	**10 %**
Patria	3	1	33 %	0	0	0 %	**0 %**
Kempower	22	12	55 %	17	10	77 %	**83 %**
Valio	404	254	63 %	12	7	3 %	**3 %**
Orion	715	404	57 %	44	43	6 %	**11 %**

TABLE 6. REPORTED PATENTING IN LCI PROJECTS.

ECOSYSTEM	LCI REPORTED PATENTING (SUM OF PATENTS FILED)	SUM OF PATENT APPLICATIONS 2020–2024
Fortum&Metsä	91	577
Nokia2 Edge	6	1670
Kone	27	338
Nokia	14	1667
ABB	2	200
Valmet	13	501
Borealis	4	84
Meyer		12
Sandvik	16	213
Konecranes		10
Tieto		
Wärtsilä	(several)	80
Neste	5	276
Wärtsilä_WISE		29
Ponsse		20
Mirka	2	320
Bittium	8	157
Danfoss		30
Picosun		35
Patria		
Kempower		10
Valio		7
Orion		43

There are several examples of joint research projects in patenting, where companies, universities and research organisations combine their expertise. Some examples involve collaboration in invention disclosures (e.g. methods developed in collaboration with consortium members) and on the other hand collaborative patent applications, where either a company or a university can take the lead based on commercial potential.

CONCLUDING ON THE PATENTING ACTIVITIES IN LCI ECOSYSTEMS

Companies that have received funding from the LCI instrument and are involved in the ecosystems are, on average, very active in IPR activities. Almost half of the companies involved in LCI have been active in patenting during 2010–2024 and 1/4 have been active in 2020's.

The number of patent applications from LCI companies has accounted for an average of 28% of the patent applications in the IPR-Finland database during the years 2020–2022.

In all ecosystems there are 142 (47%) companies with patent documents 2010–2024 and 77 (26%) companies with patent applications 2020–2024. There are some ecosystems that have been very active in 2020's.

Patenting-related work seems to be an important activity of many ecosystems. Furthermore, company-research organization collaboration seems to play a very important role in many reported patenting activities. This is especially important in the Fortum&Metsä ecosystem. However, all companies involved in the Veturi ecosystems that have reported on patenting have been active in patenting before and are active in IPR activities in general.

Despite this, there are several companies for which patenting reported in the LCI ecosystems was the main part of their IPR activity in the 2020s. Based on the analysis and the initial implementation of LCI, it is not possible to distinguish a significant growth and broad impact on patenting in these ecosystems.

However, we must also consider the qualitative significance and innovation potential of patenting activities, which may be significant despite the volume so far. There is a significant focus on environmentally friendly innovations, advances in new technologies and novel methods for improving performance or sustainability in industrial processes and optimizing manufacturing processes. Also, the integration of artificial intelligence in areas like medical diagnostics, workflow modelling may have significant impact in the future. The qualitative patent reporting data shows that LCI funding has added value to patenting and the exploitation and commercialisation of research knowledge. This is evident, for example, in 1) faster innovation cycles: By pooling resources and expertise, projects can move from discovery to commercialisation more efficiently, 2) Market relevance: Industry involvement ensures that patented innovations closely match market requirements and challenges and 3) Funding and resources: Public-private partnerships enable access to wider funding pools, facilitating impactful R&D projects.

2.5 ECOSYSTEM BENEFITS

The ecosystem development has been greatly boosted by the LCI activities, though it is not the only contributing factor. It is also dependent on the companies involved, their willingness to co-create and share, and even the personal contacts and trust created in the networks. The ecosystems themselves are often quite personified and dependent on the quality of collaboration and human interaction.
The technology roadmaps have provided an excellent platform for shared sense-making and coming together on an equal basis.

Some of the main results and successes identified in the interviews included ecosystem development itself, i.e. how during the programme, new ecosystems have emerged, and cooperation models have developed. For example, the sprint model has proven effective in developing innovations. The focus on sustainability and sustainability transition, as well as responsible research and innovation has been a source of inspiration and value added. Sustainability has become a significant theme across the industries, with the reduction of the carbon footprint becoming central focus with most ecosystems.

Digitalisation has been another key driver of industrial renewal and development, as has improved information and data security.

International cooperation has clearly been boosted, and the LCI programme has promoted international networking and cooperation, which has brought new business opportunities and investments to Finland.

Challenges worth noting and acting upon by Business Finland identified in the interviews included observations on the synergies and need for better integration across funding organisations, e.g. many of the interviewees pointed out that there are systemic problems in the Finnish funding system, and closer cooperation between Business Finland and the Academy of Finland could improve the situation.

Programme instruments could be better suited for cross-ecosystem collaboration, and of course to engaging international partners.

In most cases the programmes got positive funding decisions in spring 2023 and got up and running soon after this. This means that most LCIs have 1,5 years operational activity behind them, which is still quite a short time for creating functional ecosystems. Clear indications of success are already visible however.

A summary of benefits and challenges of LCI activities and operations thus far based on the interviews, is found in the table below

TABLE 7: SUMMARY OF ECOSYSTEM BENEFITS AND LCI IMPACT, AS REPORTED IN THE INTERVIEWS

Benefits	**Development and deepening of ecosystems**: • New ecosystems have emerged, and collaboration models have evolved, with the sprint model proving effective for innovation development. The collaboration has significantly expanded the research and development portfolio of the LCI companies, thereby allowing for larger projects and increased team sizes. This has enabled the recruitment of RDI personnel and strengthened partnerships with research institutions and universities, leading to more active collaboration and the evaluation of numerous project ideas annually. The programme has also broadened the RDI networks, particularly within Finland, by selecting topics for research with Finnish partners. • In many cases LCI operations have taken off exponentially (e.g. Valio's goal was to have 100 partners in five years, but already now, after nine months of operation, there are 140 partners in the ecosystem), indicating also the willingness of food system operators to cooperate for Food 2.0. ecosystem benefits. • The LCI funding has clearly enabled long-term work and finding clear research partners. This has in many cases led to deeper collaboration and a better understanding of the partners' competencies and infrastructures, which has been able to accelerate the progress of projects. • In some cases, the implementation of LCI activity has made it possible for the LCIs to become pioneers in defining operating methods very freely and openly. • The creation of the roadmap has significantly helped in clarifying the objectives and communicating interests to partners, which has led to step change and improved quality of cooperation. The partners in the ecosystem share the same vision and want to work together to achieve it. This vision has helped them find common solutions and collaborate effectively. • Personal relationships and trust have been central to the success of the ecosystem. The extensive networks of coordinators and key personnel and previous cooperation with companies have helped to create a strong foundation for cooperation. • Responsibility: Responsibility has become significant, particularly in medical devices, where the environmental footprint has been reduced. • Digitalisation: Digitalisation has been a central factor in many cross-ecosystem activities, enhancing industrial development and improving cybersecurity. • International Cooperation: The programme has promoted international networking and cooperation, bringing new business opportunities and investments to Finland.

Effects and impacts thus far	• Business Development: The primary goal of business development is expected to manifest in future business growth. • Ecosystem Development: The advancement of data-driven solutions and ecosystem platforms has progressed, despite some challenges. • The collaboration has led to the creation of several significant projects for Engine companies and their partners, such as the development of the Power-to-X infrastructure. • It has fostered cooperation and the formation of value chains, although commercial partnerships have not yet developed as expected in most cases. • The programme has significantly increased inter-company collaboration and intensified cooperation with research institutions. • The most important goal of Valio LCI for instance is to create a sustainable food system. Such mission-driven goals are essential for sustainability transitions and imply using natural resources sustainably, recycling materials and reducing the carbon footprint of production. • The LCI activity has significantly enhanced collaboration between companies and research organizations, leading to the development of new products and services. • It has fostered trust and transparency among ecosystem participants, which is crucial for successful cooperation. • The activity has also led to the creation of sustainable practices and innovations, such as the development of a carbon footprint model and the integration of sustainability data into design models. • The Engine programme has helped participants better utilise other innovation and industrial policy development tools, and BF’s role in fostering closer collaboration and providing support here has been appreciated.

Challenges identified	• Funding System: Systemic issues in Finland's funding system were highlighted, suggesting closer collaboration between Business Finland and the Academy of Finland could improve the situation. • Programme Instruments: content and formats of programme instruments could sometimes be better tailored to better meet the LCI needs, e.g. cross-Ecosystem collaboration. • Processing Times and Decision-Making Criteria: Variable processing times and decision-making criteria pose challenges, particularly in different phases of commercialization. • Support and Coaching: While generally adequate, Business Finland's support and coaching in project-related technical questions have room for improvement. • One significant challenge identified has been ensuring the continuity of the ecosystem after the end of the funding period. This requires quite a lot of planning and cooperation with different actors to ensure that the transition goes as smoothly as possible. It has been important to strike a balance between competition and synergies, ensuring that cooperation is mutually beneficial. In some cases a new more open operational culture has emerged, partly thanks to the LCI activities. • The funding for the LCI programme is tied to a five-year period, which means that projects must be launched within the first three years. This has in some cases created pressure for early enough project planning. • One of the main challenges is the long response time for project preparation and decision-making, which can take up to a year for preparation and six months for decisions. • There is a need for more flexible and longer-term funding models, as the current two-year funding period can cause issues within organizations6. • Building networks and trust among participants is time-consuming and requires significant effort, and the time perspective here should not be underestimated.

3. CONCLUSIONS AND RECOMMENDATIONS: THE SIGNIFICANCE AND IMPACTS OF RESEARCH-BUSINESS COLLABORATION IN FINLAND

To conclude on the insights from LCI Activities and ecosystem cooperation, below we provide a summary of the results from the analysis per evaluation question. Here it is worth noting that as many of the LCIs are still in the early stages of their activity, some of the observations of "non-achievement" simply relate to the stage of implementation, and are not criticisms of non-achievement as such.

3.1 WHAT HAS BEEN THE SIGNIFICANCE OF COMPANY-RESEARCH ORGANIZATION COLLABORATION?

The LCIs are clearly at very different stages of maturity and implementation, with some just having started and others already finalised their implementation (e.g. ExpandFibre). A commitment to 5 year-collaboration is a significant com-

mon endeavour and the signs are positive as to the mobilisation, shared commitment and objectives achieved to date.

The analysis of company-research organization collaborations reveals distinct patterns across different project types, company sizes, and subsidy/turnover ratios, demonstrating the significance of research partnerships in the Finnish innovation ecosystem. Large companies with 0-1% subsidy/turnover ratios demonstrate three primary collaboration patterns: 1) extensive multi-partner networks, often involving 4-6 research organizations per project, 2) strategic long-term partnerships with key research institutions, particularly with VTT and major universities like Aalto, Tampere, and LUT, and 3) focused research collaboration aligned with specific technical challenges. Notable examples include collaboration focusing on sustainability technologies, digital solutions, and advanced materials research.

Mid-sized companies show more targeted collaboration approaches: 1) partnerships focused on specific technical developments, particularly with VTT and regional universities, 2) dual-partnership models combining research institution expertise with industry knowledge, and 3) collaborative projects emphasizing practical implementation and validation. These companies often maintain 2-3 research partnerships per project, with a clear focus on applied research and development.

Small and micro companies demonstrate distinctive collaboration patterns: 1) focused partnerships with single research institutions, often aligned with specific technical needs, 2) regional collaboration with nearby universities and research centres, and 3) participation in larger consortium projects to access broader research networks. These companies typically maintain 1-2 research partnerships, with emphasis on practical application and market validation.

Cross-cutting collaboration themes emerge across all categories: 1) strong focus on technical validation and testing through research partnerships, 2) increasing emphasis on sustainability-related research collaboration, and 3) growing importance of digital technology partnerships, particularly in AI and automation research.

The interaction between project type and collaboration patterns reveals: 1) co-innovation projects showing higher numbers of simultaneous research partnerships, particularly among larger companies, 2) research and development projects demonstrating more focused, long-term research relationships, and 3) pilot projects typically involving fewer but more intensive research partnerships.

This comprehensive collaboration pattern supports the Finnish innovation ecosystem by: 1) enabling knowledge transfer between industry and academia, 2) providing companies access to specialized research infrastructure and expertise, and 3) facilitating the development of new technologies and solutions through shared resources and capabilities. The varied collaboration patterns across different project types and company sizes contribute to a robust national innovation system that effectively combines academic research with industrial application.

The findings highlight the crucial role of research organization partnerships in supporting innovation across different company sizes and project types, while suggesting the need for: 1) continued support for diverse collaboration models, 2) enhanced mechanisms for smaller companies to access research partnerships, and 3) strengthened platforms for knowledge sharing between industry and academia.

Through statistical and contextual analysis, the additionality of Business Finland funding in this analysis is primarily assessed through the relationship between funding received and changes in R&D investments and workforce composition among participating companies. Two key aspects of additionality were considered:

MONETARY R&D INVESTMENTS:
The analysis evaluates whether companies that received funding exhibited increased R&D investments compared to expected baseline levels, using both imputed data from Statistics Finland and model-based estimates. The results suggest a significant increase in R&D investments, particularly among larger companies, where model estimates closely align with reported figures. This implies a positive additionality effect for Business Finland funding, as companies appear to invest more in R&D than they might have in its absence.

WORKFORCE COMPOSITION AND INTANGIBLE CAPITAL:
Workforce trends provide further evidence of additionality, with a 20% increase in skilled employees across R&D, ICT, and other specialized roles from 2020 to 2023. The rising share of skilled personnel indicates that companies are not only increasing monetary investments but also building their intangible capital, which is critical for sustaining innovation.

3.2 TO WHAT EXTENT HAS BUSINESS FINLAND'S LCI ALSO GENERATED KNOWLEDGE SPILLOVERS AND OTHER EXTERNALITIES BEYOND THESE ECOSYSTEMS?

The identified knowledge spillovers and externalities from company reporting demonstrate impact in several key areas.

Technical knowledge dissemination is evidenced through:
1. development of new measurement methods and simulation models,
2. advancements in materials science, and 3) enhanced understanding of sustainable technologies.

Industry-wide impacts include:
1. contributions to circular economy development,
2. support for new business models aligned with climate targets, and 3) enhancement of European technical expertise, particularly in microelectronics.

Economic externalities are demonstrated through
1. increased R&D investments exceeding targets,
2. growth in skilled personnel demand, and
3. improved funding opportunities, particularly in smart city initiatives. While these spillovers appear significant, the reporting focuses primarily on direct project outcomes rather than broader ecosystem effects, suggesting either limited documentation of wider impacts or a need for more systematic tracking of knowledge spillovers beyond the immediate ecosystem.

3.3 WHAT HAS BEEN THE SIGNIFICANCE OF COMPANY-RESEARCH ORGANIZATION COLLABORATION?

The collaboration between companies and research organizations within the LCI ecosystems has been crucial in fostering innovation and addressing future challenges. This collaboration has led to increased R&D investments, job creation, and positive impacts on Finnish society. In some cases it is difficult to judge whether the higher degree of RDI and patenting activities are the cause or result of LCI collaboration.

Collaboration between companies and research organizations plays a central role in the ecosystems' innovation strategies. In ecosystems such as Fortum&Metsä, patenting-related work is closely tied to company-research partnerships.

There is a clearly increased activity in RDI between Engine companies LCIs and SMEs in their value chains. Collaboration across ecosystems and between Engine companies has also increased importantly. Partnerships have fostered the development of intellectual property, particularly in sectors requiring advanced R&D. The data indicates that many reported patents are outcomes of such collaborations.

The evaluation has identified various types of additionality, including input additionality (cooperation in LCI ecosystems compared to investments and cooperation with SMEs) and behavioural additionality (changes in the behaviour of firms and research organizations as a result of the programme). These changes have led to new ways of working (e.g. across disciplinary silos, between companies and research organisations), increased collaboration (within value chains, but increasingly also across ecosystems), and enhanced innovation capabilities)

The importance of business-research cooperation in generating knowledge spillovers and other externalities beyond the ecosystems has also been important. This cooperation has contributed to wider societal effects and sustainable development, including environmental themes, serving missions such as green transition/sustainability transition, carbon-neutral solutions for industry and mobility, Food 2.0. etc.

LCIs are one of the key ways in which to implement a more mission-driven approach to RDI policy in Finland. Mazzucato's mission approach to research, development, and innovation activities (RDI) emphasizes tackling grand societal challenges through targeted, mission-oriented projects that drive systemic change and foster public value (Mazzucato 2020). In the case of the Leading Company Initiatives (LCIs), this approach is applied by fostering collaboration between businesses and research organizations to create high-value ecosystems, boost R&D investments, and address significant future challenges in alignment with Finland's strategic goals more broadly.

The collaboration has been instrumental in achieving the goals of the LCI, such as building high-value business ecosystems with international success, and aligning with Finland's strategic goals around step change in RDI activity. Commitment to ecosystem collaboration and possibility to engage in missions and societal goals with partners across the spectrum (research and companies, including SMEs and start-ups).

In terms of the company-research sense-making and shared strategic foresight, the implementation of technology roadmaps is clearly a useful and hands-on approach to collaboration, as it allows for a shared view to the future, making it possible for everyone can put themselves onto the map.

Business Finland's LCI activity has also generated knowledge spillovers and other externalities beyond these ecosystems, e.g. exponential growth of the ecosystems themselves important, partnerships in most cases much broader and varied than originally envisaged. Benefits have been clear on the international level, as well, with international visibility and interest in international events having risen, which benefits Finnish brand as an active RDI nation. Here the need for collaborating more across ecosystems (in some cases already taking place, e.g. Meyer & Wärtsilä) has been identified.

3.4 WHAT HAS BEEN THE ADDITIONALITY OF LCI ACTIVITIES?

The mid-term evaluation of the Leading Company Initiative (LCI) partnerships reported here has identified several differences between companies of different sizes in terms of additionality and their ability to benefit from the LCI ecosystem collaboration and activity.

In terms of **input additionality,** it is clear that larger companies have more resources and capabilities to invest in R&D and innovation activities compared to smaller companies, and the resources mobilised through LCI Programme has been a significant boost for the Engine companies in particular, who have been able to leverage LCI funding more effectively to enhance their existing R&D activity.

In terms of **behavioural additionality,** size is less a factor, as companies of variable sizes have been able to gain access to networks and collaborative efforts, which are potentially path-breaking. Smaller companies have experiences major changes in their behaviour and operations as a result of participating in the LCI, its ecosystems and R&D projects. This includes increased collaboration with research organizations and other companies, as well as adopting new business practices and technologies. Bringing the different size companies together with researchers to open new pathways for innovation, even in disruptive and completely new cross-ecosystem initiatives has been a significant benefit.

LCI Instrument benefits different companies in variable sizes in multiple ways. Some of the benefits are summarised below:

1. LARGE COMPANIES:

- Larger companies benefit in particular from the collaboration intensity, as they often have more established networks and relationships, which can facilitate more intensive and effective collaboration within the LCI ecosystem. Smaller companies, on the other hand, may benefit from the opportunity to build new connections and partnerships that they might not have had access to otherwise.
- Large companies benefit from the resources, competences and skills of the extensive and growing multi-partner networks, typically involving 4–6 research organizations per project.
- They utilise the LCI instrument to develop advanced R&D projects, often in collaboration with universities and research centres, such as VTT and Aalto University. Also universities of applied science are active in LCIs and create active paths to concrete piloting, and RDI in local settings.
- Benefits include creating new collaborative platforms and piloting and test environments conducting high-risk, long-term research that otherwise may not have been feasible.

2. MEDIUM-SIZED ENTERPRISES (SMES):

- Large companies, but also SMEs benefit from financial and market performance. The perceived financial and market performance improvements tend to be more pronounced for larger companies due to their ability to scale innovations and integrate them into their broader business strategies. Smaller companies may see more incremental benefits but can still achieve significant growth and market expansion through LCI participation.
- SMEs have leveraged LCI funding to enhance their integration into innovation ecosystems.
- Many medium-sized enterprises focus on targeted collaboration with 2–3 research partners to achieve specific technical objectives.
- SMEs show particular progress in areas like digital transformation and sustainability, often balancing technical and commercial innovation.

3. SMALL AND MICRO ENTERPRISES:

- Both large and small companies benefit from knowledge spillovers and externalities generated through ecosystem cooperation. However, the impact may be more substantial for smaller companies as they gain access to new knowledge, technologies, and best practices that can drive their growth and development.
- Smaller companies benefit from accessing larger research networks and partnering with more established firms and research institutions.
- Their projects are typically focused on practical application and market validation, leveraging the LCI ecosystem to overcome resource constraints.
- Examples include rapid prototyping and piloting efforts that lead to faster and smoother market entry and access to new markets.

Role of Lead Companies in Generating Impacts varies from strategic direction and ecosystem development to facilitating collaboration locally, nationally and internationally. Lead companies act as anchors for ecosystem development, defining long-term goals and creating shared technology roadmaps, which help to establish trust and cooperation among participants, enabling a structured approach to solving industry challenges. By facilitating new forms of collaboration, leading companies play a crucial role in integrating SMEs, research organizations, and international stakeholders into ecosystems. They provide resources and expertise that allow smaller participants to engage in larger-scale innovation projects. By acting as innovation catalyst, leading companies help to pool resources and facilitate partnerships, and by so doing enhance the pace of innovation, particularly in areas like sustainability and digitalization. Examples include Fortum&Metsä, which has driven advancements in bio-based materials, and Nokia2 Edge, which has led developments in telecommunications.

Ecosystem Impacts include diverse collaboration models, as the LCI ecosystems have varied collaboration patterns, allowing companies of different sizes and industries to participate meaningfully. For ***large companies***, who engage in extensive multi-partner networks, and work with several research organizations and smaller companies to tackle large-scale, complex challenges (e.g., Nokia2 Edge with telecommunications innovations) the LCIs are a platform for growth and diversification across ecosystem boundaries.

SMEs and startups typically focus on targeted collaborations with fewer partners to address specific technical or commercial objectives. They benefit from shared expertise and infrastructure provided by larger companies and research organizations.

Research organizations in turn play a central role in supporting both exploratory research and practical applications, helping bridge academic insights with industrial needs.

One of the most interesting areas to explore further are the forms of RDI collaboration across ecosystems, who share resources and expertise, enhancing innovation across boundaries (e.g., joint projects between Meyer and Wärtsilä). Broad engagement across ecosystems is central to diversify RDI collaboarion and industrial renewal, even benefitting from forms of industrial disruption. Ecosystems such as Fortum&Metsä and Neste, Meyer and Wärtsilä stand out for their ability to engage a wide range of stakeholders across the value chain. Fortum&Metsä ExpandFibre Ecosystem: Focuses on bio-based materials by involving partners from forestry, chemical processing, and consumer goods industries. This has enabled the integration of research findings into industrial-scale applications, such as sustainable fiber production. Neste Ecosystem: Drives collaboration in renewable energy and biofuels by uniting suppliers, technology providers, and end-users. The ecosystem promotes innovations like low-emission fuels, which have broad market and societal impacts. The engagement strategy emphasizes creating win-win partnerships, where both SMEs and large companies contribute to and benefit from shared goals and resources.

Ecosystems are increasingly also benefitting from new openings with a strong responsibility and sustainability focus. This involves for instance a strong emphasis on sustainability is a unifying theme across ecosystems, in the form of ***environmental innovations***, as many ecosystems prioritise technologies like biomass utilisation, carbon-neutral processes, and circular economy solutions. For instance, Fortum&Metsä has spearheaded efforts in using biomass for high-performance industrial materials, reducing reliance on fossil-based resources. Better alignment with SDGs involves innovations supporting Sustainable Development Goals (SDGs), particularly in areas such as climate action (SDG 13) and responsible consumption and production (SDG 12). Industrial applications include for instance advances in carbon-neutral production methods are evident in ecosystems like Wärtsilä's Zero Emission Marine project, which develops solutions for sustainable shipping.

Further future potential is identified in many directions, e.g. emerging themes like AI-driven energy optimization (e.g., in Neste's projects) highlight how digitalization and sustainability intersect to create smarter, more efficient industrial processes.

The activities have fostered collaboration and trust among ecosystem participants, which is crucial for successful cooperation. LCI has influenced participant behaviour, fostering closer cooperation among companies and research organizations. The LCI programme has helped participants better utilise other innovation and industrial policy development tools. There has been a notable improvement in the efficiency of product development and the creation of new business models.

LCI companies accounted for 28% of patent applications in the IPR-Finland database (2020–2022), highlighting the programme's contribution to Finland's innovation ecosystem.

Input Additionality in Ecosystem Cooperation: The analysis reveals significant input additionality through ecosystem collaboration patterns: 1) large companies with 0-1% subsidy/turnover ratios demonstrate extensive multi-partner networks, typically involving 4-6 research organizations per project, creating new collaborative structures that would not otherwise exist, 2) systematic development of research-industry partnerships, particularly evident in collaborations between companies and institutions like VTT, Aalto, and other universities, and 3) creation of new collaborative platforms involving multiple stakeholders, exemplified by projects like ExpandFibre showing new models of industry-academia cooperation.

- **Behavioral Additionality**: The evidence shows substantial behavioral changes in participating organizations: 1) companies have developed new collaborative practices and knowledge-sharing mechanisms, particularly evident in how larger companies are working with research institutions, 2) transformation in R&D approaches, with companies increasingly adopting ecosystem-based innovation models rather than traditional internal development, and 3) enhanced strategic focus on sustainability and digitalization across company sizes, indicating fundamental changes in organizational behaviour and priorities.
- **Organizational Learning and Capability Development**: The programme has led to significant organizational learning effects: 1) development of new competencies in managing multi-stakeholder projects, particularly evident in how companies are coordinating complex research networks, 2) enhanced capability in integrating academic research with industrial applications, shown through numerous successful technology transfers, and 3) improved ability to leverage research partnerships for commercial innovation, demonstrated by companies' increased engagement with research institutions.
- **SME Integration and Development**: The programme shows distinct patterns in SME engagement: 1) smaller companies have developed new capabilities in accessing and utilizing research networks, 2) enhanced ability to participate in larger innovation ecosystems, often through targeted partnerships with larger companies and research institutions,

and 3) development of new business models based on ecosystem collaboration, particularly evident in technology-focused SMEs.

- **Systemic Changes**: The programme has catalysed systemic changes in innovation practices, e.g. 1) establishment of new collaborative platforms that bridge industry and academia, 2) development of shared research infrastructures and knowledge bases, particularly in sustainability and digital technologies, and 3) creation of lasting networks that continue beyond individual projects, indicating sustainable behavioural change in the innovation ecosystem.
- **Cross-cutting Impacts**: Several cross-cutting impacts emerge, e.g. 1) enhanced focus on sustainability across all participant types, indicating a fundamental shift in innovation priorities, 2) increased emphasis on digital transformation and AI integration, showing evolution in technological capabilities, and 3) stronger integration between research and commercial applications, demonstrating lasting changes in how organizations approach innovation.
- Patent analysis show that LCI funding has added value to patenting and the exploitation and commercialisation of research knowledge. This is evident, for example, in
  - **Faster innovation cycles**: By pooling resources and expertise, projects can move from discovery to commercialisation more efficiently.
  - **Higher market relevance**: Industry involvement ensures that patented innovations closely match market requirements and challenges.
  - **Better access to funding and resources**: Public-private partnerships enable access to wider funding pools, facilitating impactful R&D projects.

Leading companies have placed ecosystem cooperation strategically even higher in finding a direction for the future. LCI's are recognised as an important element in this strategy. In LCIs that have already ended or are about to end, an important impact is that the work done at LCI has opened up new prospects for the future and made it possible to confirm that it is worth investing in already known prospects for the future. Thanks to LCI's actions, participating organisations in LCI's have risen to a new level, from which the outlook for the future is clearer.

LCI's operation has made the operation of the organization's networks more comprehensive and more compact. Organizations share a common goal space even more strongly, which each of them aims for through their own actions and in cooperation with others. At the same time, LCI's activities have increased trust between operators.

The innovation intentions have been developed to a point where we can see where it is worth investing more. LCIs have also improved the longevity and sustainability of R&D cooperation in a wider group of organizations. LCI gathers a group of actors for several years behind a common goal and road map. An individual project or even many of the programme activities are shorter for companies and different actors, and on the other hand, in other R&D structures, the cooperation is often not as extensive and does not cover as broadly different industry sectors and research organizations.

In general, LCIs have enabled the expansion of the RDI activities and portfolio of the participating organizations as one factor and encouraged them to take stronger risks in order to respond to future market opportunities with the help of new RDI solutions.

3.5 WHAT HAVE BEEN THE IMPACTS TO THE FINNISH ECONOMY AND SOCIETY?

As a general conclusion, LCI clearly is a good model for collaboration in ecosystems, which has been impactful and should be continued. The development is still in early stages of maturation, in particular in terms of the closer collaboration across ecosystems, and better alignment between different funding sources (BF and Academy of Finland), as well as a clearer pathway to European and international funding remains to be identified.

The LCI Programme has provided important support for improving the Finnish companies' focus on sustainability, its achievement and measurement, as well as focus on Responsible Business and Innovation. There have also been more high skill jobs available, interesting projects and collaboration to attract skilled labour, further investments and provide future opportunities and an atmosphere of positive expectations.

Research infrastructures have also been built and taken into use in many areas, also in areas of relevance for cross-ecosystem collaboration.

According to the patent data there is a significant focus on environmentally friendly innovations, advances in new technologies, as well as novel methods for improving performance or sustainability in industrial processes and optimizing manufacturing processes. Also, the integration of artificial intelligence in areas like medical diagnostics may have significant impact in the future. Contributions to sustainability and environmental themes are evident in ecosystems. LCI ecosystems have demonstrated innovation potential and spillover effects. While the quantitative growth in patenting has been modest, the qualitative significance and the alignment with societal goals provide a solid foundation for advancing Finland's innovation ecosystem toward its R&D funding targets.

The analysis reveals significant impacts across multiple dimensions of the Finnish economy and society through LCI activities. The direct economic impacts demonstrate substantial growth, e.g. 1) large companies reported revenue increases of 20-60%, showing how ecosystem cooperation amplifies business performance, 2) mid-sized companies achieved balanced growth of 15-40%, particularly in specialised technological sectors, and 3) SMEs showed varied, but consistently positive financial outcomes, especially when participating in larger ecosystem initiatives.

The ecosystem development has created lasting structural changes in the Finnish innovation landscape: 1) establishment of extensive multi-partner networks typically involving 4-6 research organisations per project, creating sustainable collaboration structures, 2) development of new collaborative business models that enhance national competitiveness, and 3) formation of sustainable industry clusters, particularly in green technology sectors, strengthening Finland's position in emerging markets. Environmental sustainability impacts have been particularly noteworthy: 1) significant reductions in carbon emissions across multiple industries through technological innovation, 2) development of comprehensive circular economy solutions that transform industrial practices, and 3) advancement of renewable energy technologies and carbon-neutral production methods. These environmental impacts align closely with SDG goals and demonstrate how ecosystem cooperation can accelerate sustainable development.

The research and innovation capacity of the Finnish economy has been substantially enhanced through: 1) strengthened collaboration between industry and academia, creating lasting partnerships that extend beyond individual projects, 2) development of new technological capabilities, particularly in AI and digitalisation, positioning Finland at the forefront of technological innovation, and 3) creation of shared research infrastructures that benefit the entire innovation ecosystem.

Concrete examples of transformative impacts include: 1) development of fossil-free steel production technologies that position Finland as a leader in sustainable industrial transformation, 2) creation of new bio-based material solutions that open new market opportunities, and 3) implementation of AI-driven energy optimization systems that enhance industrial efficiency while reducing environmental impact. These examples demonstrate how research-business cooperation creates tangible societal benefits.

The long-term societal benefits are emerging through 1) creation of new high-skilled jobs and enhancement of national technological expertise, 2) development of sustainable industrial practices that ensure future competitiveness, and 3) strengthening of innovation ecosystems that support continued growth and development. The research-business cooperation has been crucial in achieving these impacts, creating lasting changes in industrial practices and technological capabilities.

The measurement of these impacts can be tracked through multiple indicators: 1) direct economic metrics such as revenue growth and job creation, 2) environmental indicators including carbon emission reductions and resource efficiency improvements, and 3) innovation metrics such as patent applications and new product developments. These measurements demonstrate the comprehensive nature of the impacts achieved through LCI activities.

Cooperation and information exchange between LCI ecosystems should be further supported in the future (Veturivarikko as good method in this). This has been one important added value of being involved in LCI operations. Similarly, within an individual LCI, it is necessary to ensure that information and ideas flow smoothly between different parts in a single LCI.

3.6 HOW TO CONTINUE? RECOMMENDATIONS TO BUSINESS FINLAND ON THE BASIS OF THE LCI EVALUATION

3.6.1 THE POSITIVE IMPACT ON ECOSYSTEM COLLABORATION SHOULD BE MAINTAINED AND FURTHER PROMOTED.

Whilst the LCIs are at very different stages of maturity and implementation, with some just having started and others already finalised their implementation (e.g. ExpandFibre), there is clearly positive development on going. A commitment to a 5-year collaboration is a significant common endeavour, and the signs are positive as to the mobilisation, shared commitment and objectives achieved to date. It can therefore be concluded that LCI is a good model for collaboration, and it should be continued, in order for it to reach the gaols set, and the closer collaboration across ecosystems.

3.6.2. IN ORDER TO FURTHER DEEPEN AND STRENGTHEN THE POTENTIAL POSITIVE IMPACTS FOR THE FUTURE, THE IMPACT MECHANISMS OF LCI SHOULD BE COMPARED AND CROSS-FERTILISED WITH OTHER ECOSYSTEM INSTRUMENTS AND PROGRAMMES. THIS ALSO REQUIRES CLOSER ANALYSIS.

The LCI instrument's additionality with respect to general R&D investments requires further analysis to isolate its specific effects. However, initial findings suggest that LCI funding may contribute to enhancing the scale and pace of R&D investments, particularly in sectors requiring significant upfront investment in intangible assets such as skilled personnel and organizational capital.

In order to more precisely evaluate the LCI instrument's additional impact, future analyses should:

- Compare funded companies with a control group of non-funded firms to quantify differences in investment and workforce trends attributable to the instrument.
- Explore the temporal aspect of additionality, such as whether LCI funding accelerates planned R&D investments or leads to sustained long-term growth beyond the funding period.

- Investigate the distributional effects of LCI funding, especially its role in fostering R&D activity among small and medium-sized enterprises, where data gaps **currently** limit robust conclusions.

By addressing these points, the analysis can better quantify the additionality of Business Finland funding, particularly through the LCI instrument, and identify its broader contributions to Finland's innovation ecosystem.

3.6.3. THE USE OF AI IN THIS ANALYSIS HAS REVEALED MANY INTERESTING PATTERNS AND SHOULD BE FURTHER PURSUED.

The use of NLP/LLM-based approaches in this analysis has revealed many interesting patterns and should be further pursued. Areas to be considered further in the ex-post evaluation stage include the following:

- **NLP-Based Network Analyses:**
  NLP techniques can provide detailed network analyses of participants and connections. For instance, they can analyze the links between LCIs, participating companies, research organizations, other Business Finland instruments, and EU-funded projects. This can uncover collaboration intensity, identify key stakeholders, and track the flow of knowledge and resources across ecosystems, enriching future evaluations.
- **Advanced Monitoring and Data Integration:**
  Monitoring R&D personnel, job roles, and organizational titles of participating companies based on recent data sources (e.g., Income Register) could offer deeper insights into the human capital impact of LCIs. NLP/LLM-based systems can assist in processing and analyzing this data alongside other funding and project information, enabling a more integrated and comprehensive view of resource allocation and impacts.
- **Enhanced EU Integration and Alignment:**
  NLP/LLM approaches can help align LCIs more closely with EU networks and funding opportunities. These tools can analyze trends in EU-funded projects, identify strategic themes for alignment, and predict future funding priorities. Such insights could guide LCI actors, Business Finland, and other stakeholders in strengthening their influencing work at the EU level and increasing alignment with emerging European initiatives.
- **Improved Coordination Across Funding Sources:**
  NLP-based tools can analyze historical data on funding patterns from Business Finland, the Academy of Finland, and other sources to highlight gaps and overlaps. By providing recommendations for better coordination, these tools can facilitate smoother pathways to European and international funding, fur-

ther enhancing initiatives like **Veturivarikko** to optimize information exchange within and between LCI ecosystems.

- **Fostering Knowledge Flow Within LCIs:** Within individual LCIs, ensuring smooth information flow between different parts is crucial. LLM-based knowledge management systems can capture, organize, and disseminate ideas and findings in real-time. This ensures every participant has access to relevant insights and facilitates the continuation of innovation efforts after the official LCI operation ends. LCIs should be instructed during the preparation phase to design frameworks enhanced by NLP/LLM systems to support ongoing collaboration and innovation development.
- **Automating and Enhancing Evaluations:** NLP/LLM-based tools can significantly streamline labor-intensive tasks such as analyzing large volumes of project reports, extracting qualitative insights, and identifying trends in areas such as sustainability, digitalization, and collaboration. These approaches can also convert qualitative data into quantifiable metrics, making comparisons across LCIs more structured and actionable.
- **Uncovering Hidden Patterns and Themes:** LLMs, through advanced Natural Language Processing, can uncover hidden patterns and themes in project reports and related documents. These models can cluster projects by thematic focus, identify recurring challenges, or highlight emerging trends, providing evaluators with deeper insights into the societal, environmental, and economic impacts of LCIs.
- **Long-Term Monitoring and Adaptive Models:** NLP-based models should be designed to continuously monitor and evaluate LCI impacts over time. By integrating new data dynamically, these models can adapt to changing circumstances and provide robust longitudinal analyses, ensuring relevance and utility for years after the official LCI period.
- **Ethical Considerations and Collaborative Intelligence:** The integration of NLP/LLM-based tools must prioritize transparency and ethical use of data. These systems should be explainable and auditable to enhance stakeholder trust. Furthermore, they should complement human expertise by augmenting evaluators' ability to interpret and contextualize data while retaining strategic oversight.

By leveraging NLP/LLM-based approaches, ex-post evaluations can achieve greater depth, precision, and actionable insights. These tools can facilitate more effective decision-making, amplify the impact of Finnish innovation ecosystems, and ensure sustained success through enhanced collaboration and resource optimization.

3.6.4. LCI CAN PROVIDE A BLUEPRINT FOR ECOSYSTEM COLLABORATION MORE BROADLY, IN RELATION TO THE NATIONAL STRATEGIC GOAL OF THE 4% RDI TARGET.

Based on the analysed company reporting data, some key lessons for Finland to achieve its 4% R&D/GDP goal by 2030 have been identified:

- The success of Co-Innovation and Co-Research programmes demonstrates the importance of integrated collaboration between academia, industry, and international partners
- Project flexibility and adaptive management are crucial, with data showing that successful R&D initiatives require regular monitoring and timeline adjustments, while maintaining clear communication between consortium partners.
- Strategic sector focus has proven effective, particularly in areas like hydrogen economy and chemical recycling, where international investments have significantly increased business opportunities and growth potential.
- International networking and investment attraction both play a vital role here, as evidenced by successful collaborations with Nordic cybersecurity clusters and other cross-border initiatives.
- In order for Finland to reach its ambitious 4% goal, Finland should strengthen public-private partnerships through flexible funding mechanisms, expand international research collaborations, and maintain adaptive funding structures that can quickly respond to emerging opportunities while supporting both basic research and commercial applications.

3.6.5. SOME OF THE METHODOLOGIES DEVELOPED AND TESTED IN THIS EVALUATION COULD ALSO BE RELEVANT FOR IMPACT EVALUATION WITHIN BUSINESS FINLAND, AND WITH ITS STAKEHOLDERS AND PARTNERSHIPS MORE BROADLY.

The evaluation reported here has sought to develop more real-time monitoring and development evaluation -based practice and methods for Business Finland, in particular identifying early signs of additionality for different types of beneficiaries (/different size companies) of Business Finland funding. On the methodological and data issues and how they can be taken forward by Business Finland towards the ex post phase of LCI the evaluation team welcomes the innovation and methodological ambition of Business Finland. Some recommendation on this point include:

- AI-based methods can help to shift the focus of evaluation from ex post to ex ante and real time analysis, and by so doing benefitting from a more real-time monitoring of programme activities.
- The evaluators welcome Business Finland's proactive approach to evaluation, and the willingness to develop new methodologies. Business Finland could more actively utilise advanced text analysis methods and natural language processing (NLP) more actively across its programme portfolio, which would allow for more timely and accurate data collection and analysis, helping to monitor the instrument's effectiveness in real time. For programme evaluation, this could allow for developing and testing new methods for analysing ecosystem impacts, especially through NLP methods and analyses, contributing to a better understanding of cooperation between businesses and research organisations and its impact.
- The multi-method approach that includes both quantitative and qualitative methods. can help to better capture LCI's impact more broadly, including knowledge dissemination and externalities, which are central to identifying and analysing behavioural additionality. As the BF approach to monitoring and evaluation already today covers also strategic foresight, the AI-based methodologies can help in particular in the identification of early signals, which is particularly essential in the fast-changing operational environment.

INTERVIEWS

All 23 LCI ecosystems were approached for an interview, with a suggestion that they could select who they invite to their ecosystem to give an overview of their ecosystem function-ing and impacts. The following ecosystems and their stakeholders were interviewed:

MEYER TURKU JA WÄRTSILÄ:
Ilkka Rytkölä, Meyer Turku
Juhani Määttänen, NIT Naval Interior
Valtteri Hongisto, Turun Ammattikorkeakoulu
Kenneth Widell, Wärtsilä
Markku Jokela, Business Finland

NESTE LCI:
Teija Laitinen, Neste
Juha Lehtonen, VTT
Erkko Fontell, Convion
Tuomas Hakala, Convion
Jaana Viitakangas, Helen

PONSSE LCI:
Jukka Laitinen, Ponsse

EXPAND FIBRE LCI:
Torvinen Katariina, VTT
Kemppainen Katariina, Metsä Group
Wikberg Hanne, Fortum

VALIO LCI:
Veera Virtanen, Valio
Harri Kallioinen, Valio

ATTACHMENT 1: PATENT DOCUMENT CATEGORIES:

Abstract: A summary of the patent application that briefly presents the essential features and purpose of the invention. It allows for a quick assessment of what the invention is about.

Amended Application: A modified patent application. This refers to an application that has been revised after its initial submission, often based on comments from the patent office.

Amended Patent: A modified patent that has been changed after being granted. Amend-ments can be made, for example, to limit the scope of the patent protection.

Design Right: A design right that protects the appearance or visual design of a product. It differs from a patent in that it does not protect technical solutions but rather the visual form.

Granted Patent: A granted patent means that the patent office has approved the applica-tion, and the invention has been granted patent protection in a specific country or region.

Limited Patent: A limited patent where the scope of the patent protection has been nar-rowed. The limitation can occur either at the request of the applicant or by the authority, for instance, in connection with legal proceedings.

Patent Application: A patent application that has been filed with the authority but has not yet been granted. The application may still be under review or awaiting further clarifica-tion.

Patent Of Addition: An additional patent that supplements a previously granted main pa-tent. It covers improvements to the main patent that cannot be independently patented.

Search Report: A search report that contains information about prior publications and pa-tents that may affect the novelty and inventiveness of the patent application. Patent au-thorities conduct this to assess the application's patentability.

SPC (Supplementary Protection Certificate): A supplementary protection certificate that can be granted for medicinal and plant protection products to extend patent protection af-ter the original patent has expired. This protection compensates for the time taken up by regulatory processes for medicines and plant protection products.

Unknown: An unknown or undefined category. This may appear if the document type can-not be defined or does not belong to any established category.

Three different dates in patent documents:
Priority Date: This is the earliest date on which a patent application for the invention was filed in any country. The priority date grants the applicant the right to the invention rela-tive to later applications filed in other countries. This date can be used in international ap-plications to secure the rights to the invention.

Filing Date: This is the date on which the patent application was submitted to the authori-ties. The filing date determines when patent protection begins if the patent is granted. It is also an important date that affects the processing timeline and the duration of the patent's validity.

Publication Date: This is the date on which the patent application or granted patent is made public. From the publication date onwards, the details of the application or patent are accessible to the public.

ATTACHMENT 2: INTERVIEW GUIDE

Haastattelun tarkoitus:

- Tunnistaa Veturi-ohjelman ja Business Finlandin elinkaarikustannusinvestointien vaikutukset veturiyritysen ja ekosysteemien kehitykseen ja kasvuun.
- Arvioida uudenlaisten yhteistyömuotojen merkitystä ja hyötyä tiedon leviämiselle ja ulkoisvaikutusten välittymiselle ekosysteemien ulkopuolelle.
- Haastattelun järjestelyt ja muoto:
- Haastattelu on Teams-alustalla tapahtuva ryhmäkeskustelu (1/Veturi), jonka kohderyhmän määrittelette te, Veturi-kontaktihenkilöinä.
- Toivomme, että voitte ehdottaa vastauksena tähän sähköpostiin ajankohtaa loka-marraskuussa 1–1,5 tuntia kestävälle verkkohaastattelulle.
- Voitte kutsua haastatteluun valitsemanne henkilöt veturiekosysteemistänne.
- Arvioinnin tavoitteet:
- Tunnistaa Veturi-ohjelman investointien ja toimenpiteiden lisäarvo yritysten ja tutkimuksen yhteistyön kannalta.
- Tuoda hyviä käytäntöjä ja toimintamalleja Business Finlandin veturiyritysverkoston ja ekosysteemien tietoisuuteen.
- Tarjota yhteinen pohdinnan alusta ekosysteemin toimijoille ja auttaa tunnistamaan menestymisen ja vaikuttavuuden avaintekijöitä sekä kehittämiskohteita.

HAASTTATTELUKYSYMYKSET:

1. Mikä on muuttunut LCI-ohjelman ja teidän siihen osallistumisenne myötä?
2. Miten yritysten ja tutkimusorganisaatioiden yhteistyö on kehittynyt?
3. Millaisia konkreettisia vaikutuksia ja hyötyjä ohjelmasta on syntynyt (mukana oleville, entä muille)?
4. Miten Business Finlandin ohjelmatyön toimintatavat ja välineet ovat vastanneet tarpeisiinne?
5. Miten veturiohjelma on auttanut mukana olevia tahoja hyödyntämään paremmin muita innovaatio- ja elinkeinopolitiikan kehittämisvälineitä?
6. Mitä tulisi tehdä toisin, mihin jatkossa tulisi kiinnittää huomiota?

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