REPORT 5/2016

Striving toward a vibrant ecosystem

Evaluation of Tekes' Combio, BioIT and Trial programmes

Peter Varnai, Jelena Angelis, Marja Tähtinen, Sofie Pollin, Pasi Malinen and Tomas Åström

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Evaluation Report

technopolis |group|

Tekes

Tekes Report 5/2016
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Tekes – the Finnish Funding Agency for Innovation
Tekes is the main public funding organisation for research, development and innovation in Finland. Tekes funds wide-ranging innovation activities in research communities, industry and service sectors and especially promotes cooperative and risk-intensive projects. Tekes' current strategy puts strong emphasis on growth seeking SMEs.

Tekes programmes – Tekes´ choices for the greatest impact of R&D funding
Tekes uses programmes to allocate its financing, networking and expert services to areas that are important for business and society. Tekes programmes have been contributing to changes in the Finnish innovation environment over twenty years.

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Foreword

Experimentation and risks are part of all research and innovation and other creative activities. New ideas, technologies and operating practices must be piloted in a broad-minded way, and choices must be made in an uncertain environment. Bridging the gap between academia and businesses; end-users and consumers; and regulatory bodies and policy makers is part of the support Tekes needs to provide for a functioning ecosystem.

More experimental policy approaches need new types of foresight and public RDI impact assessment practices. From the viewpoint of impact assessment, various types of spillovers are probably key drivers for sustaining ecosystems as these ensure that companies and other stakeholders can develop mutually dependent relationships, joint products, services and value creation processes.

The objective of this evaluation was to produce a review of results, impacts and efficiency of three programmes funded by Tekes: Combio (Commercialisation of Biomaterials, 2003-2007), BioIT (Solutions for Biological Information, 2013-2014), and Trial (Environmental for Cognitive Radio and Network, 2011-2014). The report contains a comprehensive benchmarking analysis. Innovations ecosystem policy has been analysed in Ireland, the Netherlands, Denmark, Sweden and Switzerland.

Tekes expresses its warmest gratitude to evaluation team led by Technopolis Group: Peter Varnai, Jelena Angelis, Pasi Malinen, Sofie Pollin, Marja Tähtinen and Tomas Åström for systematic and detailed analysis. The evaluation took a forward-looking view and suggests potential improvements in developing R&D and innovation activities in the ecosystems around the funded programmes and in creating research and innovation policy for the enhancement of the impacts and experimental culture. The results will be highly valuable when future Tekes programme and ecosystems activities are being planned.

December 2016

Tekes

Executive Summary

Tekes has commissioned the evaluation of the results, impacts and efficiency of three programmes – Combio (Commercialisation of Biomaterials Technology), BioIT (Solution for Biological Information) and Trial (Environment for Cognitive Radio and Network). The high-level aim of the evaluation was to assess the contribution of these programmes to developing an innovation ecosystem in the respective thematic areas and establishing an experimental culture in Finland. The assignment was carried out between March and September 2016 by Technopolis Group.

The empirical evidence for the evaluation consisted of literature and registry review, online survey of project participants, stakeholder interviews, review of four international benchmarks and a validation seminar with key stakeholders.

The three programmes

Combio programme (2003-2007) was a support programme from Tekes for the biomaterials field in Finland. It was designed to foster commercialisation of novel biomaterials, especially materials with potential use in health sector and medical devices. Combio was preceded by the Potra programme (Polymers for building the future, 2000-2003), which increased the know-how in polymer science and thus paved the way for biomaterials research. Combio supported a total of 22 companies, 10 research institutes and one district hospital through 31 funded projects. Most of the projects addressed implants, nine projects focussed on drug delivery and three projects on tissue engineering. The overall budget of the programme was €30.3m, of which Tekes contributed €21.3m.

BioIT programme (2013-2014) was established to create new sustainable collaborations and partnerships between traditional ICT actors and experts in biology, genetics and environmental sciences across academia and industry. It was built on the Tekes Pharma programme that ran in 2008-2011. BioIT had a total budget of €17m, of which Tekes contributed €9.6m. There were a total of 35 projects funded to 30 different organisations, mostly SMEs. At the time of this evaluation, 17 projects were still ongoing. Nevertheless, some of the early results of the BioIT projects were visible and could be measured. The projects themselves were varied within the field of biological and health data informatics: from software support to genomics data for cancer diagnostics to wireless transfer of personal health data. The programme offered both enterprise support and research funding, and it served as an important opportunity for organisations to network and get international visibility for further growth.

Trial programme (2011-2014) supported the development of wireless and mobile technology to make Finland a globally attractive cluster of expertise and a unique trial environment for cognitive radio and networks. Cognitive radio is regarded as a new disruptive technology that will boost wireless communications and present new business opportunities. Trial aimed to create the necessary environment to establish long-term research collaborations for this new technology. It funded 31 research projects and 21 industry projects with a total budget of €34m, of which Tekes contributed €15m.

All three programmes in the various thematic areas had contributed to promising developments in Finland and in the broader international context.

Results and impacts of the programmes

The objectives and goals of the three programmes were rather similar from the strategic point of view. They focused on utilising the strengths of existing research in the relevant thematic areas and advance their research and commercial potential, by building and strengthening an innovation ecosystem in Finland and contributing to their international visibility.

Combio helped to create and strengthen national collaborations between biomaterial groups and companies, gave a welcome funding boost to the sector, and focussed on establishing a new industrial cluster in Finland. It also created new employment opportunities for the funded organisations, engaged highly-skilled people with the biomaterials field, facilitated the exchange of new knowledge and increased business know-how which continues to be spread to others. However, the ambitious financial goals, set according to the expectations of key companies and preliminary market evaluation, did not materialise.

Funding through BioIT allowed companies to build new (national and international) collaborative and business networks that continued beyond the end of the fund-

ed period. Patents were filed, new products or prototypes were developed or increased substantially their technology readiness level to prepare for market launch. It was noted that in some cases, however, projects were running beyond the end of the programme, thus Tekes could not provide support services to these projects. The experience gained through the programme by companies (and Tekes management) already paid dividend since over 10 companies that had been supported by the exploratory programme are now part of the new Tekes initiative Bits of Health. This will no doubt continue to build the emerging digital health ecosystem and further integrate technology, service providers, academia and end users in Finland and beyond.

The Trial programme created a significant interest in experimentation in Finland, project partners benefitting strongly from a strengthening ecosystem and enabling them to find expertise, cross-fertilise ideas, and adapt their strategies when needed, e.g. for spectrum sensing. While there was significant interest from international companies to join this ecosystem, it was difficult to achieve it in practice. This was partly due to the lack of a viable business model available for cooperation and partly because most relevant expertise was already available in Finland. Although business breakthroughs were not yet realised at the time of the evaluation, diverse programme outcomes were noted. These include publications, regulatory trials, impact on standardisation (even outside of Finland), creation of intellectual property, collaboration and researcher training in a top-level cluster of expertise. The strongest cooperation was seen at national level, but participants were recognised internationally and they were successful to secure funding from the EU H2020 programme. In a complex environment, longer timelines are required to complete the development of a new technology platform, create a suitable business model for sharing the test bed, and form new start-ups for future product development.

Creation or strengthening of a thematic ecosystem was one of the key objectives of all three programmes. The ingredients for an ecosystem in most cases had already been available in Finland. The programmes helped to join up distinct activities and stakeholder groups, and strengthen those to create optimal conditions for enhanced innovation. Trial programme participants felt that the existing national ecosystem was significantly strengthened thanks to the Trial programme. In comparison, participants of the diverse BioIT programme felt that their individual contributions to an overall digital health ecosystem was limited. Combio programme transformed the biomaterial field from a number of closed clusters around three key locations to connected groups through joint research projects. The crucial element highlighted by the participants is the creation of interdisciplinary collaborations making the ecosystem engaging and innovative.

Reflections

The assessment of the three Tekes-funded programmes in this evaluation indicate that larger and longer programmes may in fact result in lower effectiveness and impact than smaller and shorter ones. An important requirement for launching a large programme is an appropriate design, building on relevant, world-class academic research, a critical mass of existing businesses, and willingness of stakeholders to collaborate on joint initiatives. The BioIT programme demonstrated that smaller, lean 'pop-up' programmes can be effective in piloting new ideas, activating companies and research groups, galvanising interest and enhancing the potential in a particular technology sector. These pop-up programmes may be seen as a first step in creating a larger and broader follow-on programme that would allow scaling up activities and consolidating the networks and the ecosystem. The current Tekes programme Bits of Health is a large initiative aiming to achieve lasting impact. These two types of programmes may run in parallel to combine the narrower technology focus of smaller programmes with the more cross-cutting and holistic horizontal schemes. This combined model would limit the risk for Tekes when launching large programmes and, at the same time, create room for failure, which is inherent in innovation processes.

Tekes funding has contributed to creating new national networks and new R&D-focused pilot actions in the three programme areas: biomaterial, biological and health information, as well as cognitive radio. However, when a budding ecosystem relies heavily on national public funding and the internationalisation of research projects is low, the ecosystem struggles to survive, especially in a country of the size of Finland. Therefore, it is important for the public sector to maintain a competitive funding environment where the best innovators are supported, and to avoid the formation of 'parasitic' ecosystems that cannot be sustained in the long run.

Benchmarks of international ecosystems – Ireland, Sweden, Switzerland and the Netherlands – point to the need for national programmes to become not only a method of distributing public funds but also a facilitating instrument passing on entrepreneurial and business skills to the beneficiaries. For the ecosystem to develop further, other systemic factors need to be considered, such as the availability of seed and venture capital funding, regulatory support, new piloting facilities, and involvement of large players with access to international networks for businesses and research. To continue to promote a robust ecosystem for SMEs and start-ups, key national players should harmonise activities and remove barriers to implement a national strategy of innovation, in alignment with and complementing international programmes.

Recommendations

For building new programmes that aim at developing a thriving ecosystem and experimental culture, the following key learning point may be considered, based on international benchmarks:

- A national innovation system is most effective when it is de-fragmented, thus providing streamlined channels for innovators and entrepreneurs to find the appropriate information and funding sources
- Assess the mix, type and timing of public innovation funding to accelerate growth of early stage companies (grants, loans, and equity)
- Favourable national taxation system and R&D tax credit schemes are regarded as key to attracting foreign investments into high-growth companies
- Early-stage companies are dependent on collaboration with universities and connecting to the networks and infrastructure of large (multinational) companies
- Horizon scanning and international benchmarking are two important activities to shape a national ecosystem for start-up companies to expand internationally
- Build in key consensus metrics in a monitoring framework at the start to allow formative as well as summative programme evaluations at various points in the policy cycle.

The main policy implications for research and innovation policy, based on the evaluation of the three programmes:

- Small-scale 'pop up' programmes may be institutionalised as exploratory initiatives with focus on emerging technology sectors. This represents low risk for Tekes but essential to activate young companies in new multidisciplinary fields, gauge interest and demand from diverse actors, and bring non-traditional partners together to create new networks.
- Larger cross-cutting, holistic programmes with broader thematic coverage should have international ambitions and absorb the new skills and results of the smaller pilot programmes and help sustain activities in successful projects and consortia. These longer projects, adapted to the complex life cycle of particular industries, should have a mid-term evaluation point and achievement of explicit and agreed milestones should be a requirement for continued funding. This tiered approach will create a positive competition in the ecosystem and help focus participants on the key aims and objectives of the funded project.
- These two types of programmes may run in parallel to combine their advantages and complement the technology focus with more horizontal approaches, and effectively exploit emerging opportunities and potential spill-over effects.
- Building functioning ecosystems is the key to keep the research base of high-growth companies in Finland. This requires that framework conditions are available and internationally competitive: R&D costs are affordable, research infrastructure and (global) networks are in place, and graduates with relevant skillsets provide a high-quality research base. In addition, Tekes may consider providing post-project services for companies to facilitate access to (international) private equity funding, thereby reducing reliance on national public funding and ensuring sustainability of successful project results.
- Tekes should aim at creating a few broad multidisciplinary ecosystems rather than covering specific research areas and business opportunities. This approach would provide a flexible system without fragmenting innovation into specific sectors. These innovation ecosystems would allow for easier cross-sectorial cooperation, faster adaptation to the changing international context and additional opportunities for government to support high-growth sectors.
- Tekes cannot implement R&D initiatives in isolation. It should rely on various government actors and collaborate closely as implementers of national strategies. Beyond Finland, it is important to align with and complement international programmes, such as the Horizon 2020 to fast track innovation activities in Finland.

In moving forward in supporting different types of actors in the research and innovation field in Finland, Tekes may consider:

- Review and adjust the goal, objectives and vision of larger programmes when the operational environment has changed. This will reduce over-reliance on a hand-full of organisations at the beginning of a programme which have subsequently changed their objectives and interests.
- Launching novel products and sales should not be the sole evaluation criteria for the success of a programme. Equally important may be the development of processes, analytical methods and (pre-competitive) platforms that help companies and research groups to test and characterise their products in future.
- Consider setting requirements of partnerships in project funding: teams should include other types of stakeholders, including end-users and businesses or academia and involve international partners in Tekes-funded projects.
- Finally, the sale of a Finnish company abroad should not be regarded as a loss or failure of the ecosystem. These positive examples demonstrate the success of Finnish innovation and business growth, and the resulting international brand and financial revenues should further encourage building new high-growth companies and attract foreign companies to invest in Finnish research and development.

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1 Introduction

The evaluation of the results, impacts and efficiency of three programmes funded by the Finnish Funding Agency for Innovation (Tekes) was commissioned by Tekes in February 2016. The specific programmes were Combio (Commercialisation of Biomaterials Technology), BioIT (Solution for Biological Information) and Trial (Environment for Cognitive Radio and Network). The higher-level aim of the evaluation was to assess the contribution of these programmes to developing an innovation ecosystem in the respective thematic areas and establishing an experimental culture in Finland. The evaluation was led by Technopolis Group between March and September 2016.

1.1 Evaluation questions

For the purposes of the evaluation, the list of questions set in the invitation to tender was grouped into two broad themes:

- Retrospective view
  - Recent trends in experimental Research, Development and Innovation (RDI) policy and culture
  - International practice in approaching RDI clusters, value networks, ecosystems
  - Achieved results, effectiveness, and impacts of Combio, BioIT and Trial programmes
- Forward-looking view
  - Potential improvements in developing RDI activities in the evaluated ecosystems
  - Potential developments of Tekes programme services and the ecosystem programmes
  - Suggestion for research and innovation policy for the enhancement of the impacts and experimental policy culture.

The work was grouped into four work packages (WP) answering specific evaluation questions (Table 1).

1.2 Impact logic model

The conceptual logic framework of the evaluation took an approach where the questions are linked back to the objectives of the programmes, focusing on the evaluation criteria of relevance, effectiveness, efficiency, utility and sustainability – each providing their own types of indicators. This logic-based approach assumes that there is a causal chain connecting a set of needs, problems or issues to objectives of an intervention or programme, and a set of resources (not purely financial) applied to certain activities which lead to a set of outputs that will affect the desired changes either in the relatively short term (outcomes) or in the long term (impacts). The evaluation then assesses a number of key issues or questions along that chain, as presented schematically in Figure 1.

This logic model takes into account the Tekes' impact analysis model, where interventions are analysed from four perspectives: Input, Activities, Output and Impact on society and economy. The model also captures three Tekes objectives: a wellbeing society and environment, productivity and renewal of industries, and capabilities in innovation activities (see Figure 2).

Table 1. Work packages and evaluation questions.

Work package	Evaluation questions
WP1 Literature review of operating environment	**EQ 1.1** What are the recent trends of experimental RDI policy and culture? **EQ 1.2** International benchmarking: insights of RDI cluster/value network/ecosystem approach in comparable forerunner countries
WP2 Results achieved, relevance and efficiency (BioIT and Trial)	**EQ 2.1** How relevant and challenging were the programmes' objectives? To what extent have they supported implementation of strategic choices of Finland and Tekes' own strategies? **EQ 2.2** To what extent have the objectives set for the programmes been achieved? What are the important results supporting the main objectives of the programmes? **EQ 2.3** What other programmes' results can be found that were not listed as programme objectives? Which of the results would not have been achieved without the programmes? What concrete outcomes can already be seen in the ecosystem enabled by the programmes? **EQ 2.4** How well were the most important customer groups reached? What kind of ecosystems can be identified after the completion of the programmes? Did the programmes impact on the co-operation within the ecosystem nationwide, on European level and globally? **EQ 2.5** How resilient were the programmes concerning the changes in operating environment? How well did the programmes, their services and administration meet the needs of the participants? How well did the utilised funding model serve the customers' needs and ecosystem building? **EQ 2.6** How efficient have the programmes been?
WP3 Impacts achieved and expected, effectiveness and utility (Combio)	**EQ 3.1** What are the impacts of the programme? How permanent, comprehensive and significant are these impacts? **EQ 3.2** To what extent and in what ways has the programme impacted on the following areas: • Creation of an ecosystem • RDI inputs in the ecosystem • Establishment of domestic and international networks • Changes in companies' operating practices • Important innovations and business opportunities • Growth (especially international) and value-added of participating companies • Competitiveness of the ecosystem • Finnish industry and society more generally
WP4 Conclusions	**EQ 4.1** For the RDI activities: How could RDI activities in the evaluated ecosystems be developed in the future? **EQ 4.2** For Tekes: Give the good practices that are concrete and workable and that can be used in the development of programme services and the ecosystem programmes. What kind of services should be included in order to improve the impact? What kind of orchestration is needed? How could development of ecosystems be monitored during the programmes? **EQ 4.3** For research and innovation policy: What do the findings imply for innovation policy? What other research and innovation policy measures, in addition to the measures taken by Tekes, should be applied so that impacts can be strengthened? How should experimental culture be enhanced?

Figure 1. Schematic overview of the intervention logic. Source: Technopolis Group

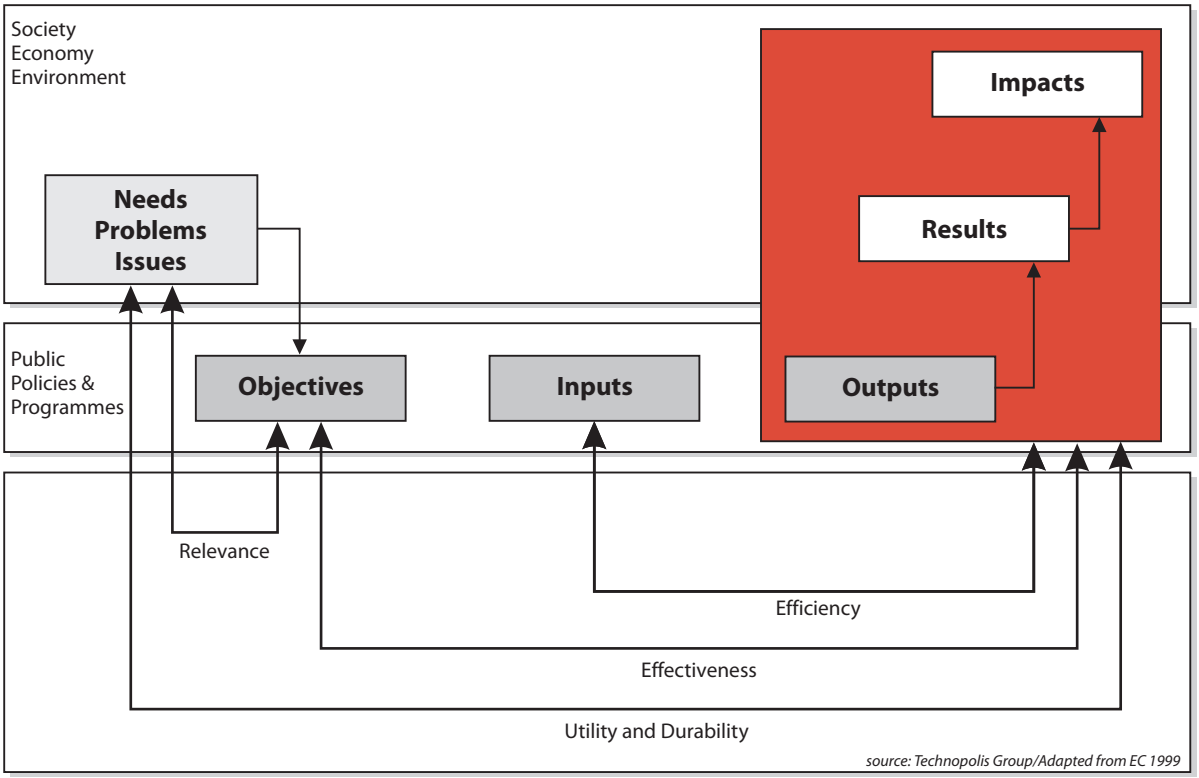
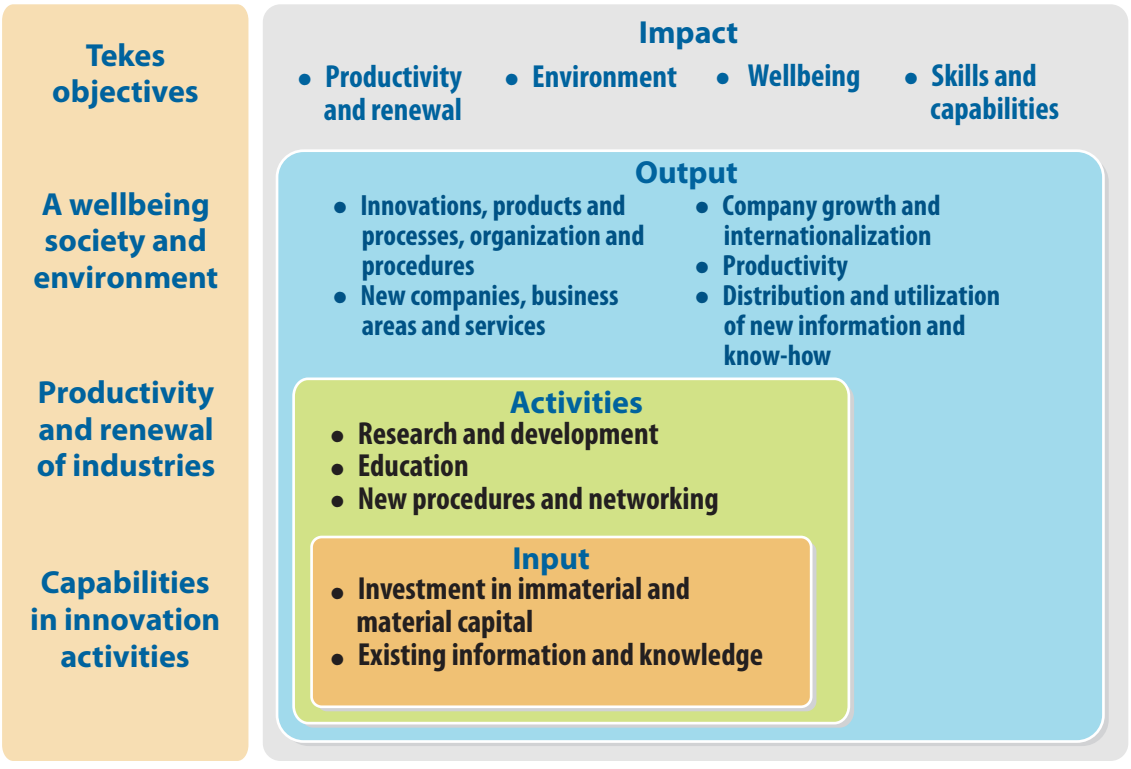


Figure 2. Impact model of Tekes. Source: Tekes



1.3 Evaluation method

Qualitative and quantitative methods are combined to answer evaluation questions, using various information and data sources, both secondary (such as Tekes reports and innovation research) and primary (such as interviews, surveys and findings from international benchmarking). This allowed for triangulation, meaning that the answer to an evaluation question is based on several types of data from different stakeholders.

The following methods were used in this evaluation:

- Document studies, comprising literature and programme files
- Exploratory interviews
- Two participant surveys
- In-depth interviews
- Review of four international benchmarks
- Validation seminar.

The way in which the methods feed into answering the evaluation questions is schematically illustrated in Figure 3 by showing four work packages (WP), their intended results, and interlinkages. The methods are described in more detail below.

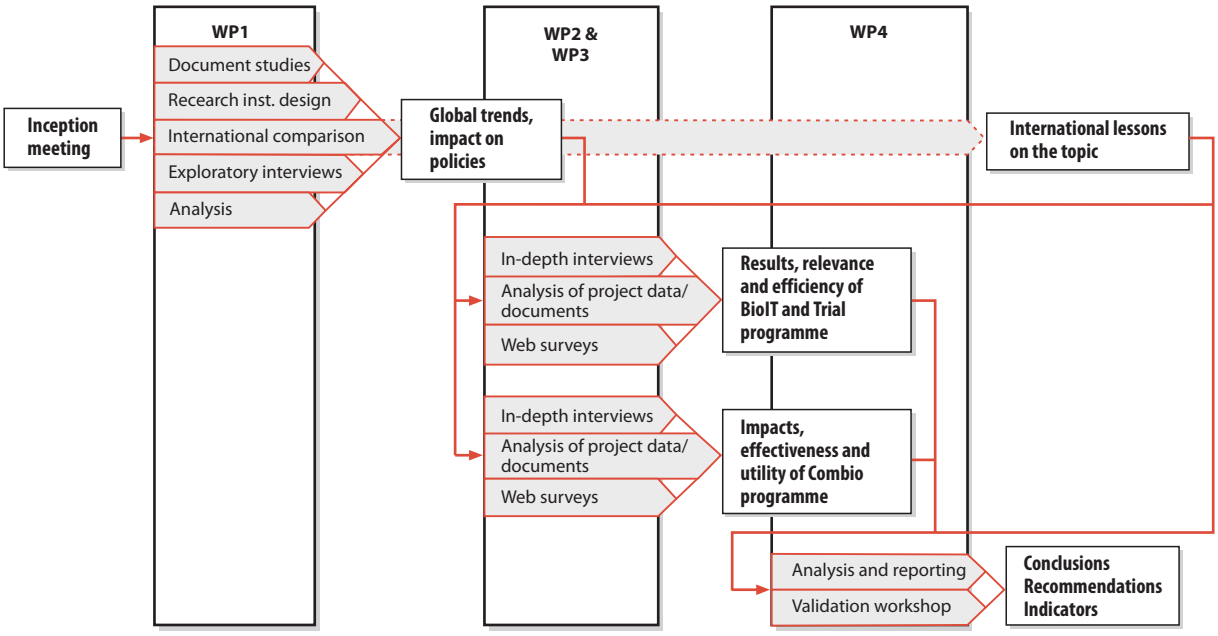
1.3.1 Document studies

The literature analysed consisted of information on the Finnish innovation policies and innovation ecosystem, as well as specific information regarding Combio, BioIT and Trial programmes which were provided by Tekes. The project lists for each programme were the main instruments used in the various calculations regarding funding distribution.

This extensive set of programme documents, mostly in Finnish, covered the entire time-span of programmes. The registers analysed include:

- Background documents for the three programme
- Evaluation and impact assessment reports
- Strategy and foresight reports
- Tekes Policy Briefs focusing on ecosystems theme
- Monitoring survey data for completed projects
- Project data from the three Tekes programmes allowed the following calculations:
  - Programme budgets (total and Tekes share) of the three programmes
  - Project funding allocations by organisation type (public or private)
  - Project allocations by organisation
  - Project funding allocations by project type (enterprise, R&D, etc.)
  - Project allocations by year.

Figure 3. Evaluation flow: Conceptual framework for the evaluation.



The analysis of these various background documents allowed to obtain a good overview of the three programmes and supported projects, and generate hypotheses that could be tested through further data collection from stakeholders.

1.3.2 Exploratory interviews

Nine scoping interviews were conducted in the initial phase of the evaluation. Interviewees included Tekes staff responsible for overall strategy, the design and implementation of the programmes, members of the programme steering committees, and industry stakeholders. A list of interviewees is presented in Appendix A.

1.3.3 Surveys

Two types of online survey questionnaires were designed: one for the BioIT and Trial programmes and another for the Combio programme, to account for the fact that the programmes took place during different time periods. The survey questions addressed to participants of the three funded programmes are shown in Appendix D.

BioIT (2013-2014) and Trial (2011-2014) programmes were more recent and the surveys included multiple, detailed and factual questions, such as the number of project partners, outcomes of the project, feedback about the programme. The aim of the survey was to gather feedback and information on immediate results of these programmes. Thus, similar questionnaires were set up for both of the programmes, adjusting for the programme information and project list in the questionnaire.

Combio programme was implemented in the period 2003-2007, and thus the decade since the end of the programme made it difficult to pose detailed questions as participants often forget project details. The aim of this survey was to understand long-term effects and impacts of the Combio programme. The respondents were asked about the project outcomes to date, feedback on Tekes, perceived contribution to Finland's innovation ecosystem, and sustained partnerships and networks.

The three surveys were launched at the end of May 2016 using contact e-mail addresses obtained from Tekes. An introductory e-mail letter was sent to all participants before the launch to verify the e-mail addresses of the participants. The addresses which were not valid had to be individually investigated. The surveys were open until August to accommodate the summer vacation period and individual reminders sent to enhance response rate. Reaching out to Combio programme participants represented a particular challenge as many of the contact details have changed. Furthermore, many of the contact people were responsible for multiple projects, impacting on project-level information even further. The evaluation team thus invested an additional effort in reaching out to contacts by telephone over the course of the survey period.

Overall, a response rate of 74% was achieved for BioIT, 49% for Trial and 31% for Combio. The complete analysis of survey results can be found in Appendix E.

1.3.4 In-depth interviews

In total, 30 in-depth semi-structured interviews were conducted with stakeholders of the three programmes. Interviewees were selected to represent all relevant stakeholder groups of the programme, sampled based on information available in the programme monitoring database and where possible complemented by survey responses to maximise coverage of potential information. For the list of interviewees for each programme, see Appendix A.

Table 2. Overview of the survey responses.

	Number of projects targeted	Number of projects responded for	Number of e-mail contacts	Number of responses	Response rate
BioIT	34	19	27	20	74%
Trial	38	18	41	20	49%
Combio	34	9	29	9	31%
Total	**106**	**46**	**97**	**49**	**51%**

Table 3. Distribution of interviewees per programme and by type of stakeholder groups.

	HEIs	RTOs	Public organisations	SMEs	Large companies	Total
BioIT	3		2	5		10
Trial	1	1		1	5	8
Combio	6			6		12
Total	**10**	**1**	**2**	**12**	**5**	**30**

Note: HEI = Higher Education Institution; RTO = Research and Technology Organisation; SME = Small and Medium-sized Enterprize

1.3.5 International benchmarking

International benchmarking of the creation of ecosystems in selected comparable forerunner countries helps to understand successes and failures around stimulation RDI clustering, networks and innovation. This informs "the best practice" from which to formulate conclusions and suggestions for the national research and innovation policy in Finland. Four countries – Ireland, Switzerland, Sweden and the Netherlands – were selected. These represent a good mix in terms of geography, size of country, levels of innovation maturity as well as thematic areas dominant in their national research and business context. The benchmarking cases are available in Appendix C.

1.3.6 Validation seminar

The evaluation team conducted a validation seminar on 29 June 2016 in Helsinki involving participants from Tekes, the public sector and project participants (see Appendix A). This provided an appropriate opportunity to present data gathered and preliminary results in order to identify potential data gaps, discuss and validate findings.

1.4 Evaluation team and steering group

The evaluation was carried out by a team consisting of:

- Dr Peter Varnai, Dr Jelena Angelis and Dr Tomas Åström, Technopolis Group
- Dr Marja Tähtinen, Finland
- Dr Sofie Pollin, TELEMIC, Department of Electrical Engineering, University of Leuven, Belgium
- Professor Pasi Malinen, Brahea Centre, University of Turku, Finland.

The assignment was led by Peter Varnai and quality controlled by Tomas Åström. Technical assistance with survey design and analysis was provided by Johanna Vallistu and Reda Nausėdaitė.

The team was guided by an evaluation steering group (see Appendix B) that the evaluation team met on 10 March 2016 (kick-off meeting), 3 May 2016 (update meeting via Skype), and 29 June 2016 (validation seminar). Finally, the team gave a presentation at Tekes 'Arvi Day Seminar' on 31 August 2016 to enhance cross-learning from multiple programme evaluations.

2 The programmes

2.1 Commercialisation of Biomaterials Technology (Combio) programme

2.1.1 Background and rationale

Biomaterials and bio-implants are synthetic or nature based diagnostic or therapeutic products, that have direct contact to human tissues, but which do not harm the function of the living organism.[1] Biomaterials can be used to replace or repair missing or damaged tissue. Synthetic biomaterials are metals, ceramic substances, and silicones of other polymers or composites. Natural biomaterials may have origins in human or animal bones, cartilage, connective tissue, lung or skin. The product development, manufacturing and use of biomaterials are strictly regulated by European standards, and special emphasis is put on clinical and toxicological test, on the chemical, physical and biological characteristics of the applications, and on the sterility of products and traceability of the materials.[2]

The European Commission has funded biomaterials research projects under its Framework Programmes. The EU support for biomaterials research began in 1997 with the Fifth Framework Programme (FP5). Although not named as a topic in its own right under the FP5, 38 biomaterials projects were funded, with a total granted amount of €66.6m at the time. Several topics – including tissue engineering, bone regeneration and drug delivery – were funded in FP5, FP6 and FP7. Moreover, biomaterials for health is also a major focus of European research efforts in the coming years and as part of the Horizon 2020 Framework Programme for Research and Innovation. They will fund applications particularly as integral parts of Advanced Therapy Medicinal Products (ATMPs) or, indeed, as complete or parts of Medical Devices.[3] Projects funded by the Commission appear to align closely with the trends of evolution in the biomaterials industry itself. Technologies for prostheses/implants and surface coatings are already well advanced in the marketplace. Current research interest focuses principally on tissue engineering, bone repair, diagnostic tools and medical adhesives.[4]

Finland has been one of the leading countries in biomaterials development. Research on biodegradable fixation materials and implants started already in 1978 as a collaboration of the University of Turku and Tampere University of Technology. First clinical trials showing the efficacy of biodegradable implants in fracture fixation were published in 1985[5], and the first companies to patent and commercialise biomaterial innovations established in 1982 and 1984, respectively. In fact, the first biomaterial implant patents in the whole world are Finnish, and they were filed by Professor Törmälä's group at Tampere University of Technology in 1986.[6] Since those days, Tampere and Turku have been the most active sites in biomaterial development in Finland.

The growth of biomaterial research in Finland was very rapid. Tekes and the Academy of Finland gave funding to this novel branch of research. Collaboration was done with several domestic research institutes and hospitals as well as with foreign institutes and companies, and Finnish scientists participated in several, multinational EU projects.[7] Also foreign investors and companies became interested in Finnish expertise, and some of the Finnish companies were merged with US companies. As a result, the products were distributed worldwide and some biomaterial companies entered the stock markets.

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2.1.2 Objectives and priorities

The Combio programme was a support programme from Tekes for the biomaterials field in Finland. It was preceded by Potra programme (Polymers for building the future) in 2000-2003, which increased the know-how in polymer science and thus paved the way for biomaterials. Combio took place in 2003-2007 and was designed to foster commercialisation of novel biomaterials, especially materials with potential use in health sector and medical devices. The explicit objectives of the programme were:

- to strengthen the commercial development of Finnish biomaterials research and products; and
- to facilitate the creation of new Finnish and international research networks in the sector as well as to boost already existing networks.[8]

These objectives aimed at strengthening research and companies operating in the biomaterials field and creating new internationally recognised and economically viable biomaterials research and products in Finland.

Economic focus was a high priority for the programme. The reasons for launching Combio came partly from the fact that Tekes had already been funding biomaterials research for a number of years, and the decision was made to switch from research to getting products on the market. This resulted in commercialisation forming the axis around which the main objectives were formed; the development of technologies had a significantly smaller role.

With the objectives for Combio being firmly established in commercialisation, Tekes also looked into potential markets to explore. Preliminary reports indicated that the biomaterials market is rapidly growing with good potential for newcomers to enter international markets. The need for implants was growing because of the ageing population, especially in the Western countries. Recognising that the current most important biomaterials market areas are Europe and the USA; the programme also meant to facilitate entering also other, perhaps less traditional for the Finnish players, markets. In particular, the Combio programme had a focus on the development of new networks and rapid market penetration in Asia, for example, China.

2.1.3 Programme vision and mission

The mission of the programme was to facilitate the emergence of an internationally recognised high level biomaterials cluster in Finland.[8] The vision was for the emergent biomaterials cluster in Finland to possess commercial know-how and create strong businesses which are profitable and are part of strong international networks[8]. According to that, there would be 3-5 Finnish biomaterials companies operating globally in 2010, and the annual sales would be around €500m.

Reflective of the objectives, both the mission and vision indicate that international visibility and recognition were strong drivers for developing the programme. Combio had high ambitions of having Finnish companies achieving international recognition and entering international markets as a result of the Combio funding.

2.1.4 Programme management and execution

An executive board – appointed by Tekes and consisting of representatives from companies, universities, Tekes and other stakeholders – led the Combio programme. The board laid out the strategic priorities for the programme, which were approved by the Tekes' Board of Directors. The Board approved the annual plan for the programme and oversaw its implementation, inter alia, by commenting on the broad aspects of the programme, monitoring the progress of the programme and coordinating evaluations. The executive board met a total of 15 times during the course of the programme.

An external to Tekes person was appointed as a programme manager and was tasked with overseeing the programme and its functions, managing communication between the different groups, responding to internal and external communications and acting as a secretary to the executive board.

Altogether 22 companies, 10 research institutes and one hospital district participated in Combio, and 31 projects received funding from it. Most of the projects dealt with implants, nine projects were about drug delivery and only three projects about tissue engineering. An overall budget of the programme was €30.3m, of which Tekes contributed €21.3m (or 70% of the total budget), see Table 4.

The Tekes budget allocations for R&D projects demonstrate a fairly standard distribution, when considering the lengths of the programmes, with the largest funding dispersed during the mid-point and dropping off towards the end. The R&D projects also show smaller deviations on a yearly basis in terms of the funding amount. As a contrast, the funding for enterprise projects demonstrates a significant rise in 2005 (with an overall increase of 326% when comparing 2004 to 2005) and a significant drop in 2006. These trends show that R&D projects were overall much more consistent while funding of the enterprise projects indicates some turbulence, with a significant interest for funding in 2005.

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8 Tekes, Combio – Terveydenhuollon biomateriaalit 2003-2007, Teknologiaohjelmaraportti 4/2007, Loppuraportti. http://www.tekes.fi/globalassets/julkaisut/combio_raportti.pdf

Table 4. Overview of projects in the Combio programme. Source: Technopolis analysis of Tekes data

	R&D projects	Enterprise projects	Total
Number of projects	45	18	63
Overall budget (million €)	13.7	16.6	30.3
Tekes budget (million €)	12.9	8.4	21.3
Tekes share of overall budget	**94%**	**51%**	**70%**

Note: The number of projects is based on the information available in the internal Tekes programme database. The calculation was made using project ID and only counting unique titles. It does differ from the number mentioned in the paragraph preceding the table. Our assumption is that in the Tekes project database different organisations have slightly different names given to a project thus resulting in multiple entries. This discrepancy, however, does not change the data analysis.

The beneficiaries of the Tekes' R&D and enterprise projects funding are shown in Figure 5. With €21.3m, the highest amount of the funding for R&D projects was granted to the University of Turku (€2.73m). Other notable beneficiaries were Tampere University of Technology (€2.27m) and the then Kuopio University (now merged and part of the University of Eastern Finland, €2.13m). On the enterprise side, Bioretec received €3.93m which places it as the highest funded company and the beneficiary as a whole. However, other enterprise projects received a significantly lower amount. When comparing the funding intensity of the R&D projects versus enterprise projects, the former as a whole had a lower difference between the most and least funded projects, ie the difference between the R&D projects was €2.1m while the difference between the enterprise projects was €3.7m.

Different type of support has been provided during the programme (see Figure 7). For example, tissue-engineering projects were funded through the programme. Tampere has been one of the most well-known sites for tissue-engineering and stem cell research. The Regea Institute for Regenerative Medicine was founded in 2004 and an ambitious project "Human spare parts" began in 2011 in BioMediTech with the support from Tekes. This programme combines the top-level know-how gathered in previous stem cell research, sensor technology research and biomaterials development. In addition to funding, Combio offered services that helped the participating organisations commercialise their innovations. These services included seminars and consultations on patenting, quality issues, regulations concerning medical devices, licensing etc.[9]

Due to a strong focus on commercial applicability and commercialisation and in order for the programme to achieve its ambitious mission, it was recognised that Combio would have to offer its participants (universities

Figure 4. Distribution of Tekes funding of enterprise and R&D projects in the Combio programme over time. Source: Technopolis analysis of Tekes data

[9] Tekes, Combio – Terveydenhuollon biomateriaalit 2003-2007, Teknologiaohjelmaraportti 4/2007, Loppuraportti. http://www.tekes.fi/globalassets/julkaisut/combio_raportti.pdf

Figure 5. Beneficiaries of Tekes funding in the Combio programme: R&D projects. Source: Technopolis analysis of Tekes data

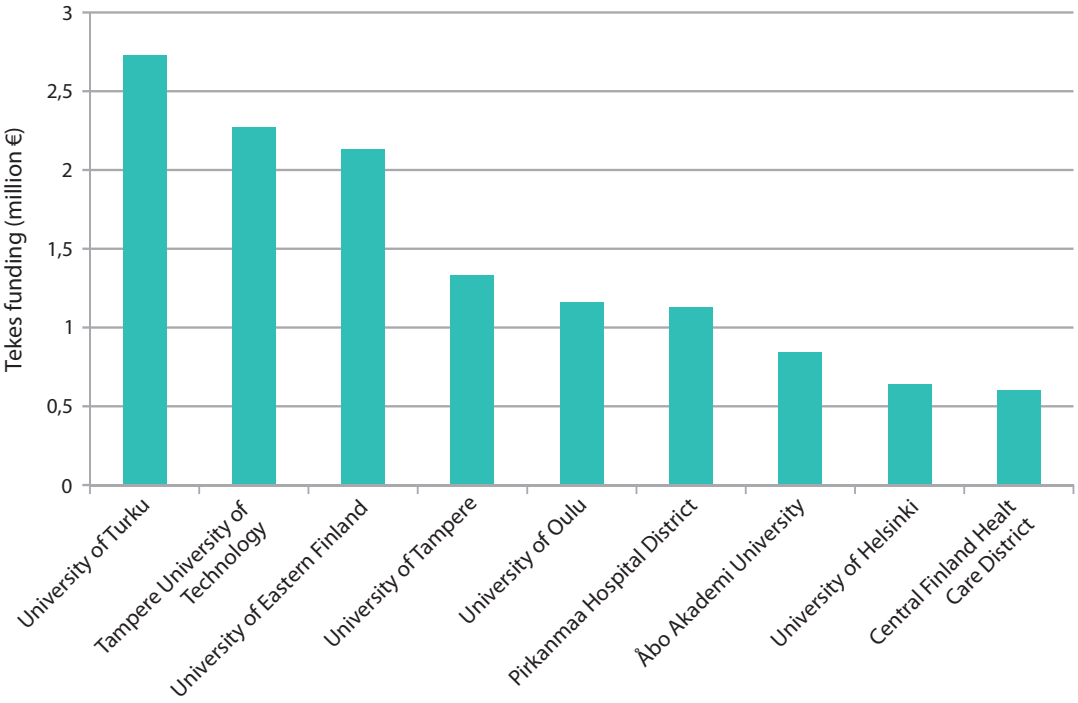
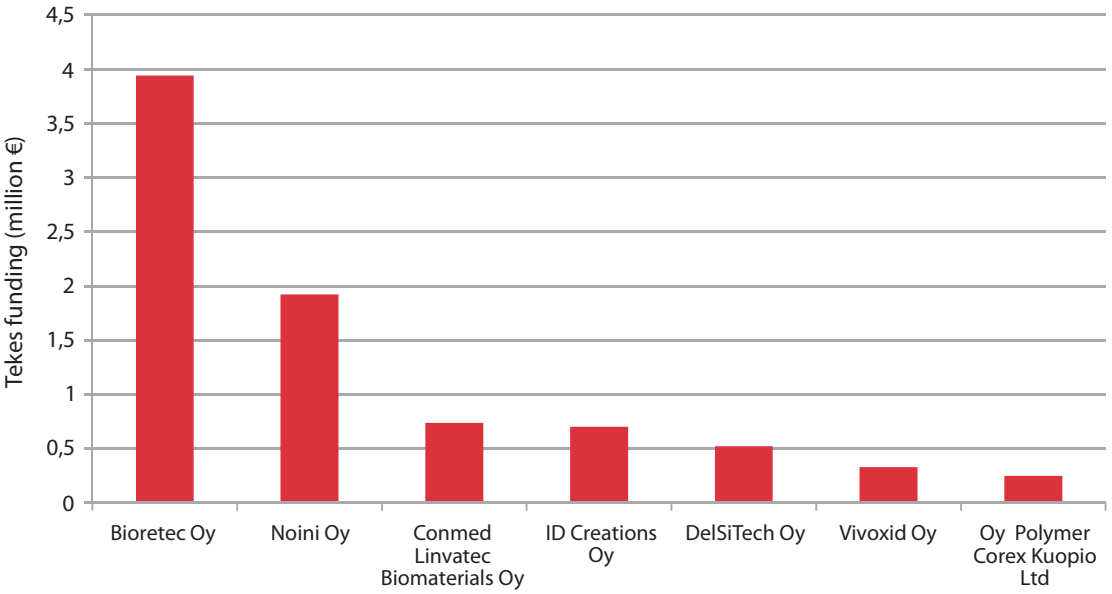


Figure 6. Beneficiaries of Tekes funding in the Combio programme: Enterprise projects. Source: Technopolis analysis of Tekes data



and research institutions in particular) necessary business know-how. The need for this was emphasised when in the early stages of the programme the participants were asked what specific business related skills Combio should focus on. With a passive response from the participants, it became apparent to the management team that the additional support for the programme will have to be designed from the top perspective as the input from the participants was negligible.

The programme offered full-day business seminars with lecturers (i.e. business strategies; capital management, preclinical animal testing). During these sessions, the participants performed practice-based exercises and received some homework. The programme manager was

Figure 7. Combio support for participating organisations. Source: Technopolis analysis of background documents, eg Combio – Terveydenhuollon biomateriaalit 2003-2007, Teknologiaohjelmaraportti 4/2007, Loppuraportti. http://www.tekes.fi/globalassets/julkaisut/combio_raportti.pdf

Combio support for participants					
Business seminars	**Celemi's Apples & Oranges**	**Consulting services**	**NERAC services**	**International trips**	**International market reports**
Value-driven project and portfolio management Fundamentals in Business Plan Development Finances in biotechnology companies Strategy process in companies Licensing Workshop Courses on capital investment	Simulated exercises about the foundations of business Participants encouraged to think like businesses owners Financial advice given	Consulting services on optional prizing Consulting on licensing and certification	Training sessions related to patenting: Intellectual property basics; Protection of biotechnology inventions. Programme borrowed from NERAC.	Visit to Tekes office in Tokyo International trip to China International trip to Singapore International trip to France International trip India	Report on biotechnology in China Report on China's biomaterials Clearing biomaterials distribution channels in the USA and Europe Introduction to India's health care system Internationalisation of Finnish Biomaterials in India

in charge of developing much of this curriculum and was a key figure in organising the Celemi's Apples & Oranges, a game centred on a series of simulated exercises about the foundations of business, which empowered the participants to think like business owners. During the course of the game participants learnt how to monitor cash flow, better utilise resources and improve productivity. Balance sheets and income statements were also analysed to teach the participants about how to measure results and understand financial and strategic impact daily decisions have on the company.

Due to the strong focus on internationalisation and, in particular, penetration of the Asian markets, programme participants were offered numerous opportunities for international visits to China, India, Japan and Singapore. The objective of the trips was to facilitate cooperation between Asian and Finnish biomaterials companies and research institutions; allow Finnish representatives to familiarise themselves with the local climate on biomaterials research; introduce the Finnish biomaterials sector to foreign companies and research institutions; and help set up potential partnerships. In addition, a number of reports on the Asian biomaterials markets were produced and made available to the participants of the Combio programme.

2.2 Solution for Biological Information (BioIT) programme

2.2.1 Background and rationale

With the exponential increase of biological and medical information, new solutions are needed to better organise, store and analyse these data to fully exploit their potential to prevent, diagnose and mitigate diseases and enhance human well-being.

The EU has been supporting bioinformatics research and infrastructure through the European Bioinformatics Institute (EBI) and various Framework Programmes. In FP7, a specific challenge area was devoted to ICT for Health, Ageing Well and Independent Living. Flagship projects included Virtual Physiological Human, Ambient Assisted Living and Personal Health Systems. EBI is running industry partnership programmes to disseminate the latest technologies to industry and boost their R&D. There is a specific SME forum organised annually addressing the needs of small businesses.

Finland has a good pool of academic expertise and huge potential in the field of bioinformatics. Finland supports the development of pan-European biomedical research infrastructures[10] in bioinformatics (ELIXIR), clinical

[10] http://www.emtrain.eu/index.php/partners/esfri-bms-partners

research (ECRIN), biobanking (BBMRI) and translational medicine (EATRIS).

Tekes' strategy[11] has among its focus areas health and wellbeing and a number of relevant programmes have been introduced over the years, with successive evaluations. Tekes recognised the need for early funding of innovative bioinformatics and the broader 'quantified self' ideas to enable promising companies to further test and develop their products and demonstrate their value for money. Tekes started the new programme BioIT after an intensive preparatory period between September to December 2012, discussing the new programme idea with stakeholders, including representatives of companies, universities, VTT, and public bodies. Note that programme officers originally listed about 40 companies in the bioinformatics field but, after broadening the focus, about 100 companies participated in some of the BioIT activities. The new programme was built on experiences from previous programmes at Tekes, such the Pharma programme, Food and well-being, etc.

As net exporter of health technologies, Finland is already attracting investment and new initiatives and this trend is set to continue. For example, the Vertical Startup Accelerator (established in 2015) offers an environment and business assistance to early stage companies within the fields of bioscience, health technology and nutrition. Another recent example is the Health Innovation Village, initiated by GE Healthcare Finland in late 2014, where start-ups can share space and come up with pioneering ideas in healthcare of the future.

The current section is aimed at shedding light on the relevance and inputs of the BioIT programme in the Finnish innovation landscape, the tangible results achieved by these 35 projects and their sustainability, as well as any intended and unintended consequences of the funding are described in a later section.

2.2.2 Objectives and priorities

The focus of Tekes' BioIT programme was to create new sustainable collaborations and partnerships between traditional ICT actors and experts in biology, genetics and environmental sciences across academia and industry. The programme ran over 2 years with most projects starting in 2013 and 2014 and a total budget close to €17m; Tekes funding amounted to about €9m. There have been 35 projects to 30 different companies, mostly SMEs. Note that 17 projects were still ongoing at the time of the evaluation in 2016. Nevertheless, some of the early results of the BioIT projects were visible and could be measured.

The projects themselves varied within the field of biological and health data informatics: from software support to molecular level genomics data to improve cancer diagnostics to wireless transfer for monitoring personal health data. The programme offered both enterprise support and research funding, but beyond funding and expertise, it also served as an important opportunity for organisations to network and get international visibility for further growth.

The objectives of the programme were to cater for the needs of SMEs using an agile approach to achieve:

- Translation and commercialisation of academic research through collaboration and spinouts
- Growth of SMEs and their internationalisation
- Creation of sustainable value chains, networks and a national ecosystem.

2.2.3 Programme vision and mission

The generation of massive biological, clinical and life-style data requires new data management, storage and analytical solutions to extract the information and use the knowledge to enhance the health of citizens. Despite the considerable national knowledge base, actors in this new area were not joined up, fragmentation and lack of established networks prevented capitalising on a new growth potential in Finland. Consequently, linking up the biological and health data producers and IT companies (small and large) was a cross-disciplinary challenge as well as huge opportunity both nationally and internationally. While the programme focussed on high-growth SMEs, large companies were seen as enabling partners offering their networks, insight and information on customer needs, as well as direct beneficiaries of new services developed. In addition, unique data and promising processing tools in the academic sector needed to be linked up with industrial partners so that these can effectively reach the market.

The BioIT programme was thus meant to expand the reach of biological and clinical data producers nationally and internationally and provide new business opportunities to traditional ICT actors in a joined-up programme. It decisively aimed to accelerate commercial exploitation of existing solutions rather than embarking on a large-scale research and development exercise. SMEs however often lacked the necessary business skills or the protected space to experiment with their new business models.

The mission of the programme was to bring new business ideas to market, from both academic and SME settings, connect the various actors of the new BioIT ecosystem, and create sustainable growth BioIT companies in

[11] https://www.tekes.fi/globalassets/julkaisut/tekes_strategy_engl_2011.pdf
https://www.tekes.fi/globalassets/julkaisut/elvi_arviointi_7_2014.pdf
https://www.tekes.fi/globalassets/julkaisut/wellbeing_and_environment_308_2014.pdf

Finland. In order to achieve these ambitious goals, Tekes aimed to utilise existing frameworks and operational channels, as well as leverage the funding activities of other agencies such the Academy of Finland, Japan Science and Technology Agency (JST) and the European Commission's H2020 programme.

2.2.4 Programme management and execution

The BioIT programme was foreseen with a smaller budget of about €10m than previous Tekes programmes to be active for a shorter period of time, only for 2 years (with a possible extension for a third year[12]). This was despite the diverse activities planned, including a normal amount of international collaboration for companies. In addition, the operational budget for the programme was rather lean, with a small team of 3 people (one of them leaving before the end of the programme), without the help of an external steering board or external coordinator. Note that eventually an external company had to be commissioned on an ad hoc basis for managing events. It was recognised early that this project represents a departure from traditional Tekes programmes but was considered an interesting experiment.

In total, the programme comprised 35 projects with an overall budget of €35m, of which Tekes contributed €9.6m (60% of total budget), see Table 5.

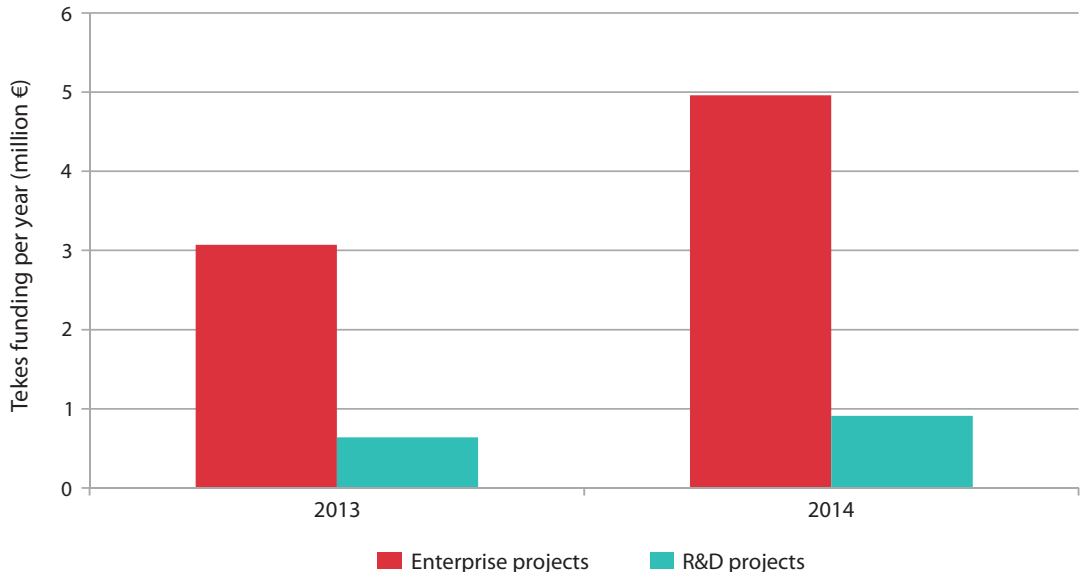
Overall, grants to companies amounted to €3.2m (34%), loans to companies €4.8m (50%) and support for public research projects to €1.6m (16%). The Tekes funding to companies largely went to SMEs (94%) and the rest to large enterprises (6%).

The breakdown of the 35 funded projects by the BioIT programme shows 26 SME projects, 3 large enterprises (i.e. Valio, Roal, and Boreal), 5 for universities and research institutes (i.e. University of Helsinki, University of Eastern Finland, University of Jyväskylä, and VTT) and 1 for a public district hospital. Note that there were a number of pro-

Table 5. Overview of projects in the BioIT programme. Source: Technopolis analysis of Tekes data

	R&D projects	Enterprise projects	Total
Number of projects	5	30	35
Overall budget (million €)	2.3	13.7	16
Tekes budget (million €)	1.5	8.1	9.6
Tekes share of overall budget	**65%**	**59%**	**60%**

Figure 8. Distribution of Tekes funding of enterprise and R&D projects in the BioIT programme over time.
Source: Technopolis analysis of Tekes data



[12] Note that there was eventually no extension of the programme. Instead a new, larger programme was launched in 2015: Bits of Health, with the aim to make Finland the digital hub of health, thus with a large overlap with the BioIT programme and hence can be considered as a natural continuation. All companies funded in the BioIT programme were introduced to the new Birs of Health programme: http://www.tekes.fi/en/programmes-and-services/tekes-programmes/bits-of-health/

jects which technically were not funded out of the BioIT programme budget but in terms of thematic area they belonged to the BioIT programme.

The Tekes funding trends, when analysed by year (Figure 8), reveal that while the funding for both R&D and enterprise projects rose from 2013 into 2014, enterprise projects (with an increase of 61%) saw a significantly larger increase in funding when compared to R&D projects (with an increase of only 42%).

The beneficiaries of the Tekes R&D funding are shown in Figure 9. With the total Tekes budget for R&D projects being €1.5m, the VTT Technical Research Centre of Finland was granted the largest amount (at €0.5m) of all Tekes funding of R&D projects. However, the funding for enterprise projects far exceeded R&D project funding with 5 enterprise projects surpassing the VTT Technical Research Centre of Finland. PulseOn had the highest funded project at €1.4m, with Blueprint Genetics in a close second place at €1.2m.

Figure 9. Beneficiaries of Tekes funding in the BioIT programme: R&D projects. Source: Technopolis analysis of Tekes data

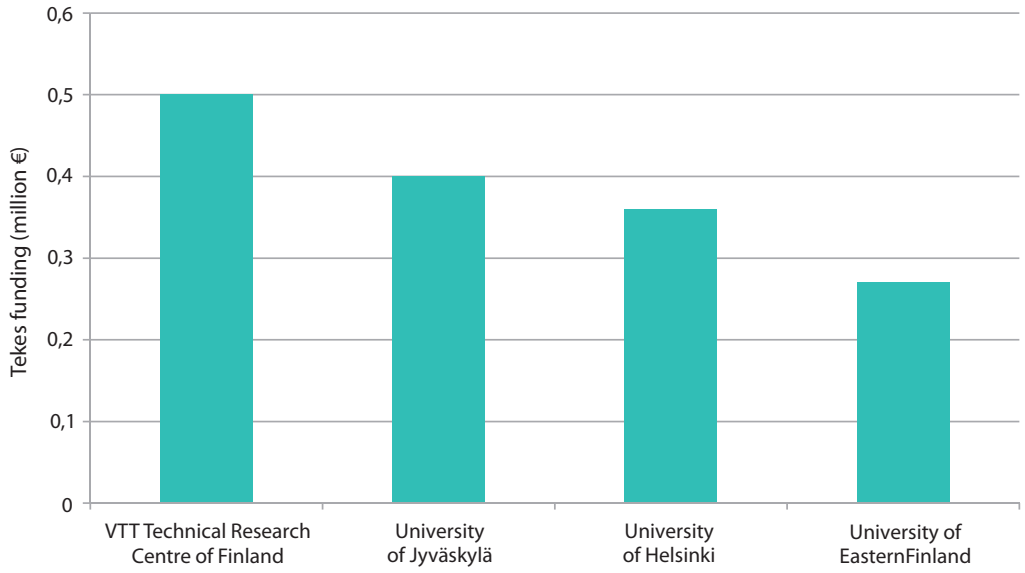
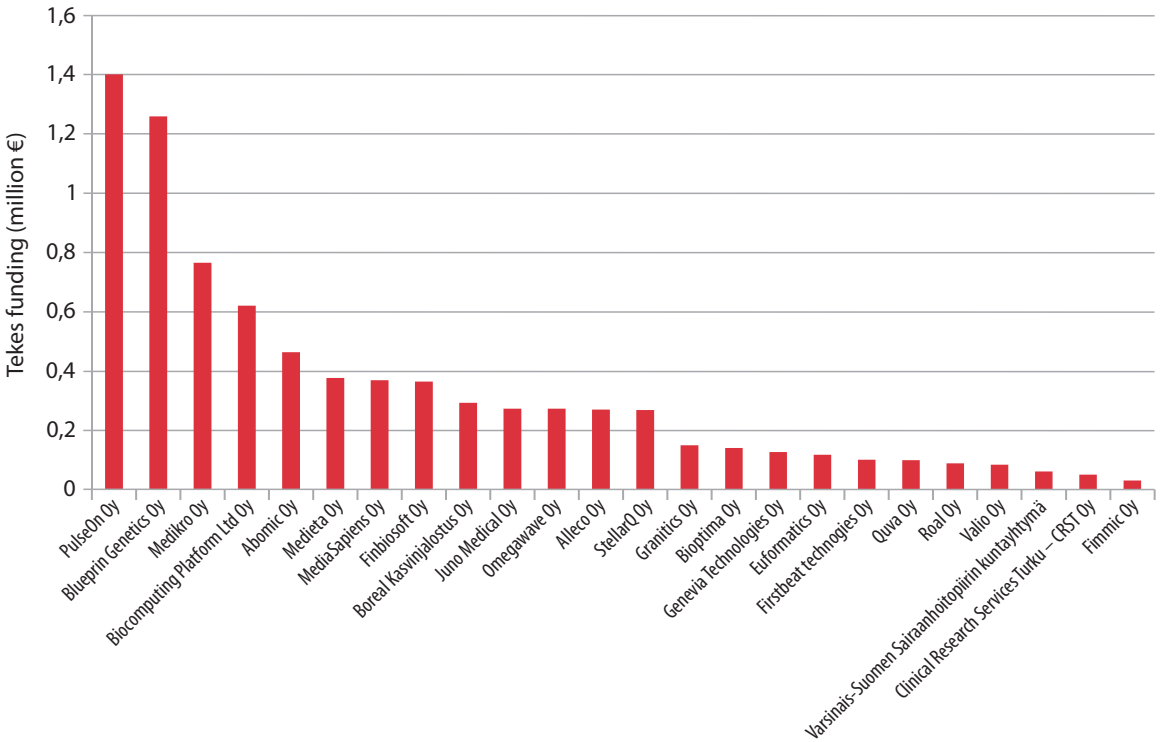


Figure 10. Beneficiaries of Tekes funding in the BioIT programme: Enterprise projects. Source: Technopolis analysis of Tekes data



In terms of activities, the lean and short BioIT programme offered a surprisingly large number of activities, thanks to the smart leveraging of existing resources:

- **Scoping.** Surveys were commissioned and workshops organised about BioIT area when preparing the programme (i.e. Knowledge and Application of Bioinformatics Technology Survey). The new programme was introduced in cities across Finland through roadshows in early 2013, as well as at Finnish Bioindustries and IBC Finland.
- **International BioIT experts list.** A company was contracted early in the programme to prepare a largely UK expert list (with skills and contact details) so that experts can be available for business development advice and mentoring upon call by Finish companies on a consultancy basis.
- **Networking days.** Two events each year with about 100 participants[13]. The interactive activities and lively discussions create awareness.[14] International trend lecture was also provided by Frost-Sullivan in 2014.
- **Newsletters.** Five newsletters were circulated annually to funded companies and interested parties
- **Training.** A need was recognised in the IPR field for company representatives (Dec 2013). In addition, commercialisation training was provided (once in 2013, twice in 2014), mostly for companies (19) and research institutes (6). Note: Tekes has separate instrument for universities commercialisation funding[15] to promote commercialisation of research ideas at universities. Nevertheless, universities with projects in the BioIT field were included in the commercialisation training activities of the BioIT programme. Tekes has already adopted the NABC Method from Stanford Research Institute.
- **Seminars on BioIT to traditional IT companies.** A special seminar organised for ex-Nokia staff in 2014.
- **Investors events.** Developed investor relationship for funded companies, including with FiBAN (Finnish Business Angel Network) in September 2014. BioIT investor breakfast was also part of the creative matchmaking events.
- **Internationalisation.** As a resource intensive activity, BioIT received support from other initiatives of Team Finland with the aim to identify opportunities in the USA, Japan, India, and China. 2 large delegations travelled to USA (California and Boston area) with the thematic focus of 'digital health'. In addition, 2 joint calls with the Finnish Academy and JST funded relevant (mostly university) projects in the more basic research field, not technically part of the BioIT programme activities. BioIT participants were also invited to the EU H2020 information days.
- **Report commissioned on the commercial possibility of Biobanks.**[16]

2.3 Environmental for Cognitive Radio and Network (Trial) programme

2.3.1 Background and rationale

Cognitive radio (CR) is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. Such a CR does not rely on rigid, fixed spectrum allocation to avoid interference between radio systems, and consequently, this technology optimises the use of scarce radio-frequency (RF) spectrum. The conception of good CR technology relies on a tight interaction between different stakeholders: technology providers, network operators or service providers, and regulatory bodies.

CR technology requires innovations on analogy software defined radio, as well as various methods to improve context and spectrum awareness. The CR can be used in many ways such as a transceiver to determine its geographic location, identify and authorise its user, encrypt or decrypt signals, sense neighbouring wireless devices in operation, and adjust output power and modulation characteristics. In principle there are two main types of cognitive radio. First is full cognitive radio, which takes into account all parameters that a wireless node or network can be aware of; and second is spectrum-sensing cognitive radio, which is used to detect channels in the radio frequency spectrum.[17] Overall, there are many different approaches towards CR, and the research community is still actively researching what is the best technology and business model to enable CR. In addition to the aforementioned view of a CR as a radio that determines and learns the context locally, there is a large amount of research targeting the creation of radio maps in EU or geolocation databases in the USA.

There has been sizable EU funding related to research on the topic of cognitive radio, totalling €52.3m between 2007 and 2012 (for example, through the EU funded pro-

13 https://tapahtumat.tekes.fi/tapahtuma/bioitverkottumistilaisuus
14 https://tapahtumat.tekes.fi/uploads/74db1228/Cait_Murray-1095.pdf
15 http://www.tekes.fi/en/funding/research_organisations/new-knowledge-and-business-from-research-ideas
16 https://www.tekes.fi/en/whats-going-on/news/biopankkien-tietovarannoista-uutta-liiketoimintaa/
17 http://searchnetworking.techtarget.com/definition/cognitive-radio

jects such as QoSMOS[18], COGEU[19], FARAMIR[20] etc).[21] The driver for research in the field is the increasing importance of wireless connectivity in the economy at large and the predicted exponential growth of wireless data traffic. For example, there are approximately 40 million wireless devices sold in Europe annually operating in the 863-870 MHz licence-exempt SRD band. Also currently the Wi-Fi networks carry more than 20 times as much Internet data as all the cellular networks combined and more than half of all smartphone traffic is routed via Wi-Fi. Thus, the current wireless networks are struggling to carry the data traffic generated by smart phones and other mobile devices. Cognitive radio is expected to provide a significant boost for wireless communications and introduce new business opportunities. The EU expects radical novel business opportunities form solutions that share the spectrum (collaboratively), and saw spectrum sharing as one of its two grand challenges in 2015[22]. CR and wireless communication research is also widely seen as an area where experimental research is a must, so in FP7 a CR experimental facility (CREW) was set up [23].

The issue is also present on the EU policy agenda. The Radio Spectrum Policy Programme (RSPP)[24] sets out the goal to maximize the socio-economic and environmental benefits that can be generated through the use of radio spectrum and foster wireless innovation in Europe. Moreover, the Digital Agenda for Europe (DAE)[25] states that it is important to ensure radio spectrum contributes to broadband targets. Finally, it is also important to support sustainable growth in the internal market as set out in Europe 2020 Strategy[26]. The strategy sets out environmental objectives for a sustainable, energy-efficient and competitive economy, which can be met with the help of wireless technologies.

Finland is one of the leading countries in the research field as ICT is in the centre of national R&D policy. In the past, there have been several national programmes in the field such as the VTT project Channel State Estimation and Spectrum Management for Cognitive Radios (CHESS) project in 2006–2007 (co-funded by Tekes) or the COGNAC project (2008–2011) done in cooperation between VTT and the CWC[27].

More recently several active trial environments in the country such as VTT Cognitive Trial Environment or Nokia Cognitive Radio Testbed have emerged through the Trial programme. The Trial Environment for Cognitive Radio and Network programme[28] funded by Tekes is supporting the field in order to make Finland globally attractive cluster of expertise and unique trial environment for cognitive radio and networks.

2.3.2 Objectives and priorities

The objectives of the programme were as follows:

- Finland is at global top level in the research and development of cognitive radio and networks
- Finnish companies utilise the business potential of the cognitive radio and networks
- National and international co-operation is created
- Finland is a tempting trial environment for foreign companies.

The main objective and priority of the programme was to establish an ecosystem in Finland enabling to share knowledge, expertise and hardware (Trial environment) related to Cognitive Radio.

2.3.3 Programme vision and mission

Wireless and mobile technology is important for Finland. The mobile ecosystem is growing rapidly, and it is believed that a novel disruptive technology is needed to continue the explosive growth. Cognitive radio is expected to provide a significant boost for wireless communications and introduce new business opportunities. While this novel cognitive radio technology promises high gains, the risks are also high as the technology is unknown, and also depends to a large extent on regulation. For this long term, high gain yet high risk technology, a research-oriented programme was needed.

The mission of the programme was to lead Finland to become "the place to be" for cognitive radio research and experiments. The aim of Tekes' Trial Environment for Cognitive Radio and Network programme was to transform

18 http://www.ict-qosmos.eu
19 http://www.ict-cogeu.eu
20 http://www.ict-faramir.eu
21 https://tapahtumat.tekes.fi/uploads/9778d82/Philippe_Lefebvre_TRIAL_Seminar_EU_contr_for_publication-3253.pdf
22 http://ec.europa.eu/research/horizonprize/index.cfm?prize=spectrum-sharing
23 http://www.crew-project.eu
24 https://ec.europa.eu/digital-agenda/en/radio-spectrum-policy-program-roadmap-wireless-europe
25 https://ec.europa.eu/digital-agenda/en
26 http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/index_en.htm
27 http://www.vtt.fi/inf/pdf/tiedotteet/2011/T2575.pdf
28 http://www.tekes.fi/en/programmes-and-services/tekes-programmes/trial/services/

Finland into a globally attractive cluster of expertise and unique trial environment for cognitive radio and networks. By pooling together all knowledge and hardware, and give access to some very large mobile companies and an innovative regulatory body, a unique world-leading knowledge and trial cluster for cognitive radio could be created, showcasing Finland's wireless potential.

2.3.4 Programme management and execution

The Trial programme consisted of several large consortia or project clusters that were managed by a project manager. Within each of those large consortia, parallel projects enabled companies to focus on specific business needs or IP creation. Information exchange between the large clusters was taken care of by the interest group, which was the main forum for the programme organised by Tekes. The meetings of the interest group were seen as very important for disseminating information inside the programme and for coordinating the actions. Tekes was very active in promotion of programme results. An external steering group was responsible for the selection of the specific theme, i.e. CR as a priority for Finland.

The total budget of the programme was approximately €34m, from which 31 research projects and 21 industry projects were funded.[29] Industry partners included, for example, NSN, Nokia, Elektrobit, Anite Telecoms, Exfo, Renesas/Broadcom, Digita, Fairspectrum, Pehutec, PPO-Yhtiöt. Public sector partners included as an example the Finnish Communications Regulatory Authority (FICORA), the Finnish Defence Forces, and the Ministry of Transport and Communications.

In total, the programme comprised 52 projects with an overall budget of €33.8m, of which Tekes contributed €14.97m, see Table 6.

Analysing the distribution of Tekes funding by year 2011 saw the largest distribution of funding (with R&D projects receiving €3.6m and enterprise projects receiving €4.3m). Overall, in 2011 over 52% of the total Tekes budget had already been allocated. The funding trends for both R&D and enterprise projects largely followed the same patterns, with a significant drop observed in 2012 (when no enterprise project received any allocations) and a rise in 2013. 2014 and 2015 saw the lowest levels of allocations, which can be attributed to the programme coming to a close. Between 2012 and 2013 R&D projects received the overall larger amount of funding, when compared to enterprise projects; while enterprise projects overtook their R&D counterparts in 2011, 2014 and 2015.

The beneficiaries of the Tekes funding of R&D and enterprise projects are shown in Figure 12. With the total Tekes budget reaching €14.97m, Aalto University Foundation was awarded with the highest amount of Tekes funding (€1.97m) for an R&D project and VTT Technical Research Centre of Finland coming in close second (€1.85m). Note that Anite Telecoms Oy (although a company and not a university or a research centre as other beneficiaries) received money for the R&D project (ATRIAL II). Among enterprise projects Nokia was awarded €2m and is overall the top recipient of Tekes funding. When analysing the distribution of funding between R&D and enterprise projects Trial in general has a rather even distribution with the funding curve being similar for both R&D and enterprises. However, R&D projects demonstrate a slightly smaller gap between the highest and lowest funded projects (€1.7m) when compared to the gap between the highest and lowest funded enterprise projects (€1.9m).

Table 6. Overview of projects in the Trial programme. Source: Technopolis analysis of Tekes data

	R&D projects	Enterprise projects	Total
Number of projects	31	21	52
Overall budget (million €)	13.1	20.7	33.8
Tekes budget (million €)	8.28	6.69	14.97
Tekes share of overall budget	**63%**	**32%**	**44%**

[29] https://www.tekes.fi/globalassets/global/ohjelmat-ja-palvelut/ohjelmat/5thgear/opening-seminar-120315/trial-overview.pdf

Figure 11. Distribution of Tekes funding in the Trial programme over time. Source: Technopolis analysis of Tekes data

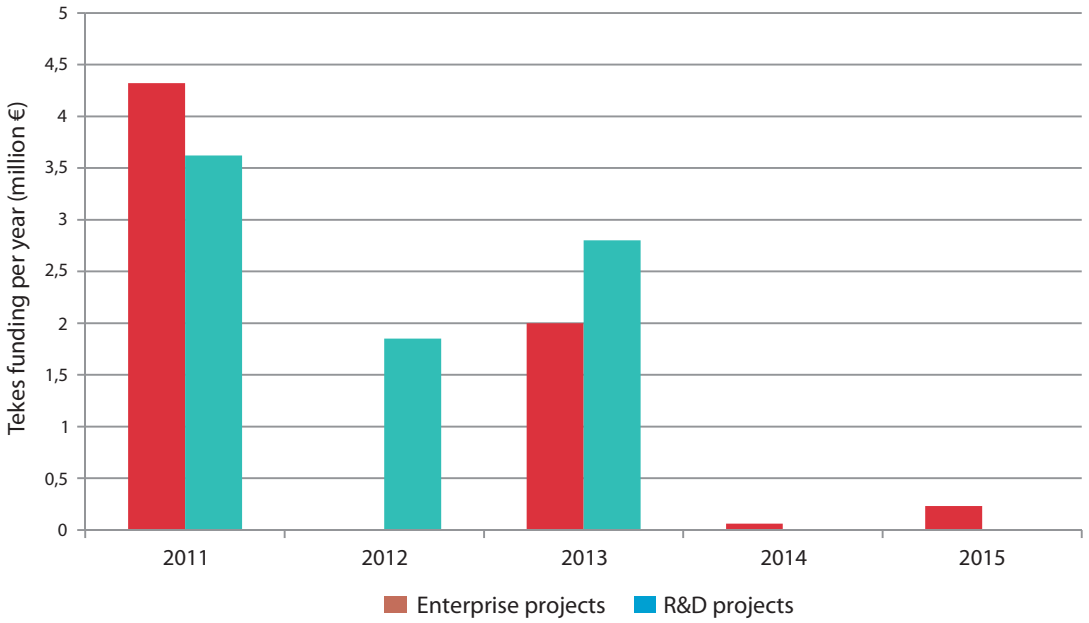


Figure 12. Beneficiaries of Tekes funding in the Trial programme: R&D projects. Source: Technopolis analysis of Tekes data

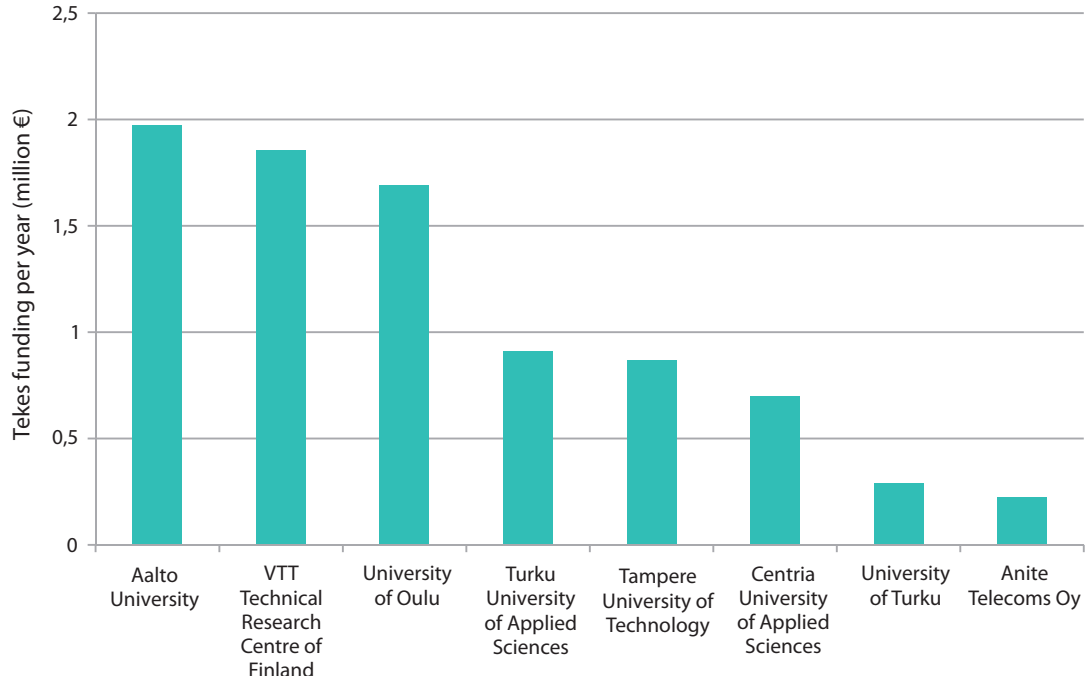
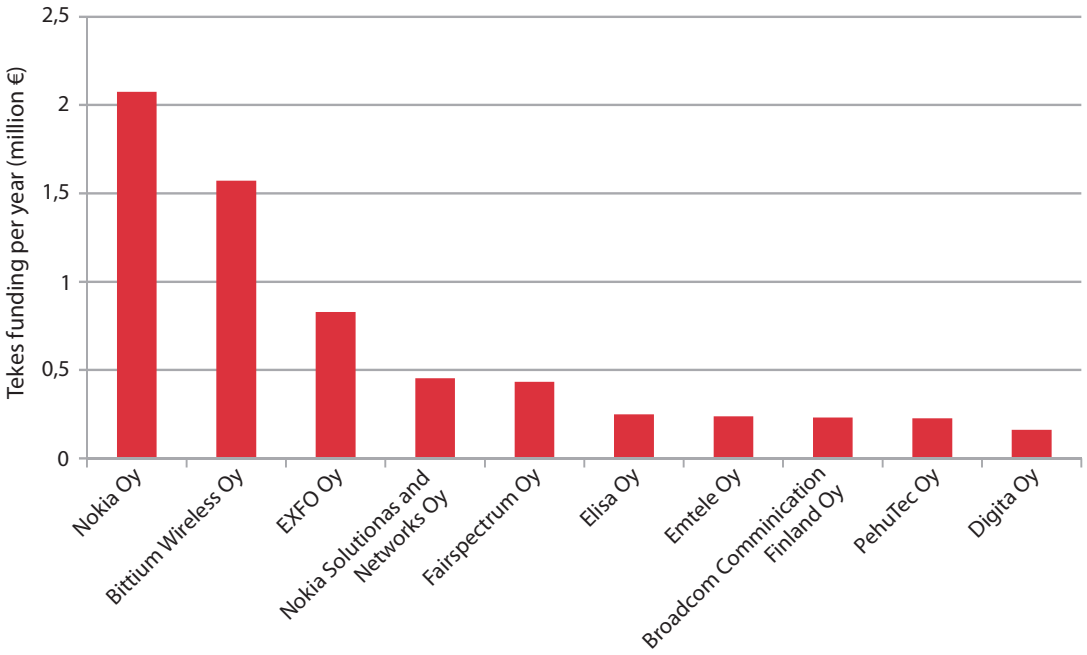


Figure 13. Beneficiaries of Tekes funding in the Trial programme: enterprise projects. Source: Technopolis analysis of Tekes data



3 Results and impacts

This chapter presents the results and impact that the evaluation has been able to document.

3.1 Combio programme

3.1.1 Results

The Combio programme was built on two decades of biomaterials research in Finland. It started from the situation where no real networking was taking place between the players outside the two key locations (ie Tampere and Turku). There were only a few big companies to assist in commercialisation activities. The existing Finnish companies were too small and research oriented. The sector was rather traditional and multidisciplinary research was needed. In addition, in medical devices sector, the legislation and standards environment is restrictive and there was also no risk money available. Some notable results were achieved as a result of the programme but it was short of realising its long-term goals. It helped creating and strengthening national collaborations between biomaterials groups and companies, gave a welcome funding boost to the sector, and focussed on establishing a new industrial cluster in Finland.

Projects were delivered **focusing on different elements of the biomaterials sector and bought results of varied nature**. Among private sector participants, Bioretec has achieved substantial results. The company was founded in 2003 to develop, manufacture and market bioabsorbable, bioactive and drug-releasing surgical implants for orthopaedic, trauma and sport medicine surgeries. In the area of mechanically active implants (such as pins and screws), the company brought first products (active implants) to market in 2006-2007; the R&D work started already earlier but was finalised with Combio funding. In the area of antibody-containing implants, Bioretec developed a manufacturing process and analysis methods during Combio and in 2010 launched its first biodegradable, antibody releasing fixation screws, which are used to prevent infections on operation surfaces.

Among the research organisations, Tampere University of Technology achieved substantial developments. Even though no new products were brought to market, a lot of work was done in process development, for example, novel methods to modify melted material were created as well as methods to analyse and characterise the materials and their stability in vivo. In addition, methods to analyse behaviour of the materials in human body were developed, for example, a PET scanning system to detect the dissolution of antibiotics from antibiotics carrying orthopaedic screws. These methods or modifications thereof are now in use in various biomaterials groups and companies in Tampere. This example shows that not only marketable products are an important outcome of the funded research; equally important is the work done to develop the manufacturing and characterisation processes.

Some research groups **continued the work that had started before the Combio programme**. For example, the group of professor Levänen (Tampere University of Technology) has been investigating porous ceramic materials since the 1990s and Combio was a natural continuum for their previous work. They also participated in Tekes funded Lääke 2000 programme[30] with their functional, ceramics materials. Professor Urtti (also at the University of Helsinki) has investigated drug delivery systems for a long time. His group had already participated in Tekes' funded Potra programme[31] and based on the experience there provided input into the design of the Combio programme. Professor Kellomäki had done composite research before the Combio programme but with Combio funding a big collaboration project called Biowaffle[32] started involving universities of Tampere, Oulu and Åbo Akademi and companies Conmed Linvatec, Bioretec, Vivoxid, BBS (Biological Bone Substitutes).

In a programme of such breadth and in the unpredictable field of research and innovation, it is understandable

30 Drug 2000 Technology Programme ran in 2001-2006 and covered the pharmaceutical research chain from the identification and validation of new drug targets to the development of pharmaceutical products and new drug formulations.

31 "Polymers for building the future" programme ran in 2000-2003.

32 The goal of the project was to develop, manufacture and study properties of porous, load bearing, biodegradable and bioactive materials for a variety of clinical applications.

that **some projects were not finalised** during Combio and were lost. Some were lost because the funding for the biomaterials research in the opinion of the participants stopped completely after Combio. However, some projects with good results are in the back-pocket of the companies, waiting that some day when the financial situation is better, they might be continued and finalised. Also, even though a project did not end in a ready-made product, some data, ideas, methods and/or knowledge received during it may have been used in other projects, even outside biomaterial sector. Research organisations noted that their methodological know-how increased and over the years has spread to other organisations. In universities, the research findings and business know-how was passed to new students via teaching. Some researchers went on post-docs or research positions not only within Finland but also outside (e.g. to the USA). Numerous patent applications were filed and PhD theses were defended.

Participation in the programme also opened **new employment opportunities** for the funded organisations, engaged highly-skilled people, facilitated the exchange of new knowledge and increased their business know-how which continues to be spread to others.

These positive changes had **less noticeable impact on the operational practices** on the management of participating organisations but did bring some changes to other areas. Examples of the change include change in laboratory practices which became more routine and in which quality issues were considered more than before, strengthening collaboration with companies, learning about the materials that the respondents worked with and also learning from the collaborators. Nevertheless, the programme allowed direct beneficiaries to expand their business practices, which have resulted in some new business opportunities.

One of the best things in Combio, according to its participants, was its **interdisciplinary**. It connected experts on various topics, e.g. 'optics + materials + doctors' or 'biology + tissue technology + medicine + engineering'. Former Combio participants strongly believe that combination of know-how from various fields in solid interdisciplinary projects can produce much more interesting results than when cooperating within one field.

> *"Both projects in which we were involved were very interdisciplinary in their nature and combined know-how from very different research areas. Innovation happens often in interfaces..."*

Various educational activities and services were offered to the Combio participants. Information about the thematic area was the most beneficial; followed by the biomaterials market evaluation reports and market analyses and information concerning the funding opportunities. On the other hand, licensing know-how, distribution strategies know-how, help in establishing international networks and help in getting involved in international networks received weak evaluation.

When the support services from Combio are broken down the apparent trend was that participants were **active when offered services on developing business know-how; however, the services that provided more practical support**, which would allow to utilise the developed business skills, were practically unused. Two such services are noticeable and were borrowed by Tekes from other companies. First, participating organisations were offered the opportunity to use consulting services of a German company. With these services the participants could test 5-10 alternative product development paths with possible outcomes for each one being calculated and projected. However, according to the Programme manager, only one company used this service. For the second service, Combio borrowed a programme from NERAC which offered the participants a database that allowed to search for patents, competitors, technologies from the chosen field. This sparkled a different level of interest among the participants – some were not so interested in this programme; other used it quite extensively. Some companies reported using this service also after the end of the Combio programme. Having said that, some scientists commented that many of practical elements were useful as the scientists could learn how important it is to think of commercialisation already during research phase. This way, Combio transferred some responsibility for commercialisation to researchers – an attempt which was not welcomed by all. In general, business know-how increased at personal level and this knowledge is now spread to other people through teaching, which is a fundamental part of work at the universities.

What was **missing** (in the opinion of some of the participants) was the **knowledge how to bring products to market** (especially keeping the international perspective in mind).

> *"We couldn't get proper marketing people. None of the ones we got had an idea on how to get international launch/market…Perhaps we can put more focus in education on training physics and chemistry students some commercialisation topics as part of their training?"*

It is very challenging and a lot of preclinical and clinical studies have to be done. These are expensive and it is important to find the right partners from various countries. In addition, purchase processes and state compensation systems for drugs or medical devices vary in each country and even in various hospitals. It is important to know each country's regulations when trying to enter the market. A programme should have contained more information on these and other related matters.

In hindsight, the programme's goals might have been overly optimistic, the timeframe too short and specific follow-on support missing. **The ambitious goals**, set according to the expectations of key companies and to the preliminary market evaluation (i.e. annual sales to exceed €500m), **did not materialise**. One aspect that may explain this fact is that the programme did not succeed in linking national organisations to global players.

The vision of creating 3-5 globally operating Finnish biomaterials companies turned into a stagnating sector with some companies disappeared, some sold abroad or merged, but practically no new companies established to sell advanced products. The companies that still operate in Finland have an estimated annual turnover under €5m during the last years.

Another explanation lies in the fact that there were no big companies in Finland which could continue the research and bring novel innovation to market after Combio or work with smaller companies and help them deliver their innovations. The programme was designed with very clear companies in mind, e.g. Schering (which bought Finnish Leiras), Bayer, Santen. Schering was already selling an intrauterine hormone device (Mirena®) originally developed in Finland, which was an example of a novel drug-delivery device; Santen was interested in novel applications for eyes; and Bayer was one of the companies that seemed very interested in functional biomaterials that could be used for drug delivery and release. Because these companies were so interested in developing biomaterial research and applications, the targets of the programme were ambitious and optimistic. Unfortunately, these companies encountered certain organisational and strategic changes during Combio, and their interest in the field went down. This was a disappointment, as much hope was put on their capacity to help bring products to market.

On a positive note, today Bayer Finland is again interested in the research done in Finland and there are companies from outside the sector, for example UPM, interested in developing innovation and linking sectors (like biomaterials and forest) together. A biomaterial recently developed at the University of Helsinki is a nanocellulosa material GrowDex® that can be used for growing stem cells in a 3D environment. GrowDex has also potential to be used as a material for controlled drug delivery. This innovation is now developed in collaboration with UPM, one of the biggest bio and forest companies in Finland.

3.1.2 Impacts

Biomaterial research is a long-term investment, requiring often 10-15 years for clear results and products to materialise. However, the research performed over the years during the Combio programme **laid the foundation for the next generation research and projects**. Novel knowledge was received from different approaches and novel ideas to use these in issues that had similar problems arise, for example, laser-topography, laser for surface treatments, the mechanism in drug delivery that can be used in other functional structures, anti-microbial approaches that can be used in other clean surface applications etc. Preliminary applications developed back in the Combio days led to the development of second-generation applications. For example, research groups at Tampere University of Technology investigated technical characteristics (e.g. flexibility and surface structure) of biomaterials, which is extremely important for the development of implants. They developed novel 2D calculation system that can be used in modelling. The new 3D system developed later has origins in the 2D one and is used for numerous developments in the field.

The biomaterial sector is constantly evolving. The 3D printing opportunities are taking more and more interest in the biomaterial and impact technologies. To be utilised 3D opportunities effectively, novel biopolymers suitable for printing and safe in vivo are needed, and in this sense, the biomaterial research is still a hot topic. One of the key persons in this research is professor Seppälä at the University of Aalto University, who among other things produced artificial larynx using 3D-printing technology.

However, overall the i**nternational aspect was perceived as rather weak**. Although one of the elements in the Combio programme was visits to a number of selected countries, such as Japan, Singapore, they did not bring many tangible results. China-Finland collaboration started from Combio, but did not lead to permanent relationship. Another drawback was that no international partners were involved in the projects (although some of the work, e.g. animal studies, was outsourced abroad), thus making visits abroad perhaps less productive. Although participants did not report any immediate results ("we negotiated with a company but no new collaboration networks were created"), it is feasible to expect some longer-term and in parts unexpected impact. One participant mentioned that they are negotiating with some Asian partners right now and although these negotiations are not linked to the previous research project, the knowledge about Asian culture and how to negotiate there acquired during the Combio programme is proving to be useful now.

The **biomaterial sector and research still exist in Finland** and products originating from Finland are sold all over the world. Although some old companies have been sold abroad, some of them still have operations in Finland, and some novel companies have emerged. Active companies are, for example, DelsiTech, Bioretec, BonAlive Biomaterials, BBS. Some of the old players have disappeared, but biomaterial research is still active. Research groups are active at Tampere University of Technology, University of Turku, Åbo Academi University, University of Helsinki, Aalto University

and the University of Oulu. For example, cartilage biomaterials will be commercialised in the near future when a new start-up company is set up. The research has continued after Combio under the Tekes funded TUTL funding instrument[33].

Some sub-fields have developed in a more unexpected way. For example, tissue technology, which was a novel topic and where (according to the Combio participants) no big expectation existed, has become a very important research area in Tampere, and commercial innovations are already available. BioMediTech has created close connections to Japanese scientists developing IPS-stem cells, and Finnish scientists have been able to rapidly utilise international innovations.

However, the overall perception is that **the biomaterials sector's growth has stagnated**, since practically no new companies have been formed. This is not only due to the lack of the research funding but also due to lack of early stage risk money, and due to the fact that more advanced products and companies have not yet made proper international sales. In practically all areas, especially in Tampere area, biomaterials sector has diminished. There has not been any noticeable and focused support from the public sector (Tekes etc.) to the field after Combio.

3.1.3 Programme's efficiency

There is a general perception that the funding period of projects in the fields like biomaterials (which require more time for the results to come through) should be longer. This will be in line with the product development cycle, where sufficient funding and time is needed for the results to be properly tested. The beneficiaries who participated in the online survey during this evaluation commonly agreed that in order to keep biomaterials research groups from re-specialising to other research areas, a smoother transition period would have been needed after Combio.

> *"The discontinuation of the Combio programme had significant negative effects for R&D&I within the area".*

Another idea expressed during this evaluation was one around a two-phase funding. For example, only best projects would get second-round funding which will stimulate people to work hard right from the beginning. However, this needs to be carefully thought through as such competitive approach could perhaps weaken the open atmosphere.

3.1.4 Programme's impact on national, European and global ecosystem

Research, projects and collaborations during the Combio programme had **a varied effect on the biomaterials ecosystem creation in Finland**. Some participants believed that the ecosystem was already there (*"the group had been working with biomaterial for years so they knew the players well already before"*). However, these were present locally in the areas which have been historically strong in the biomaterials research (ie Turku, Tampere). Combio connected these groups by requiring joined research projects. More so, even in case of already existing connections, Combio brought novel collaborations with scientists and companies, not only strengthening the ecosystem but also creating interdisciplinary collaborations. Some other participants are convinced that although the programme did not create an ecosystem as such it was a good start for that. It helped in finding others operating in the same sector and broke existing cliques. In case of yet another group of participants, development of the ecosystem and long-lasting connections (including abroad) did take place.

The beneficiaries who took part in this evaluation believed that the effect was small or average when assessing the creation of national and international networks, Finland taking a bigger role in international biomaterials market, increasing income and profit, important innovations and business practices. Nevertheless, the programme had quite an important role in increasing the competitiveness of the Finnish biomaterials sector.

3.1.5 Programme's administration

The participants felt that the programme worked well in practice. The research topics were clear to the majority of the participants and the programme contained a lot of common issues that interested everyone (*"nowadays this is not always the case"*). People felt that the atmosphere was open allowing the participants to share their results and ideas, which increased social cohesion.

Working with Tekes (especially on project application and project reporting) received mostly positive feedback from the participants. On the other hand, getting support for finding project partners in the industry and research outside Finland was poor and sometimes a good understanding of the sector among Tekes officials was missing.

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33 'New knowledge and business from research ideas'

3.2 BioIT programme

3.2.1 Programme's results

Finland had a traditionally strong research base in biology and bioinformatics as well as companies active in data storage and management and operating cloud-based platforms in 2013, at the start of the programme. Earlier Tekes funding programmes targeted the pharmaceutical sector and Tekes felt the need (after broad stakeholder consultation) to link up the national knowledge base and boost an interdisciplinary sector including health informatics and wellbeing ('quantified self'). In recent years, Finland has developed new legislation for biobanks (2013), a comprehensive health sector growth strategy for research and innovation activities (2014) and a national genome strategy (2015) to develop a competitive edge in a new and growing international market.

The BioIT programme was a particularly lean exploratory funding programme conducted over two years to gauge interest and potential for research and business development in this new field. Starting with about 40 bioinformatics companies and bringing in more traditional IT companies, the demand exceeded expectations, with eventual participation of more than 100 companies in aspects of the BioIT programme. Research and development projects, building on established and trusted collaborations, were supported as well as new partnerships created to explore new business ideas.

The vast majority of the total funding went to companies, predominantly to SMEs, as loans (50%) and grants (34%), with public research organisations, hospitals and large enterprises representing a minority of projects. Those companies that partnered with others, including with international business and research organisations, considered it essential for the success of their projects.

Tekes supported participants through a broad range of services, from organising well-attended networking events and meetings with investors, to training in intellectual property rights and business strategy. The programme management created an international expert mentoring list and joined up with Team Finland to enable international visits for participants. Although participants welcomed such activities, more practical support linked to their focus area would have been useful. This, however, was beyond the capacity of the programme at the time.

Funding through BioIT allowed companies to **build new collaborative and business networks** that continued beyond the end of the funded period. Survey results showed that all participants that responded to the online questionnaire had one or more national partners in the project, reaching out to business partners and research organisations (Appendix E.1). Note that often these collaborations were established 'informally' without MoU and other contractual obligations. Some participants indicated that international collaborations were part of their BioIT project. International partners resided in the USA (4), Germany (3), China (2), Switzerland (2), United Kingdom (2), France (1), and Singapore (1). Project participants considered highly important these collaborations and claimed to continue working with these partners on the same or new projects. One project participant expressed:

> *"For us, it was highly important to collaborate with business and public organizations in order to learn about technology, market and future trends as well as commercial potential of the idea."*

Tangible results were also achieved after such a short support. Over 15 survey respondents mentioned that they **launched a commercial product** or service to the market or developed a **prototype** and hence increased substantially their technology readiness level to prepare for market launch. These achievements were also coupled to these companies becoming **part of a new value chain**/partnership. Nevertheless, at least in one case, the project led to the company needing to change its business model. This result however strengthens the declared aim of the programme that is to allow companies sufficient and **protected space to experiment** and to come up with the right business model for their products.

Some n**ew patents** (4) were filed, and two respondents noted new peer-reviewed publications. Overall, survey respondents were positive about benefits gained through the programme; most indicated enhanced **international visibility**, created new business partnerships and ultimately contributed **revenue growth**. This is a strong endorsement of the alignment of the programme's objectives and the results achieved by participating companies.

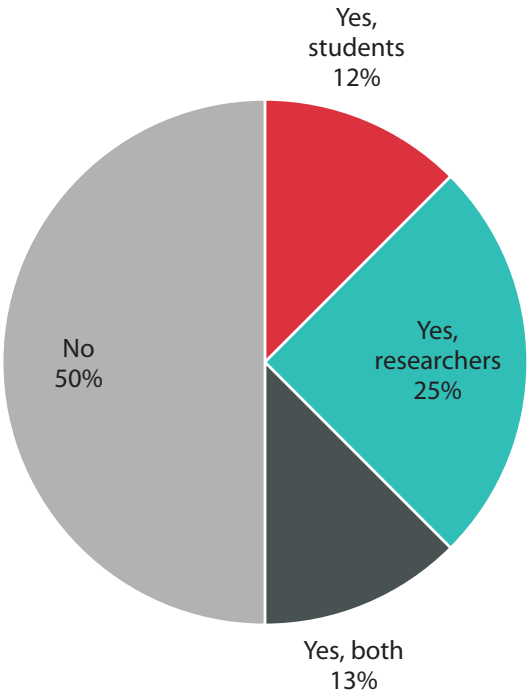
Programme participants indicated in half of the cases that the project resulted in direct recruitment of students or academic staff (Figure 15). In one case, moving from academia to industry had a larger impact than simply knowledge transfer:

> *"We have made new recruitments who were formerly working in academic positions, but made redundant."*

However it is fairly early to expect significant impacts from the BioIT programme, many of the projects are still running, and in other cases, although the funding is over, the product or service is not fully market-ready and more testing and development is required. In particular, we have not been able to ascertain if any new spinouts or startups have been formed as a result of the programme.

Figure 14. Survey results showing how the organisation benefitted from the BioIT programme?
Source: Online survey of the programmes participants (n=21), Technopolis Group

Figure 15. Has the project resulted in students and/or academic researchers moving to work in business?



3.2.2 Programme's efficiency

The BioIT programme was an ambitious initiative with a multi-disciplinary focus at international scale, delivered on a small funding and operational budget without an external steering board. A 2-year programme is useful for piloting, but may be too short for staged delivery of larger projects or refocusing in case of need. (Nevertheless, the second year of the BioIT programme saw the moderate re-focussing and broadening the scope of the programme.) In some cases, however, the projects are running until 2016 or 2017, beyond the end of the programme in 2014, thus with Tekes providing no further specific support services. These projects will not benefit from the services of the Tekes team and could understandably be disappointed.

Nevertheless, the overall satisfaction with the BioIT programme was very good: 12 survey respondents mentioned that they were very satisfied, 6 were moderately satisfied, and none claimed to be dissatisfied.

The majority of the respondents found that the funding size and the project duration was about right (respectively 14 and 10). Six respondents however believed that the duration was too short and one thought that it was too long. At the same time, four respondents noted that the funding was too small but none mentioned that it would have been too large. One respondent sums up perfectly the situation:

"The project duration estimation is difficult. Operating abroad brings a lot of delay due to the physical distance to the pilot users".

Survey respondents and interviewees expressed the difficulty for small companies without large capital reserves to take on high ratio of loan or the need to invest cash from working capital; this may limit young companies' participation in experimental projects funded by Tekes. It is understood that the loans Tekes offers are convertible to grant in case the project does not succeed in generating revenues with the new product or service. Nevertheless, one project participant expressed:

"We were brave in trying this, and we tried extremely hard. I think that is appreciated and it will promote 'experimental' culture. However, we have now a big problem with the loan which, at its worst, can ruin our new business model."

3.2.3 Programme's outreach

The programme has created mostly national and in some cases international collaborations and partnerships. Some of the Finnish companies supported by the BioIT programme are truly world-class and the programme further increased their visibility and allowed them to develop a product portfolio and customised business plan that would help them to take on fierce international competition.

In addition, thanks to the programme's support activities, many participant companies were exposed to the EU H2020 information days and there had already been 25 applications at H2020 by companies who had taken part in the BioIT programme. These applications were submitted by 9 companies. These include, Abomics, Biocomputing Platforms, Bioptima, Euformatics, FinBiosoft, Genevia, Medieta and MediSapiens. All in all, 9 SMEs (45%) of participants in the programme have already sought funding outside of Finland, leveraging the expertise gained from Tekes national innovation programme.

3.2.4 Programme's administration

The BioIT programme might have (accidentally) served as a paradigm for a small-scale exploratory programme at Tekes, allowing for experimentation internally as well as externally. In terms of activities, it offered a surprisingly large number of activities, leveraging of existing Tekes and national resources. The programme was run by 2-3 dedicated Tekes personnel which inevitably meant compromise in terms of scale and focus of service delivery.

Respondents rated the support they received from Tekes in different areas in the online survey. The highest general score (very good) was received regarding the project application support, followed by project reporting, which shows the effort invested in attracting companies to participate in a new cross-disciplinary business area. Other support functions, more specific to the needs of companies, such as getting market research insight or facilitating partnerships, which possibly require more technical knowledge and network at the Tekes programme team, were scored somewhat lower. As one project participant put it:

"Generic support has been available, but more specific support has been absent. We have not expected Tekes to be able to provide such support. We operate in a new field, about which Tekes or its contractors have almost no knowledge."

3.2.5 Programme's impact on national, European and global ecosystems

BioIT was a timely and an unique offering from Tekes to companies in 2013. Before the BioIT programme, there was no coordinated action to explore the field and to support this large global opportunity. Networking therefore was an important first step to form an understanding about the sector in Finland. Although the programme was short, it provided the necessary boost for companies to experiment with new products and business models. There is no innovation without risk; and project participants felt that the risk-reward ratio was suitable to attempt to develop new solutions and take to market. In some cases this led to abandoning the original project plan and redesign the product portfolio or business model to suit internal capabilities and capacity, as well as to fend off the external (international) competition. The established partnerships appear to continue well, in general, although the demand for new products may create companies switching to new collaborations.

"Every international project is an eye opener. Market knowledge was gathered and new ideas were generated."

"The change of our company strategy and business model was unplanned."

A broader follow-up Tekes programme, Bits of Health, was launched in 2015 that can be considered as a more holistic initiative, following on from the BioIT programme, with larger ambitions (to make Finland the business hub for digital health) and timescale. It was a very important step to keep the momentum generated by the BioIT programme and not lose achievements. The experience gained by companies and Tekes through the BioIT programme has already paid dividend, since over 10 companies that were supported by the exploratory programme are now part of the new initiative. This will no doubt continue to build the

emerging digital health ecosystem and further integrate technology, service providers, academia and end users in Finland and beyond.

Programme participants felt that the BioIT programme objectives were highly relevant and supported the implementation of their organisation's strategies. In addition, participants considered that the programme also supported the implementation of Finland's strategic needs and push companies towards internationalisation. As one satisfied participants put it:

> *"We are a very active player in our field in Finland and internationally. We are open and actively seek collaboration, and we have developed good relationships with several important international partners. That is not very typical in Finland, therefore we see that our role is much larger than our size."*

Other programmes running in the thematic area ensure that the knowledge base and capacity of researchers will not diminish over time. The Finnish Academy has programmes for (basic) researchers[34] such as the past programme for Systems Biology and Bioinformatics (2004-2007), and current programmes for Personalised medicine (2015-2019), and Digital Humanities (2016-2019).

There are many new developments in Europe and globally in this field, both related to new technologies in the IT sector and the relentless flow of new information in biology and medicine. In Europe, the European Bioinformatics Institute (EBI) continues to be the leader in this space, EBI is running industry partnership programmes and a specific SME forum addressing the needs of small businesses. In addition, the pan-European biomedical research infrastructures[35] in bioinformatics (ELIXIR) has a node in Finland since 2015, offering large-scale computation and storage, training and support services to biomedical researchers and research groups. The European Institute of Innovation and Partnership (EIT) also considers healthcare informatics and digital health innovation of primary importance. It aims to galvanise the community of higher education institutions, research labs and companies to form cross-border partnerships for innovation and entrepreneurship across Europe.

3.3 Trial programme

3.3.1 Programme's results

The Trial programme aimed to create a globally competitive cognitive radio and networking research environment in Finland that national and international partners can use to learn about the technology, and business potential, and find both talent and technology to quickly try out new concepts. To achieve these goals, projects ranged from small initiatives with a single partner to large cooperative projects through academia-led consortia.

Although the programme was primarily oriented toward research collaboration, it did involve industry partners and SMEs targeting the creation of specific products and IP, enabling an exchange of knowledge and ideas, and sharing research infrastructure in cooperation research projects and parallel industry projects. The project built on strong existing expertise in Finland and has continued to develop an ecosystem during the Trial programme as well as the follow-up programme 5thGear, running in 2014-2019.

The programme consisted of large cluster projects, where large cooperative R&D projects and parallel industry projects where clustered around a certain topic or test environment. These cooperative and individual parallel projects were complementary to each other, the Trial environments have been working well and a good and tight network between the research institutes and companies has been created as a result. Furthermore, tens of patents, hundreds of publications and thesis and several networking events and studies have emerged from the project activities. The international measure was created through co-operation projects with US and Japan. The programme also had impact on related Finnish regulation and standardisation.[36]

During the online survey, the results that were most often listed by the programme participants were related to knowledge exchange or access to new business partners in Finland (Figure 16). These were all enabled by the creation of an ecosystem and large collaborative projects with many partners. Contributions to revenue growth was the least obvious result, although some partners that received funding in single partner projects indicated that they could use this towards further recruitment and consolidation of

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34 http://www.aka.fi/en/research-and-science-policy/academy-programmes/completed-programmes/systems-biology-and-bioinformatics-sysbio-2004-2007
http://www.aka.fi/en/research-and-science-policy/academy-programmes/current-programmes/phealt
http://www.aka.fi/en/research-and-science-policy/academy-programmes/current-programmes/digihum

35 http://www.emtrain.eu/index.php/partners/esfri-bms-partners

36 https://www.tekes.fi/globalassets/global/ohjelmat-ja-palvelut/ohjelmat/5thgear/opening-seminar-120315/trial-overview.pdf

Figure 16. How the organisations of respondents benefited from the Trial programme. Source: Online survey of the programmes' participants performed by Technopolis Group

the team. It is important to mention here that CR is a disruptive technology, that requires a tight interaction already during the research phase between technology, regulation, standardisation and business. This complexity demands for focused yet multi-disciplinary ecosystems where all stakeholders can interact and share information and join forces to quickly prototype new ideas. The Trial programme created a significant interest in experimentation in Finland, project partners benefitting strongly from a strengthening ecosystem and enabling them to find expertise, cross-fertilise ideas, and adapt their strategies when needed (e.g. spectrum sensing). While there was a lot of interest from international companies to join the ecosystem, it was difficult in practice, partly due to the lack of a viable business model and partly as most expertise was already available in Finland. **A major result of the Trial programme is that it enabled the creation of such a multi-disciplinary and vibrant ecosystem in Finland, with a reputation and impact well beyond its borders.**

The Trial programme had a relatively narrow focus on Cognitive Radio which appeared realistic with access to limited funding of €15m from Tekes. Given the many possible definitions of CR, the Trial programme was flexible enough to enable projects focusing on multiple different aspects of CR. Trial was regarded as a route to a systematic transformation of the field, with actors from research, policy, business and regulatory fields closely involved and engaged to bring a disruptive wireless technology closer to the market. Most participants in the evaluation of Trial and the in-depth interviews agreed that a building a unique innovation environment for the wireless ecosystem is important for Finland, as it is an important topic where Finland is historically strong and innovative. While agreed that a focus was important to ensure sufficient results were obtained with a modest budget, a majority of the participants that were interviewed indicated that they had to shift their research focus to align to the Trial programme. For research institutes and academia, the shift in focus was mainly due to moving from theory to experiments. For the involved industry, the Trial programme was disruptive, as no CR products or business existed when the programme started, so all companies had to start thinking how they could bring some of the novel CR technology to the markets in their products or service offering. During the online survey, the statements on the programme supporting the implementation of Finland's strategic needs and the strategies of the respondents' organisation, received the lowest general score. This can be explained by the narrow focus of the programme, not always directly related to the existing product or business lines of the involved companies, consistent with the shift in focus that was often mentioned during the interviews. The evaluation of the survey illustrating this can be found in Figure 15 in Section 4.

Considering concrete programme results, diverse outcomes have already been achieved. These include publications, regulatory trials, impact on standardisation (even outside Finland), IP creation and researcher training and collaboration in a top-level expertise cluster. Some technology developed was added as commercial product features, for which revenue growth is expected in the future.

Large business breakthroughs have not yet been realised, which is as expected given the complexity of the technology, and the fact that it requires a disruptive change in regulation and standardisation. Implementing such a change takes several years, and needs a good interaction with regulation and standardisation, which was clearly

achieved by some of the Trial projects (eg CORE and WISE). One participant mentioned:

> *"CR is a huge/disruptive change for the mobile industry/wireless networking. Due to the link with regulation, it takes time and it is necessary to create an ecosystem where all stakeholders can interact."*

The Trial programme was very successful as it enabled that much required novel research approach researching policy, business and technology in the very same project.

The strongest cooperation was seen at national level (which was sufficient as most expertise was present), however participants were internationally recognised and managed to enter the EU FP7 or Horizon 2020 programme in international consortia, e.g. the METIS project which is a very important one setting the stage for 5G in the EU. Cooperation in this and other EU projects was enabled by the unique Trial environment, boosting the unique technical capabilities of Finnish partners, as well as the reputation of Finland as an innovator in the wireless domain. As mentioned during the interviews:

> *"By having access to the WISE/EECRT/CORE Trial environment and knowledge, we can rely on an unique asset that can be used to enter competitive H2020 projects and consortia (selling point of Finland)."*

3.3.2 Programme's efficiency

As the programme was aiming to strengthen an existing ecosystem, and focused on a relatively narrow yet disruptive technology, it was possible to achieve the challenging objectives with a relatively small programme.

The programme participants did acknowledge the need for funding, and the fact that the funding accelerated their research.

> *"We were able to develop prototype faster than what was possible without Tekes."*

It is remarkable that such a small programme enabled such an important **paradigm shift** in wireless research. Research groups were now motivated to focus **beyond theory on experiments**. Companies learned that in order to innovate within the CR domain, they had **to engage closely with regulation and standardisation within large multi-disciplinary ecosystems**. The paradigm shift enabled by the Trial programme will persist in the continuation programmes, such as 5thGear. Many participants in the interviews already mentioned that the ecosystem, contacts, projects or experimental environment is now used as a starting point for the work in 5thGear.

3.3.3 Programme's outreach

The programme's outreach was exceptionally successful towards the EU and the rest of the world. Especially the LSA/ASA trial from the CORE project could benefit from a lot of international outreach. In general, all projects created a lot of publications, measurement results and demonstrations.

Beyond EU and worldwide outreach, the national outreach was organised in the form of the interest group where results between projects could be shared. These interest group meetings were organised by Tekes, and all results of the project clusters would be presented. This enabled information sharing, avoiding overlap between clusters, and encouraged companies to align with one or multiple research consortia. Several participants mentioned that the meetings of the interest group were very interesting, during the interviews. They were also seen as key in establishing the truly interdisciplinary nature of the Trial ecosystem:

> *"Towards the end it was multi-disciplinary. Slow start in the beginning, partners focused on their own sub projects. Started to collaborate more towards the end."*

Given the complementarity of the clusters, the information sharing worked and overlap was avoided.

3.3.4 Programme's administration

The project administration was light, with little involvement from Tekes, which was as expected from the participants. As projects were very technical in nature, there was no need for many of the non-technical workshops or other non-technical support such as market research support. The (still technical) interest group, created to ensure information sharing between different clusters and projects, was considered to be a useful added value. This conclusion is confirmed by the online survey, where the feedback on the project implementation and the role of Tekes as such was mainly seen during the project application phase, as well as in promotion and visibility activities, for example:

> *"Our project is very technology specific (narrow area), so Tekes's main function is funding."*

Regarding the budget and the project timeline, the project respondents mostly mentioned that the project duration was about right, yet that it was important to have continuation projects, ensuring that the work could be carried out over longer periods than two years. Although the Trial programme ended, most participants are now continuing the work in the 5thGear programme. The budget size was ok, although respondents mentioned that one can always do more.

3.3.5 Programme's impact on national, European and global ecosystems

The Trial programme enabled the creation of a **multi-disciplinary and vibrant ecosystem** related to CR, which was mentioned as very important for both exchanging knowledge as creating business contacts. Contributing to enhanced international visibility and providing access to new business partners outside Finland was also mentioned a lot. Some even mentioned that because of the Trial environment, that with worldwide reputation, they could easier create novel business contacts (this was of course only the case for the smaller companies, that did not have yet a large international network).

In addition to the multi-disciplinary research ecosystem, the Trial environment also specifically created a **business ecosystem** for the involved companies and SMEs. Such a business ecosystem was important in this thematic area to (a) enable SMEs to set up partnerships with larger companies and get international recognition, or (b) to enable all companies to quickly try out new ideas related to the disruptive CR technology, or (c) enable to build up large enough consortia with all expertise present (from technology to business to regulation and standardisation).

One of the most visible outcomes of the programme, was the impact of CORE and WISE on the regulation and standardisation bodies and the **increased Finnish visibility in those international regulation forums and related ecosystems**. Several participants in the online survey mentioned this, and also during the interviews the successes and impact of cooperation with regulation and standardization were mentioned several times.

"Our position in regulation forums and related eco-system become much stronger. We did the world's first LSA/ASA demonstrator".

"The project strongly contributed to European and international spectrum policy making. It presented world's first and leading trials of new Licensed Shared Access (LSA) spectrum sharing concept introduced by the European Commission."

The programme, and larger Trial environment, also enabled some research groups to participate in the EU FP7 project METIS, that is to drive the development of 5G, ensuring that Finland has a continued impact on the wireless and mobile technology in Europe.

"The demonstration platform designed in the project became the main demonstration platform of the 25-million European FP7 project METIS. This lead to unpredicted visibility."

It is of key important for Finland to be part of this METIS project and ecosystem.

Finally, there was a strong belief that the project helped to establish an experimental culture in Finland. This **experimental culture** was good in (a) creating international impact, (b) quickly testing the feasibility of novel business ideas, and (c) decrease the gap between theory and practice.

4 Conclusions

In this chapter, we summarise the evaluation's findings, reflect upon them and formulate our recommendations.

4.1 The programmes and their objectives

The objectives and goals for the BioIT, Trial and Combio programmes were rather similar from the strategic point of view. They focused on utilising the strengths of existing research in their relevant thematic areas and further building research or/and business potential, thus, thriving to build or strengthen an ecosystem in Finland and make the sector and the country better known internationally.

The Trial programme aimed to strengthen the cooperation between different stakeholders (academic, research institutes, large and small companies) and create an ecosystem in a domain where Finland was already historically strong. Cognitive radio is a disruptive technology, but all stakeholders agreed that it made sense to focus on a narrow topic (given limited budget), that was quite risky but if successful could lead to an important breakthrough in the wireless domain. The focus of the BioIT programme was to create new sustainable collaborations and partnerships between traditional ICT actors and experts in biology, genetics and environmental sciences across academia and industry. Whereas the vision of Combio was to facilitate the emergence of an internationally recognised high level biomaterials cluster and for the cluster to possess commercial know-how and create strong businesses which are profitable and are part of strong international networks.

The participants viewed the objectives both relevant and challenging (see Figure 17). The Trial choice for a focused programme, on a high risk/high gain topic in line with Finland's historical strengths, was appreciated by all participants. Achievement of objectives should lead to placing Finland at top level globally in the cognitive radio and networks area. In the thematic field of digital health, Finlands aims to become the digital hub for health. Challenging as these objectives may sound, it does build on the existing knowledge in the area. More so, the programmes supported the implementation of Tekes' strategies and Finland's strategic needs. They were also instrumental for the implementation of the strategies of individual organisations. The alignment of organisational and Tekes/national strategies was particularly notable for BioIT participants but less so in the case of Trial. Organisations which took part in the Trial programme noted that they had to shift their research focus to align with the programme. More so, lots research organisations were involved in the programme and such specific research topics like Cognitive Radio rarely end up in the overall strategy of the organisation. In case of Combio, the funded organisations which contributed to this evaluation felt that the objectives set out for the programme were too ambitious. This was especially noticeable given a relatively short timeframe (vis-à-vis an average time requirement for biomedical research to become commercial).

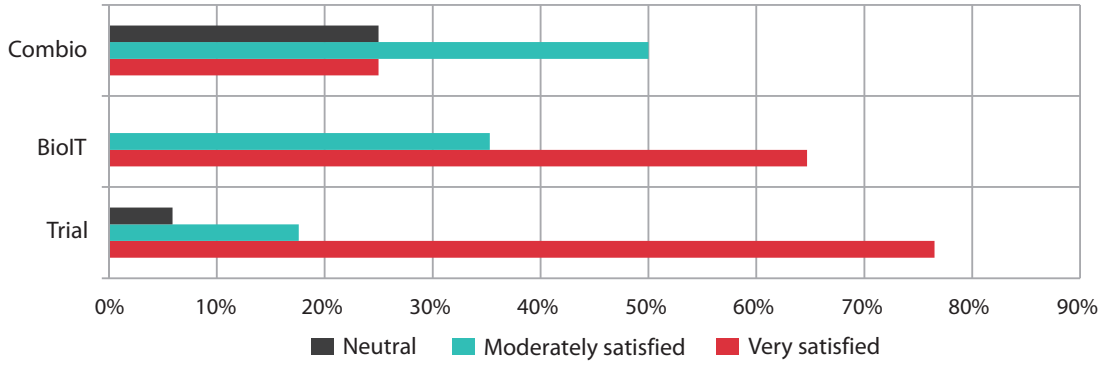
Although the objectives led to certain results, the general feeling was that programmes may need broader themes to create critical mass and suitable absorptive capacity.

Overall, the BioIT and Trial participants were highly satisfied with the programmes (Figure 18). Combio participants were mostly moderately satisfied; perhaps, largely because this programme finished longer time ago compared to the other two programmes and not everybody could remember the programme that well. It is important to note that across all three programmes there were no dissatisfied respondents.

All participants were very positive about the Trial programme, and said that it worked well. Although the programme was not very competitive, most participants delivered and did what was expected by the consortia. Some partners were working more independently, but also this is sometimes needed to enable the creation of strategic IP or patents. Overall, the programme contained a good mix of larger and smaller projects. One could argue that the programme could be more competitive (ie replace groups that do not deliver) or cooperative (i.e. avoid stand-alone research). On the other hand, the programme worked very well without all administrative overhead needed to verify progress or constraints to enforce strict cooperation. Light and focused programmes seem to work.

Figure 17. Views of the respondents on the BioIT and Trial programmes. Source: Online survey of the programmes participants, Technopolis Group

Figure 18. Overall satisfaction with the Tekes' programme. Source: Online survey of the programmes participants, Technopolis Group



4.2 Results and impact of the three programmes

Different results were expected from the three funded programme requiring various framework conditions, funding and timeframe to materialise. A substantial longer time is needed to assess impacts delivered by the programmes. It is possible to talk about impacts in case of Combio which ended nearly a decade ago but it makes less (or almost no) sense to talk about achieved impacts in case BioIT and Trial. It is possible, however, to give some indication about excepted impact.

The relatively small **Trial programme enabled a paradigm shift** in wireless technology research. Beyond focusing on technology or even theory only, researchers learned to embrace a truly multi-disciplinary approach going from theory to experiments, considering not only technology but also standardisation, regulation and business. The main impact and results of the Trial programme are that it enabled the creation of such multi-disciplinary and Trial ecosystem in Finland, consisting of four main project clusters and several independent industry projects that all worked harmoniously and shared insight, results or even technology where relevant. By joining forces, the group of researchers managed to have a strong impact in the EU regulatory and standardisation fora. To date, the existence of this ecosystem, Trial environment, and proven track record in creating international industry-relevant impact, is still helping many of the Finnish companies in growing their impact. Given the continuation in the 5thGear programme, stakeholders are able to continue their work in this domain, creating impact and business in the wireless and mobile industry.

"This programme gave a great opportunity to do world class research and present it to the world."
"The programme enabled a paradigm shift in the research and education at Aalto university, related to wireless networks. Funding for development of testbed activities significantly boosted the experimental way of work at Aalto".

The projects performed in the **Combio programme brought different results to different players**. Some companies managed to deliver marketable products; however, the majority ended up with less tangible but nevertheless important outcomes. Manufacturing and characterisation processes were strengthened, know-how increased and over the years spread to other organisations, research continued from the earlier projects, patents filed, PhD theses defended, new employment opportunities created. Some projects (especially in the research organisations) unfortunately were not finalised and thus resulted in a failure to deliver the results.

In comparing the effects on participating organisations, **all programmes facilitated access to domestic and international research** but with a slightly different emphasis (Figure 19). Trial had a balance in accessing both domestic and international research. BioIT led more to international outreach. Whereas, Combio had more effects domestically. Despite a reported good access to international research, increased contacts with foreign companies, only very few participants reported an increase in international connections. Such results are not surprising given the fact that Combio programme was designed with Finland-based companies (both national and foreign) in mind.

Over the years, participants **increased contacts with foreign companies** (Figure 20). It is useful to interpret this result in comparison with the international connections made assuming that gaining foreign contacts should result in long-term communication and potential partnerships. In this aspect Trial is the most successful programme with BioIT being a close second. However, despite an internationalisation element present in Combio, it has barely produced any solid international connections for the participants. Partly this was probably due to the fact that Tekes-funded projects did not allow participation of foreign companies. However, largely it was probably because not so many participants took part in foreign missions and because the programme was largely designed with companies already present in Finland. In this regard Trial and BioIT are much more likely to produce long-term international partnerships than Combio.

Commercialisation and R&D results are another important elements of the programmes. The largest difference between BioIT and Trial programmes was in the ratio of projects which resulted in technologies and basic know-how versus projects which resulted in R&D platforms. This seconds the objectives of the programmes (with Trial being more research focused; whereas BioIT focusing on the application of research in practice) and the type of projects involved. The BioIT projects gave a large number of R&D related results such as technologies and know-how; whereas the Trial programme was successful in facilitating the emergence of R&D platforms as was set out in the objectives. The Trial projects have also produced basic know-how for the study area – the only programme with these R&D results. This allows to conclude that while the know-how resulted from BioIT projects is inward driven and primarily beneficial for the participants, Trial has also produced outwardly driven know-how which the participants expect will benefit other organisations working in the respective research

Figure 19. Impacts of the programmes on participating organisations. Source: Technopolis analysis of Tekes monitoring data

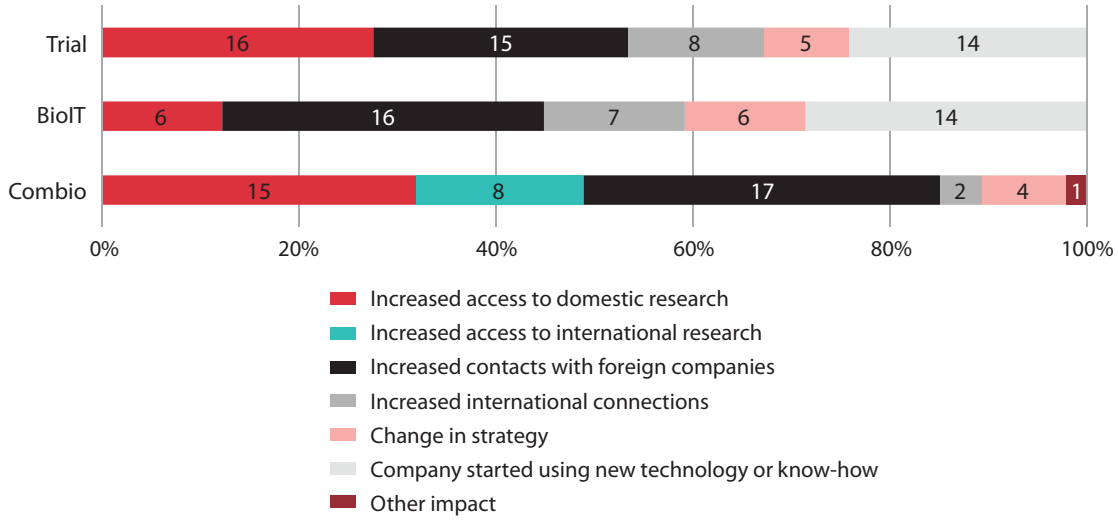


Figure 20. Potential for long-term international partnerships formed during the programmes. Source: Technopolis analysis of Tekes monitoring data

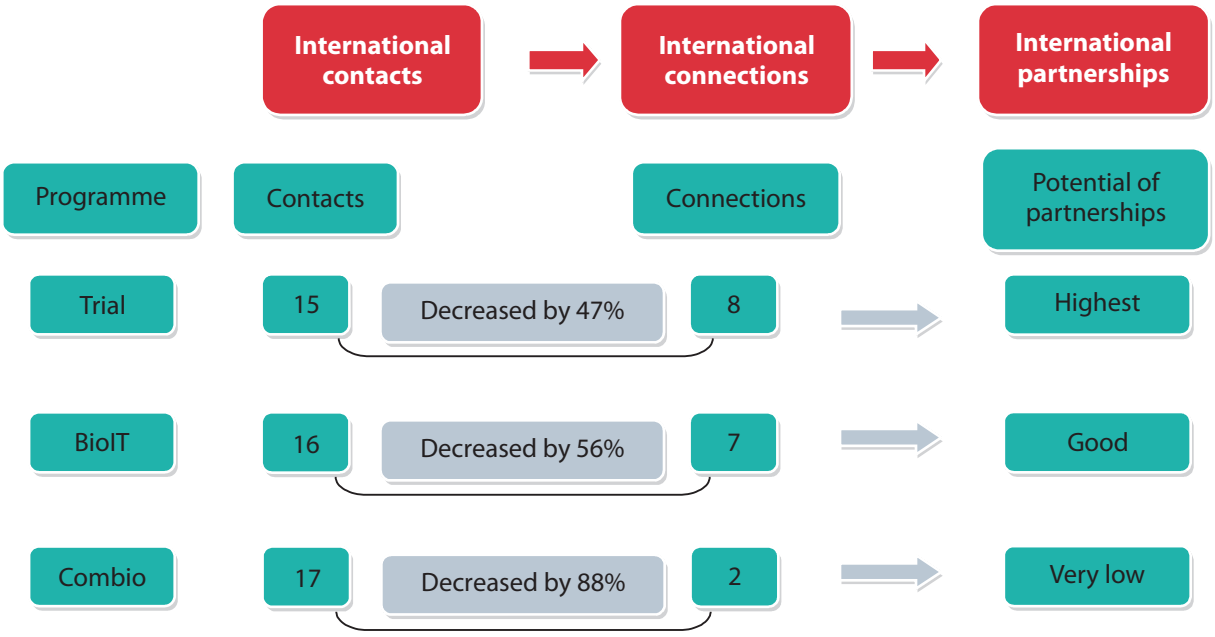
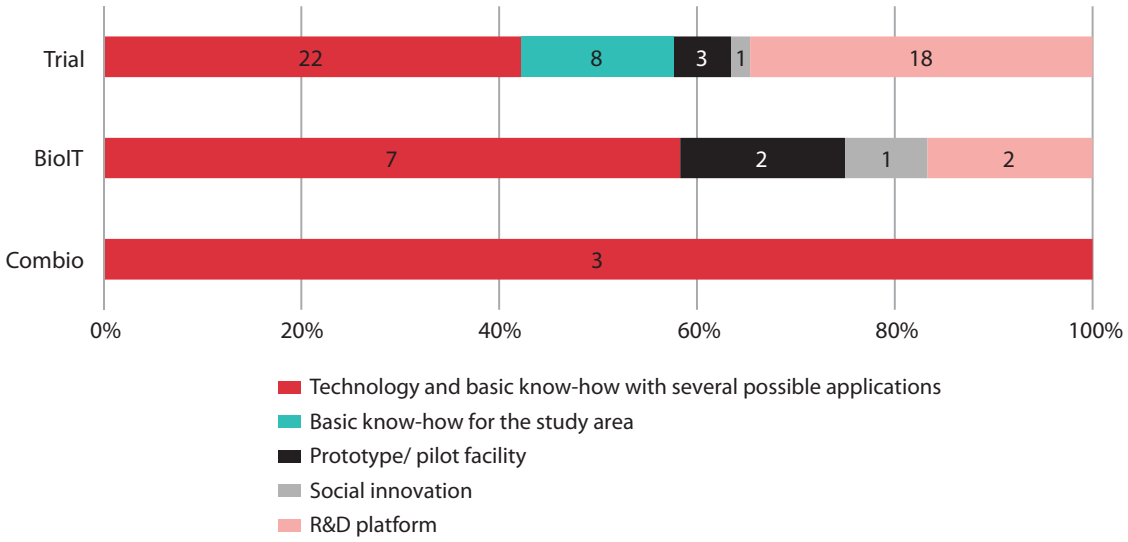


Figure 21. R&D related results. Source: Technopolis analysis of Tekes monitoring data



field. Combio funding laid the foundation for the next generation research and projects, produced some commercial results but not to level of ambition set for the programme. Discontinuation of targeted public funding for this sector resulted in fewer effects in research and innovation and certain stagnation in the field as was planned at the start of the programme. The growth and development within the sector has stagnated over the years but the sector and research do still exist and produce results. Some of the active companies (or parts of their R&D) have been sold abroad. Although perhaps to some extent this comes across as a negative result of the public funding; international acquisitions as such prove that Finnish companies achieved substantial progress in their field making themselves interested to other players.

Considering results linked to commercial applicability, one needs to be mindful that Combio funded projects that resulted in new processes and either improved or entirely

created new products. However, there were not many of such new products. This may be explained by the fact that the timeframe needed for launching a biomaterial product on the market is rather long; and knowledge of actually bringing a product to market (especially internationally) was largely missing among the participants. Trial did not have commercialisation as a target, i.e. all outcomes are considered as equally relevant and possible to be commercially relevant and important at this point. Most commercial results are yet to be realised and it is yet not possible to quantify what concrete results gave the best 'return on investment'. Even if barely, the strong point of Trial proves to be the creation of public-private partnerships – the most common result related to commercialisation. On the other hand, BioIT clearly shows a strong leaning towards the creation of new products or applications. This further allows distinguishing Trial from BioIT in terms of achieved results. Trial in the end indicates that its participants worked towards goals resulting in networking between different organisations and research with research-area applicability. In other words, Trial was instrumental in developing both a research network and an innovation ecosystem, as the participating organisations were much more interested in partnerships and platform building. BioIT on the other hand was more beneficial to the individual participants, facilitating new research, technologies that result in new commercially applicable products.

At the point of this evaluation, only Trial and Combio programme participants have provided information in the monitoring database on how they will use their project results. Nearly half of the Combio funded projects indicate interest in exploiting the study performed under their respective project; with another half choosing to decide later. While a point should be made that research funded by Combio takes a longer time span to provide tangible results and certain projects need further funding; nevertheless, it is surprising that a decade after the end of the programme some of the participants are still undecided (or indeed do not know) how they would use the research results achieved during Combio. Trial also indicates that the participants have yet to achieve their final research results (which is in line with the focus of the programme being more research oriented). However, Trial projects indicate a clear direction of either making use of the performed research themselves or other companies benefitting from it. Current tangible results are in the forms of studies and only a small part of the results being currently produced products.

Combio and Trial show similarities in that current results are more academic and study based, rather than concrete applicable products. However, while Combio participants generally seem to be in the unknown as to how their research products will be used, Trial indicates that participating organisations have a clear understanding and vision for their project results.

Figure 22. Commercialisation related results. Source: Technopolis analysis of Tekes monitoring data

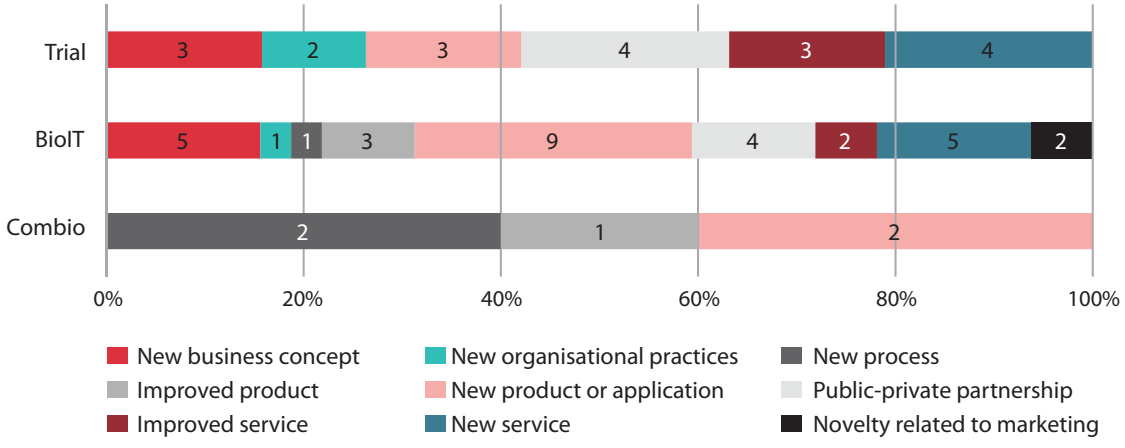
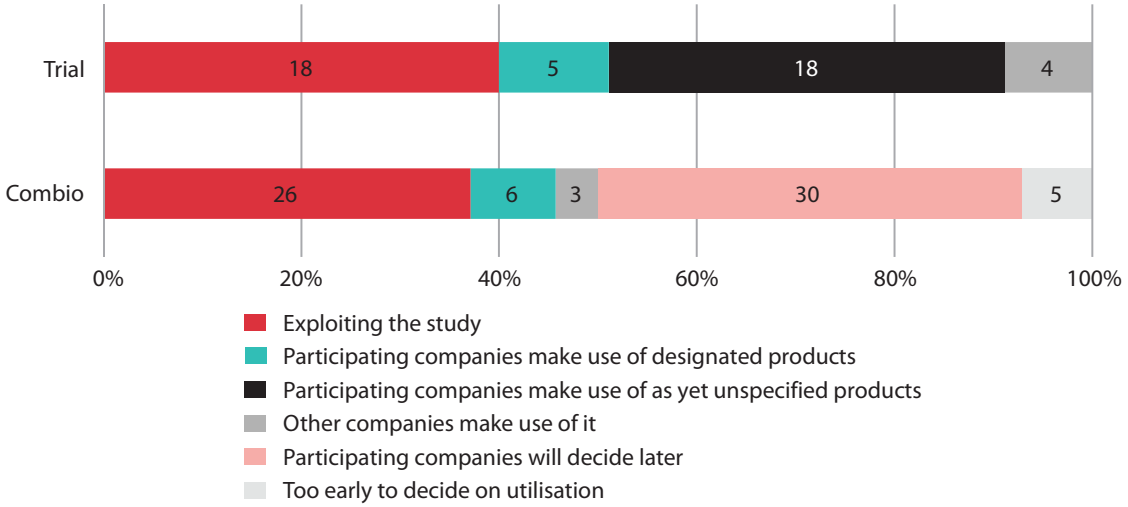


Figure 23. In what form the results will be used. Source: Technopolis analysis of Tekes monitoring data



4.3 Contribution of the three programmes to the Finnish ecosystems

Creation or strengthening of an ecosystem was one of the important elements in all three programmes.

The seeds of the ecosystem in most cases were already sown. The programme helped strengthening them and creating conditions for more innovation. The ecosystem that was already there was strengthened due to the Trial programme (Figure 24). The ecosystem evolved to a true knowledge cluster around CR, and people did find that it helped them to know where to find the experts on various aspects related to CR. Both industry and academic groups appreciated the network and learned a lot from the mutual interactions. The focus on a trial environment, or testbed, was also seen as positive both by academia and industry. The vibrant CR and trial ecosystem is currently being used as an important starting point for the research in the 5thGear programme. In comparison, participants of the BioIT programme were less positive regarding contribution of their projects towards the ecosystem creation. The ecosystem in the biomaterial field as such has existed before Combio but it did change from being a number of closed clusters around three key locations to connected groups around joint research projects. The important element highlighted by the participants is the creation of interdisciplinary collaborations thus making an ecosystem more engaging and innovative.

Creation of an 'experimental' culture is a related question to the ecosystem creation. Participants of the Trial programme evaluated the contribution of their projects towards establishing such an experimental culture in Finland as either high or very high; whereas the largest proportion of BioIT participants rated the contribution as moderate (Figure 26).

Figure 24. Contribution of the project to establishing a business ecosystem in thematic area. Source: Online survey of the programmes participants, Technopolis Group

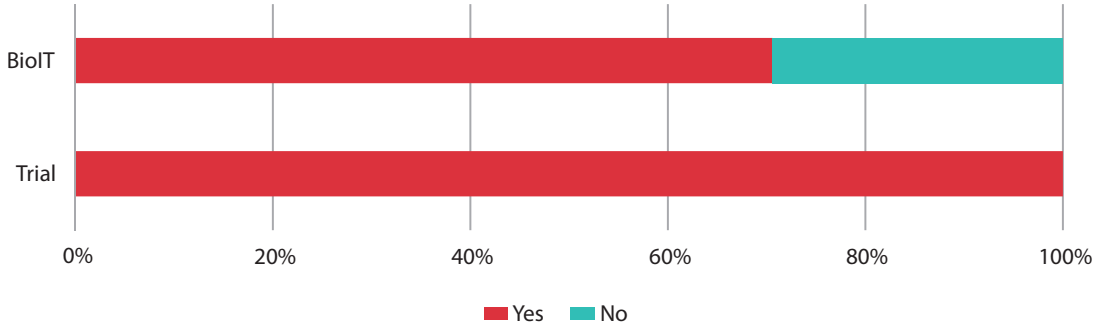


Figure 25. Contribution of the Combio programme towards establishing the innovation ecosystem in the biomaterials field in Finland. Source: Online survey of the programmes participants, Technopolis Group

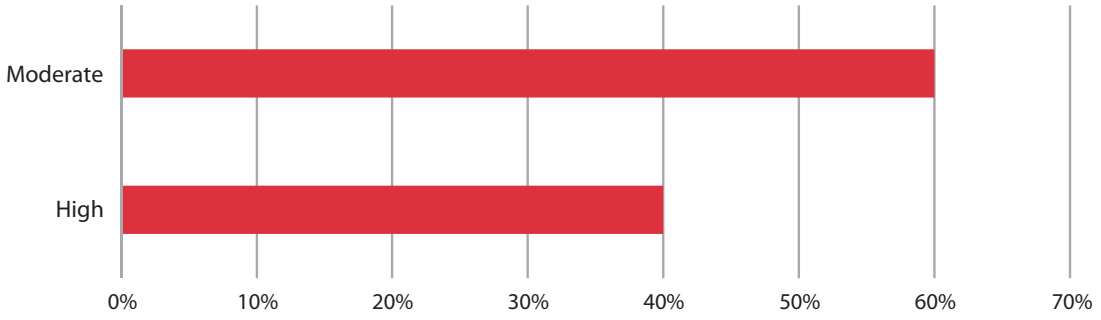
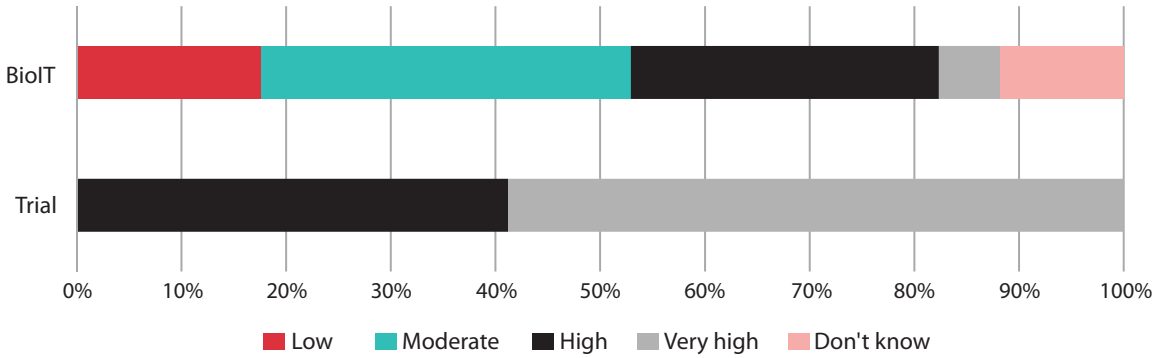


Figure 26. Rating the contribution of one's project towards establishing an experimental culture in Finland. Source: Online survey of the programmes' participants performed by Technopolis Group



4.4 SWOT analysis of Tekes programme design

Strengths of evaluated programmes

- Tekes funding in the various technology sectors was instrumental for most programme participants
- Tekes programme staff are helpful and knowledgeable about technology sectors and business development
- Programmes provided beyond funds (grants and loans) additional services to participants to help to create new collaborations, train entrepreneurial and business skills, and enhance international visibility of project results
- Experimental environment made it possible to test new ideas and refine business strategies
- Creating new test beds also represent a unique selling point for Finland globally
- New specific products have been developed and either launched or increased their technology readiness level for launch in the market
- Successful projects have seen students and researchers from academia moving to work in businesses.

Weaknesses of evaluated programmes

- Misalignment of project ambitions and timescales with funding received from Tekes resulted in lower realisation of business opportunities
- Pilot programmes with small funding/ operational budget and with short timelines cannot effectively support projects in technology sectors where industry life cycles are longer or where regulatory changes and standardisation are essential pre-requisite of projects' success
- It was challenging to deliver specific support services to programme participants with diverse project focus (i.e., matchmaking partners or supplying market research information)
- Some funded projects missed a clear plan on taking products to market or having the right partnerships in place at project start.

Opportunities to reap future benefits of the programmes

- Enhanced (and incentivised) cooperation between academic and industry partners in projects will bring about new innovative ideas to explore
- Involvement of end-users and consumers in the project design phase will make products and services relevant to their needs
- Engagement of policy makers, regulatory and standardisation bodies in programme design and key projects
- Align with and complement international programmes, such as the EU H2020, to facilitate international cooperation
- Use of public and tacit information on specific businesses will help Tekes promote partnerships and innovation networks
- Closer cooperation with other national agencies will help implement national strategies, and help promote Finland's expertise abroad and attract FDI
- Closer programme coordination and joint initiatives in the Nordics will help create critical mass and access to a larger market (e.g. in the biomaterials field with Sweden)
- Increased thematic breadth of larger, horizontal programmes at Tekes will absorb the new skills and results of the smaller pilot programmes and help sustain activities in successful projects and consortia.

Threats for reaping future benefits of the programmes

- Smaller programmes with promising projects are not followed on with access to further funding to allow new products reaching the market
- Taking high ratio of loan or the need to invest cash from working capital may limit young companies' participation in experimental projects funded by Tekes
- Lack of access to private risk funding from venture capitalists puts pressure on companies' growth ambitions in Finland
- Projects without access to international partners may result in products not commercialisable in the global markets
- Entrepreneurial skills in public research groups and willingness to collaborate with industry may limit innovative ideas to be taken all the way to the market
- Lack of a functioning ecosystem in Finland may result in limited domestic growth and successful companies moving abroad.

5 Reflections from international comparisons

Building of a thriving ecosystem was one of the key expectation from the three programmes. Ecosystems comprise of a network of actors interested and incentivised to create joint value and deliver products and services to customers. Ecosystems should allow for experimentation of new ideas, with possible successes and failures in innovation, and where the best solutions can be tested and scaled up. Effective ecosystems are connected to international value chains and they take advantage of global markets to commercialise research efforts.

In this evaluation, four countries – Ireland, Switzerland, Sweden and the Netherlands – were selected as benchmarks for evaluating the Finnish innovation ecosystem. The chosen countries all represent different strengths and weaknesses in regards to their innovation policies and innovation ecosystems and they were selected for their potential to produce good practice examples that could be adopted in Finland.

5.1 Key features

Figure 27 presents the GEDI data innovation indicators as compared between each country (the four benchmarks and Finland). Here, Ireland in many ways presents a case study of a small country, which has recognised the areas in which it is strongest and focuses on maintaining and further developing them. Overall, while the country scores low on opportunity perception and risk acceptance; at the same time, they demonstrate strength in areas such as encouraging high growth, human capital and internationalisation. In their policy statement, the Irish government expresses that they will keep focus on maintaining the strengths mentioned above.[37]

To briefly bring up the topic of internationalisation, in this area Finland scores lower than all the benchmarked countries. This is indicative of a much wider and, in many ways, a common problem for all Nordic countries, which are usually weak regarding internationalisation. However, Sweden has managed to break this mould and has been successful in achieving good internationalisation scores. The country is also strong in areas such as opportunity perception, networking, technology absorption, and product and process innovation. However, start-up skills, risk acceptance and high growth score lower than several other benchmarked countries with only Switzerland scoring lower regarding start-up skills.

While start-up skills and cultural support indicators are the lowest in Switzerland (among the benchmarked countries) Switzerland is strong in areas such as risk acceptance, competition, internationalisation and risk capital. In many ways Switzerland represents an example of a linear progression from strong support for internationalisation which attracts the interest of risk capital, which in turn leads to high levels of innovation production. However, as it will be discussed further, Switzerland's over-focus on internationalisation is also the cause of the previously discussed weak start-up skills.

The Netherlands have been performing well in areas such as networking and cultural support. However, opportunity perception, human capital score rather low and high growth is the lowest among the studied countries (Finland included). However, these low scores do not necessarily indicate a weak ecosystem. The Netherlands are an interesting case due to a very strong SME support which, coupled with good networking, has allowed the Netherlands to overcome some of the weaknesses of their ecosystem.

Lastly, when compared to selected countries Finland scores high in networking and product innovation. Interestingly enough cultural support for innovation is high in Finland. However, in the Finnish innovation system competition, internationalisation, technology absorption, and human capital are seen as weak links.

By analysing the selected countries and mapping their strengths and weaknesses, we have been able to identify key features of their innovation ecosystems. These features form the good practice examples which can be instrumental in helping Finland overcome the weaknesses discussed previously.

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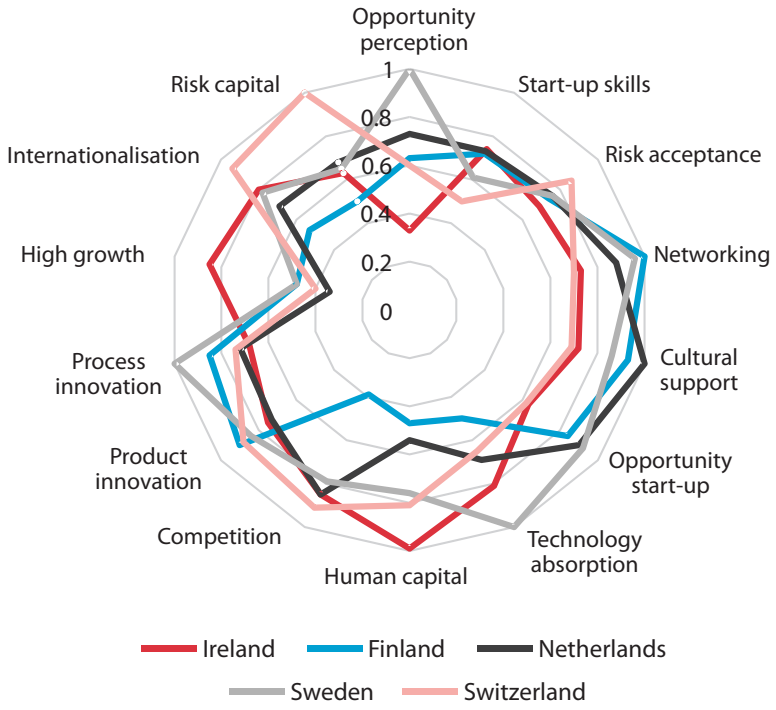
[37] National Policy Statement on Entrepreneurship in Ireland 2014.

Figure 27. GEDI Pillar Comparison. Source: Data from GEDI. https://thegedi.org/tool/



5.2 Good practices

Benchmarks of international ecosystems point to the need for national programmes to become not only a method of distributing public funds but also a facilitating instrument passing on entrepreneurial and business skills to the beneficiaries. This may be a particularly important service to provide for young start-up companies and research groups in public research organisations.

Entrepreneurial education in general is an important factor for the growth and sustainability of an innovation ecosystem. Switzerland has fostered a healthy environment for innovation and market conditions with an open R&D policy towards both national and foreign participants, inviting significant interest from international investors to support public-private partnerships. However, Switzerland was relatively late to recognise that focussing on large multinational organisations and large-scale projects would eventually starve start-up companies of new entrepreneurs, skills and resources. Therefore, as a direct response Switzerland is introducing entrepreneurial education and training programmes in order to kick-start the emergence of its start-up scene.

The Netherlands on the other hand has a broad network of start-ups providing more established companies the opportunity to outsource tasks to specialised businesses. This may slow down some of the growth in terms of business size but Dutch SMEs appear to remain globally competitive using this business strategy. The approach adopted by the Netherlands also demonstrates a key strength that is required to foster an ecosystem – a cross-sectorial cooperation.

One of the key messages of the study is that international benchmarks emphasise the need for a holistic approach to innovation. Innovation succeeds when actors are a part of a network in a broad multidisciplinary ecosystem covering more than a few targeted research areas. This approach provides a more flexible system than fragmenting innovation into specific sectors which can lead to unnecessary administrative burden and lack of coherence for the ecosystem participants. Sweden is an example of an ecosystem, which, while producing positive results, is also hindered by high fragmentation between research sectors. This has resulted in Sweden suffering from excessive administrative costs that are inherently needed to maintain a system that lacks centralisation. A national innovation ecosystem should allow for easier cross-sectorial cooperation, faster adaptation to the changing international context and additional opportunities for government to support high-growth sectors. Funding broader themes also allows participants to bring unusual companies together, absorb new skills and business models, and exploit emerging opportunities and spill-over effects.

6 Recommendations

6.1 Recommendations for building of the ecosystem and experimental culture

The results from the three Tekes programmes in this evaluation indicate that larger and longer programmes may in fact result in lower impact than smaller and shorter ones. An important requirement of launching a large programme is the appropriate design, building on relevant, world-class academic research, a critical mass of existing businesses, and willingness to collaborate on joint initiatives. The Combio programme is a prime example of a long-term initiative targeting a very specific sector that failed to deliver the expected results. However, Combio perhaps better illustrates the failure of trying to develop a very specific ecosystem. In this case, the programme was expected to facilitate the emergence of a biomaterials ecosystem in Finland. The flawed assumption here was trying to develop an ecosystem grounded in a single research field. This approach failed to recognise the potential of multidisciplinary cooperation and cross-sector application of developed innovation products. However, we are not trying to make a point that Combio was unsuccessful because it targeted a specific research field; rather, we make the case that its design by nature was to facilitate fragmenting, instead of unifying innovation in Finland.

On the other hand, the BioIT programme demonstrated that smaller, lean 'pop-up' programmes can be effective in piloting ideas, activating companies and research groups and establishing the scale of interest and potential in a particular technology sector. These programmes may be seen as a first step in creating a larger and broader follow-on programme that would allow scaling up activities and consolidating the networks and the ecosystem. The current Bits of Health programme is a far larger initiative aiming to achieve lasting impact. These two types of programmes may well run in parallel to combine the narrower technology focus of smaller programmes with the more cross-cutting and holistic horizontal schemes. This combined model would limit the risk for Tekes when launching large programmes and, at the same time, create room for failure, which is inherent in innovation processes.

Participants consulted in the three programmes felt that their projects (and the programme itself) had a moderate to high contribution towards establishing an experimental culture and innovation ecosystem in Finland, Trial being the top performer on this aspect and Combio indicating the need for further improvement. Tekes funding has contributed to creating new national networks and new R&D-focused pilot actions in the three programme areas: biomaterial, biological and health data, as well as cognitive radio. However, when a budding ecosystem relies heavily on national public funding and the internationalisation of research projects is low, an ecosystem struggles to survive, especially in a country of the size of Finland. Therefore, it is important for the public sector to maintain a competitive funding environment where the best innovators are supported and avoid the creation of 'parasitic' ecosystems that cannot be sustained in the long run.

A functioning ecosystem is capable of keeping commercially competitive companies in Finland where R&D costs are affordable, research infrastructure and networks are in place, and education produces graduates with employable skillsets providing a high-quality research base. However, for the ecosystem to develop further, other factors need to be considered, such as the availability of seed and venture capital funding, regulatory support, new piloting facilities, and involvement of large players with access to international networks for businesses and research. Obstacles for SMEs and start-ups are often related to everyday struggles and problems. In order to promote a robust ecosystem, the state should minimise or even remove these obstacles.

In addition, in order to achieve a thriving ecosystem, Tekes needs to work together with other agencies in Finland, including Finpro, Sitra, Team Finland and the Academy, and collaborate closely as implementers of the national strategy. Beyond Finland, it is important to align with and complement international programmes, such as the Horizon 2020 to fast track innovation activities in Finland.

Based on the analysis of the publicly-funded Combio, BioIT and Trial programmes as well as the observations and lessons taken from the international benchmark countries, we propose the following key learning points that could be adopted by Finland:

- In order to develop an ecosystem **a nation needs to set goals and strategies** as to reach these goals. Goal setting needs metrics and ecosystem needs to be evaluated on regular basis in order to improve the system.
- **Legal frameworks and entrepreneurial policies** are important features for promoting investments in innovation and thus SMEs and start-ups. Different government policies function as growth accelerators when the government "does it right". The right type of funding, particularly at the right time, can accelerate early-stage companies. However, what kind of support that is the right type is a topic that is widely discussed, and it is difficult to give an unambiguous answer.
- **There is a demand for a non-fragmented system.** The system to coordinate R&D&T activities in Switzerland is more or less centralised. On the other hand, the Swedish innovation system is rather fragmented, and consequently rather ineffective in some areas. A fragmented system can result in, for example, excessive administrative costs. Another problem due to a fragmented system is that innovators and entrepreneurs don't know where to find the right funding (and this is inextricably linked to the importance of information, see next bullet).
- **There is a need for more, and better information (regarding the ecosystem as a whole, different funding alternatives, intellectual property, etc.).** In Ireland, the SME State Bodies Group will continue to raise awareness of the schemes in the country by promoting the Supporting SMEs online tool. Enterprise Ireland and the Business Innovation Centres help their clients to become investor ready and guide them in the fundraising process in order to enhance their access of securing funding.
- **Collaboration with universities and large companies is important for smaller companies.** Swiss companies, as well as companies in the other benchmarked countries have, more or less, a tradition in collaborating with top universities. In Sweden and the Netherlands, open innovation is a useful way for start-ups to connect with large companies. Large companies can play major roles for early-stage companies in their growth and development. Better access to both R&D, infrastructure (data, software, etc.) and knowledge are valuable for **early-stage companies and SMEs. However, early-stage companies** can play important roles for other similar companies as well. They can mentor and inform. In some cases, they can even provide economic support for other entrepreneurs and start-ups.
- **Attracting foreign investments can be of importance.** For instance, favourable taxation, and a developed financial system seem to attract foreign investments (which include VC, etc.). Favourable taxation seems to function well in, for example, Ireland.
- Several benchmarked countries have different kinds of **R&D tax credit schemes**. However, these have not been evaluated so that we have knowledge about how these schemes affect start-ups specifically and the entrepreneurial capacity.
- Governments often have a strong country specific focus in their ecosystem policies. Differences between countries are common and if a start-up wants to expand and go global, there are potential issues for this reason. Start-ups often face similar issues, and these (can) have an impact on the major growth accelerators as well as the major growth challenges for early-stage companies. **Horizon scanning and international benchmarking can be two important features in building a robust ecosystem. Here, the decision of the Irish government to keep the focus on maintaining country's innovation strengths is a good example.**
- **Previous and existing policies, policy initiatives and instruments should be reviewed and evaluated (ex-ante and ex-post)** in order to ensure they meet their aims, and consequently, for example, provide value for the companies, value for money and i.e. value for the country (as well as globally). Several benchmarked countries ex-post evaluate their support and funding mechanisms, for example Sweden. However, there is also a need for evaluating policies and policy initiatives, even ex-ante.

6.2 Recommendations for research and innovation policy

As proven by the results achieved in Combio, Trial and BioIT in particular, public funding is an excellent way to provide a jumpstart for companies and boost innovation, but it cannot become their lifeblood. National governments have to invest not only in setting up programmes and allocate public funds to promising projects, but also need to ensure that the beneficiaries do not become overly reliant on public money for continued operation. This highlights the need for support at the right juncture in the product development cycle and that the scale and scope of the support is capable of taking the project to the next milestone for further third-party funding.

The need for this type of nurturing was recognised by Tekes and provided services to programme participants. The BioIT programme, for example, organised networking

events, training in intellectual property rights and sales pitch, investors meeting, and other national and international road shows. Combio, with a leaning towards global market penetration, not only provided business consulting, but the programme organised international expeditions to key identified markets (Asia in particular) as well as compiling market studies and market reports, available to participating organisations. These services are recognised as variably of major value, depending on the maturity and background of the participating organisation and the specific field of activity.

In many cases this evaluation indicated that there is a gap between the academic community and businesses; end-users and consumers are not part of the value creation process, and regulatory bodies and policy makers are not engaged with the ecosystem to provide standards and legislation and facilitate innovation processes.

The main policy implications coming out of this evaluation are therefore the following:

1. Small-scale 'pop up' programmes may be institutionalised as exploratory initiatives with focus on emerging technology sectors. This represents low risk for Tekes but essential to activate young companies in new multidisciplinary fields, gauge interest and demand from diverse actors, and bring non-traditional partners together to create new networks.
2. Larger cross-cutting, holistic programmes with broader thematic coverage should have international ambitions and absorb the new skills and results of the smaller pilot programmes and help sustain activities in successful projects and consortia. These longer projects, adapted to the complex life cycle of particular industries, should have a mid-term evaluation point and achievement of explicit and agreed milestones should be a requirement for continued funding. This tiered approach will create a positive competition in the ecosystem and help focus participants on the key aims and objectives of the funded project.
3. These two types of programmes may run in parallel to combine their advantages and complement the technology focus with more horizontal approaches, and effectively exploit emerging opportunities and potential spill-over effects.
4. Building functioning ecosystems is the key to keep the research base of high-growth companies in Finland. This requires that framework conditions are available and internationally competitive: R&D costs are affordable, research infrastructure and (global) networks are in place, and graduates with relevant skillsets provide a high-quality research base. In addition, Tekes may consider providing post-project services for companies to facilitate access to (international) private equity funding, thereby reducing reliance on national public funding and ensuring sustainability of successful project results.
5. Tekes should aim for creating a few broad multidisciplinary ecosystems rather than covering specific research areas and business opportunities. This approach would provide a flexible system without fragmenting innovation into specific sectors. These innovation ecosystems would allow for easier cross-sectorial cooperation, faster adaptation to the changing international context and additional opportunities for government to support high-growth sectors.
6. Tekes cannot implement R&D initiatives in isolation. It should rely on various government actors and collaborate closely as implementers of national strategies. Beyond Finland, it is important to align with and complement international programmes, such as the Horizon 2020 to fast track innovation activities in Finland.

6.3 Recommendations for Tekes

In moving forward in supporting different types of actors in the research and innovation field in Finland, Tekes may want to consider:

- Review and adjust the goal, objectives and vision of larger programmes when the operational environment has changed (e.g. restructuring in the sector). This will remove over-reliance on a hand-full of organisations which considered as key players at the beginning of a programme but which have subsequently changed their objectives and interests.
- Launching novel products and sales should not be the only evaluation criteria for the success of a programme. Equally important may be the development of processes, analytical methods and (pre-competitive) platforms that help companies and research groups to test and characterise their products in future.
- Consider setting requirements of partnerships in project funding: teams should include other types of stakeholders, including end-users and businesses or academia and involve international partners in Tekes-funded projects.
- Finally, the sale of a Finnish company abroad should not be regarded as a loss or failure of the ecosystem. These positive examples demonstrate the success of Finnish innovation and business growth, and the resulting international brand and financial revenues should further encourage building new high-growth companies and attract foreign companies to invest in Finnish research and development.

Appendix A. List of interviewees and attendees of the validation workshop

A.1 Exploratory interviews

Figure 28. Exploratory interviews.

Interviewee	Job Title / Role	Organisation
Pirjo Kyläkoski	Foresight Manager	Tekes
Teppo Tuomikoski	BioIT programme manager	Tekes
Mika Sievi-Korte	Combio programme coordinator Member of programme board	Tekes
Heikki Laurila	Combio programme manager	Industrial Biotechnology Cluster Finland Innomedica Ltd
Carmela Kantor-Aaltonen	Director	Finnish Bioindustries FIB
Tero Piispanen	Director	BioTurku cluster, Turku Science Park
Katja Ahola	Trial programme manager	Tekes
Kari Horneman	Program manager at Nokia Networks External steering group member of Trial	Nokia Networks
Mikko Uusitalo	Head of a Research Department, Wireless Advanced Technologies External steering group member of Trial	Nokia Bell Labs

A.2 In-depth interviews

Figure 29. Trial programme in-depth interviews.

Interviewee	Organisation represented in the programme	Type of organisation
Kari Heiska	Digita	Large Company
Taavi Hirnonen	Bittium Wireless	Large company
Kari Rikkinen	Renesas Mobile	Large Company
Seppo Salonen	Anite Telecoms	Large company
Seppo Yrjölä	NSN	Large company
Heikki Kokkinen	Fairspectrum	SME
Marja Matinmikko	Teknologian tutkimuskeskus (VTT)	Public research organisation
Mikko Valkama	Tampere University of Technology	University

Figure 30. Combio programme in-depth interviews.

Interviewee	Organisation represented during the programme	Current organisation	Type of organisation
Mikko Kananen	Polymer Corex Kuopio	Lehtikankaan Apteekki	SME
Ilkka Kangasniemi	Vivoxid	Vivoxid	SME
Olli Keränen	Medtentia	Medtentia	SME
Kimmo Lähteenkorva	Conmed	ConMed Corporation	SME
Minna Veiranto	Bioretec	Bioretec	SME
Eeva Moilanen	University of Tampere	University of Tampere	University
Timo Narhi	University of Turku	University of Turku	University
Erkki Levanen	Tampere University of Technology	Tampere University of Technology	University
Ilkka Kiviranta	Central Finland Health Care District	HUS - The Hospital District of Helsinki and Uusimaa	University
Minna Kellomäki	Tampere University of Technology	Tampere University of Technology	University
Timo Jämsä	University of Oulu	University of Oulu	University
Tuomo Nieminen	n/a	University of Helsinki	University

Figure 31. BioIT programme in-depth interviews.

Interviewee	Organisation represented during the programme	Current organisation	Type of organisation
Minna Hendolin	Tekes	University of Turku	University
Kari Kataja	Tekes	Tekes (Bits of Health)	Public innovation agency
Pauli Saarenketo	Tekes (Pharma programme manager 2008-2011)	Natural Resources Institute Finland (Luke)	Public research organisation
Jari Forsström	Abomics	Abomics	SME
Jani Huttunen	Finbiosoft	Finbiosoft	SME
Joni Kettunen	Firstbeat Technologies	Firstbeat Technologies	SME
Sami Kilpinen	MediSapiens	MediSapiens	SME
Tero Silvola	BCPlatforms	BCPlatforms	SME
Esko Kankuri	University of Helsinki	University of Helsinki	University
Kirsi Sipilä	University of Eastern Finland	University of Eastern Finland	University

A.3 Attendees of validation seminar

Figure 32. Attendees of the evaluation validation seminar.

Name	Organisation/role	Programme
Pekka Pesonen	Tekes, Chief Advisor	All
Pirjo Kylakoski	Tekes, Foresight Manager	All
Peter Varnai	Technopolis Group/ Evaluation team	All
Jelena Angelis	Technopolis Group/ Evaluation team	All
Sofie Pollin	Evaluation team	All
Marja Tähtinen	Evaluation team	All
Heikki Laurila	ex-Tekes, Programme manager Industrial Biotechnology Cluster Finland, Innomedica Ltd	Combio
Katja Ahola	Tekes, Programme manager	Trial
Petteri Annamaa	Pulse Electronics	Trial
Jan Engelberg	Ficora (Finnish Communications Regulatory Authority)	Trial
Tapio Halkola	Puolustusvoimat	Trial
Ari Hulkkonen	Bittium	Trial
Seppo Salonen	Anite Telecoms	Trial
Seppo Yrjölä	Nokia Networks	Trial
Anita Eliasson	BCPlatforms	BioIT
Sami Kilpinen	Medisapiens	BioIT
Minna Hendolin	ex-Tekes, Programme director Director, Strategy and Innovations, University of Turku	BioIT
Teppo Tuomikoski	Tekes, Senior Advisor	BioIT

Appendix B. Evaluation steering group

Name	Job title	Organisation
Pekka Pesonen	Chief advisor	Tekes
Pirjo Kyläkoski	Foresight manager	Tekes
Tiina Nurmi	Programme manager	Tekes

Appendix C. Benchmarks

C.1 Ireland

C.1.1 Background and strategic vision

Ireland ranks as number eight of the 141 countries in the 2015 Global Innovation Index. This figure is higher than previous years (number eleven in 2014, number ten in 2013 and number nine in 2012).[38] Ireland is above EU average for innovation performance in the European Innovation Scoreboard 2016. Ireland's relative strengths are several, for instance, innovators and human resources and the country performs above the EU average on license and patent, revenues from abroad, international scientific co-publications, and exports of knowledge intensive services. The weaknesses (still same as 2014) are community designs, non-R&D innovation expenditures, and R&D expenditures in the public sector.[39]

In recent years, Ireland has increased its R&D output by 10.7%. Business expenditure on R&D has increased from €1.2b in 2003, to €1.8b in 2011, and has remained constant during the recession. In the same period, business expenditure on R&D has increased as a percentage of GNP. However, the total public support to business R&D in Ireland is not especially high in relation to the country's GDP, and the Irish overall innovation capacity is weaker than other small advanced countries such as Sweden and Switzerland.[40] In 2012, total in-house spend on R&D was €1.3b, an increase by 14%.[41] The productivity growth has been declining and according to OECD, the domestic SME sector is behind several other countries regarding levels of both competitiveness and productivity as well as R&D spending.[42]

In 2014, approximately 20,400 individuals started a new firm in Ireland. This is similar figures to 2010, 2011 and 2012, but lower than 2013. A recent study from the Central Bank shows that start-ups in the first five years of existence account for over 65% of all new jobs created in Ireland. Still, young firms in Ireland do not scale very well as many other OECD countries, and in addition, the country has relatively few young patenting firms.[43]

Table 7 shows the number of start-ups and percentage of existing enterprises in sector in 2011.

Data from CSO Business Demography shows that there were almost 190,000 enterprises and 12,000 start-ups in 2011 in Ireland. 90% of the start-ups were in the services, distribution and construction sectors. 16 Irish companies are listed in the latest EU Industrial R&D Investment Scoreboard from 2013. The list includes the top 1,000 EU companies investing the largest sums in R&D. Since previous year, this is an increase by two companies.[44]

Data from the Global Entrepreneurship Monitor (GEM) shows that the GEM measure of total early-stage entrepreneurial activity, known as TEA, was 9.8% in 2005. The corresponding figure for 2012 was 6.1%, and Ireland went from scoring average to be in the bottom among the European

Table 7. Number of start-ups and percentage of existing enterprises in sector in 2011. Source: CSO Business Demography 2011 in National Policy Statement on Entrepreneurship in Ireland 2014.

Start-ups (2011)	Number	% of Existing Enterprises in Sector
Industry	725	5.2
Construction	1 976	5.3
Distribution	2 335	5.4
Services	6 429	7.1
Finance and Tourism	372	6.8
Total	**11 847**	**6.2**

38 https://www.globalinnovationindex.org/gii-2015-report

39 European Commission, Innovation Union Scoreboard 2016. According to data from the Commission, "performance relative to the EU shows a similar trend, with a significant drop in 2013, and increased relative performance in 2014-2015"

40 European Commission, 2013 EU Industrial R&D Investment Scoreboard, see also OECD (2015). Ireland – Economic Review.

41 Data from IDA Ireland.

42 https://www.oecd.org/policy-briefs/ireland-better-innovation-policies-for-better-lives.pdf

43 Fitzsimons, et al. (2014). Entrepreneurship in Ireland 2014. Global Entrepreneurship Monitor (GEM) Annual report for Ireland.

44 https://www.oecd.org/policy-briefs/ireland-better-innovation-policies-for-better-lives.pdf

countries. In 2013 (most recent data), Ireland the TEA rate increased to 9.2%. In addition, data from 2013 shows improvement in attitudes towards entrepreneurship. 50% of the Irish respondents considered entrepreneurship to be a good career choice, an increase with 5% compared with 2012.[45]

Collaboration between industry and academia is, as stated in the Action Plan for Jobs, published in 2014, a key area for the Irish government. However, a newly published report from KPMG indicates that the number of companies collaborating with a so called third-level institution has decreased. 32% of the companies have collaborated on an innovation project with a third level institution. The corresponding figure for small companies is 13%. These numbers indicate that large companies are more than two times more likely to be collaborating with a third-level institution as small companies. One explanation is that collaboration involves investment in resources, both in money and time, resources that small companies often have less of, or even lack.[46]

The IP Protocol 2016, an update to the IP Protocol published in 2012, is about supporting the industry (from start-ups and SMEs to multinational corporations) to access the R&D carried out in universities and other research performing organisations in Ireland. The protocol describes the government's policies to encourage industry to benefit from this R&D and the practical arrangements and focuses mainly on collaborative research. In addition, it encompasses all forms of R&D activity from pure and applied research, to incremental and near-market development.[47]

Ireland has multiple shared facilities and research centres. They mainly focus on RDI projects for specific key industry sectors. The centres are:

- ADAPT (Centre for Digital Content Platform Research)
- AMBER (Advanced Materials and Bio-Engineering Research)
- APC (Alimentary Pharmabiotic Centre)
- CONNECT is a flagship research centre for communications networking, services, applications and technologies
- CúRAM (Centre for Research in Medical Devices)
- iCrag (Irish Centre for Research in Applied Geosciences)
- INFANT (Irish Centre for Fetal and Neonatal Translational Research)
- INSIGHT (Irelands Big Data and Analytics Research Centre)
- IPIC (Irish Photonic Integration Research Centre)
- LERO (The Irish Software Research Centre)
- MaREI (Marine Renewable Energy Ireland)
- SSPC (Synthesis & Solid State Pharmaceutical Cluster)
- Tyndall National Institute research centre in ICT
- Telecommunications Software and Systems Group.

The first twelve research centres are SFI Research Centres and represent the largest ever state and industry co-funded research investment in Ireland. The research centres have been established through an investment of €355m from the government through Science Foundation Ireland (SFI). Together, the centres represent a €190m co-investment by over 250 industry partners. SFI Research Centres may be funded between €1m to €5m per year in direct costs. A review for scientific excellence and impact was carried out after the first seven centres were established in 2013. Five more centres were approved in 2014, and started in early 2015.

Besides access to markets, access to finance is a critical issue for early-stage companies and previous studies have shown that many companies rely on bank loans. However, bank loans have been negatively affected by the previous recession, and banks are often restricted to companies without previous credit history. Stated in the National Policy Statement on Entrepreneurship in Ireland, "banks will need to engage more deeply with individual sectors of the economy and develop both relevant expertise and financial products to support enterprises within these sectors", for instance through improved access to working capital for exporting firms and the provision of trade finance to business.[48]

The Irish government states in the National Policy Statement on Entrepreneurship in Ireland 2014 that more diverse sources of finance are needed, and under the last decade, the seed and venture capital markets have tripled in size in Ireland. For instance, Enterprise Ireland funds have under the last decade increased the availability of seed funding. In the last decade, Irish venture capital firms have invested €1.5b in Irish SMEs and the capital has leveraged €1.5b from international investors.[49]

Approximately €800m is available through networks of angel investors, seed and venture capital and development capital firms in Ireland. €685m is under management in SVC funds supported by Enterprise Ireland. The funds in both more generic but also in different thematic areas include, for example AIB Seed Capital Fund (€53m) and AIB Start-up Accelerator Fund (€22m), Bank of Ireland Early Stage

45 National Policy Statement on Entrepreneurship in Ireland 2014.

46 KPMG (2014). Innovation Monitor 2014/2015. Insights into Innovation & R&D in Ireland.

47 Department of Jobs, Enterprise and Innovation 2015). Inspiring Partnership – the national IP Protocol 2016. Policies and resources to help industry make good use of public research in Ireland.

48 The Irish government has introduced legislation to establish the Strategic Banking Corporation Ireland, known as SBCI (over €800m in new credit to Irish SMEs).

49 https://www.enterprise-ireland.com/en/

Equity Fund (€32m), Bank of Ireland Kernel Capital Partners (€51m), Bank of Ireland Start-up and Emerging Sectors Equity Fund (€17m), Delta Partners (€105m), Fountain Healthcare Partners (€73m), Seroba Kernel Lifesciences (€75mln) and NCB Ulster Bank Diageo Fund (€75m).

The Innovation Fund Ireland is a government initiative (by the National Pensions Reserve Fund and Enterprise Ireland) to attract leading international venture capital fund managers to Ireland. Enterprise Ireland has made four investment commitments (approximately €80m) through the Innovation Fund by 2014. Total allocation from Enterprise Ireland to the fund was €125m. At the same time, the National Pensions Reserve Fund has made seven investment commitments (combined value of approximately €116m of the €125m allocation from the National Pensions Reserve Fund to the Innovation Fund).[50]

The Development Capital Scheme in Ireland aims at providing funding for mid-sized, export-oriented businesses, particularly manufacturing and technology companies in traditional sectors such as engineering, food, life sciences, services and electronics. The funds invest approximately €2-10m in equity, quasi equity and debt: MML Capital Ireland (€125m), BDO Development Capital Fund (€75m) and Cardinal Carlyle Ireland Fund (€290m).[51]

In 2012, two initiatives to address two categories of business experiencing difficulties in obtaining conventional bank finance were introduced: Microfinance Ireland and the SME Credit Guarantee. The Credit Guarantee, that provides a 75% State guarantee to banks against losses on qualifying loans, facilitates the provision of additional bank lending to commercially viable SMEs that have insufficient collateral or operate in categories perceived by the commercial banks as being high risk. Microfinance Ireland offers loans from the Microenterprise Loan Fund. The loans is maximum €25 000, targeted at microenterprises that have been declined bank loans. Stated in the National Policy Statement on Entrepreneurship in Ireland, the schemes by SMEs has not been as popular as anticipated and a review is underway.[52]

C.1.2 Historic trends in the ecosystem creation

Since the 1990s, the Ireland's Research Development and Innovation policy has developed greatly. During the same period, the country experienced a rapid economy expansion, fuelled by, for instance, strong growth in export markets. Another driving force was the inward investment policies that were implemented during the late 1990s. The government committed over €630m to a Technology Foresight Fund for the seven year period of the National Development Plan 2000-2006. The aim was to develop world-class research capabilities in strategic technologies to underpin the future development and competitiveness of the Irish industry and facilitate the undertaking of R&D in Ireland by multinational companies in order to support the further development of that sector in Ireland. Additional objective was to attract more high technology companies to Ireland and enhance the environment for the creation of new technology-based firms. During the same period, Science Foundation Ireland was established to fund the building of research excellence in biotechnology and ICT. During the beginning of the 2000s, the report Building Ireland's Knowledge Economy, published 2004, recommended a major improvement in enterprise research and innovation performance and absorptive capacity. In the Strategy for Science, Technology and Innovation 2006-2013, specific actions aimed at achieving the target of growing business enterprise expenditure on research and development were highlighted. The strategy suggested increased resources for building a world class research system, for enhancing the commercialisation capabilities to translate state funded research into applications, and for driving economic growth through research and innovation in enterprises.[53]

Published in 2014, and already mentioned above, the National Policy Statement on Entrepreneurship in Ireland aims to clearly identify the framework needed to make Ireland one of the most entrepreneurial nations in the world. This is the first time a government has published a comprehensive national strategy for entrepreneurship. The policy statement sets out the Irish government's strategic objectives in its role as a facilitator within the Irish entrepreneurship ecosystem, covering the key areas that affect both entrepreneurs and start-ups. In addition, the policy statement shows the focus of public policy in the coming years. A clear programme of specific actions for each year, delivered through the Action Plan for Jobs, will help to ensure delivery of these strategic objectives. The six key elements (shortened) are:

- Culture, human capital and education
  - Make entrepreneurship an integral part of our ambition as a nation
  - Celebrate and reward successful entrepreneurs
  - Ensure that greater numbers of people, particularly in underrepresented cohorts start and run their own business
  - Improve the quality and range of ICT professionals domestically to make Ireland a hub for technology start-ups

50 National Policy Statement on Entrepreneurship in Ireland 2014.

51 For more information, see Seed and Venture Capital 2015 report, published by Enterprise Ireland https://www.enterprise-ireland.com/en/Publications/Reports-Published-Strategies/Seed-and-Venture-Capital-Reports/2015-Seed-and-Venture-Capital-Report.pdf.

52 National Policy Statement on Entrepreneurship in Ireland 2014.

53 Forfás, Evaluation of Enterprise Supports for Research and Development and Innovation, 2013.

- Business environment and supports
  - Create a business environment in Ireland where it is easy to start up and grow a new business
  - Promote best in class standards across the network of Enterprise Ireland and Local Enterprise Offices
  - Stimulate and support high levels of quality entrepreneurial ventures with high growth, export, wealth and job creation potential
- Innovation
  - Make Ireland a location of choice for high quality international start-ups
  - Develop the best infrastructure to support technology transfer into commercialisation as a new business opportunity
  - Develop a support framework where innovative start-ups can reach their full potential
- Access to finance
  - Expand the range of access to finance instruments to match our ambition as a start-up hub so that all viable businesses have the opportunity to access sufficient finance to meet their needs
  - Attract more angel and international venture capital investors and continue to develop the domestic venture capital sector
  - Ensure that the banks develop the skills and focus necessary to deliver appropriate financial instruments to start-ups and early stage entrepreneurs
- Entrepreneurial networks and mentoring
  - Improve the impact of mentoring as a tool to support entrepreneurship
  - Increase the levels of peer networks for mentoring, angel finance and problem solving that sustain entrepreneurship
  - Build world class entrepreneurial hubs and achieve greater regional spread of such hubs
- Access to markets
  - Encourage local and national private enterprises to commit to offer opportunities for fledgling businesses to find a market
  - Encourage public local and national authorities to commit to offer opportunities for fledgling businesses to find a market
  - Ensure start-ups have clearly identified customer/market segments and clearly developed value propositions and where appropriate are export oriented in their thinking early in their development.[54]

In late 2015, the Irish government published the new innovation strategy Innovation 2020: Excellent Talent Impact, Ireland's five-year strategy for research and development, science and technology. The strategy is aimed at building on success in science strategy of past decade through private-public collaborations. The innovation strategy is a key element of the government's overall jobs strategy, aimed at building a new economy based on exports and enterprise. The targets are, for instance:

- to increase total investment in R&D in Ireland to 2.5% of GNP
- to double private investment of R&D performed in the public research system
- to increase the number of research personnel in enterprise by 60% to 40,000 and the share of PhD researchers transferring from Science Foundation Ireland research teams to industry by 40%
- to expand Ireland's participation in International Research Organisations
- to further develop the network of centres building critical mass and addressing enterprise needs
- to initiate challenge-centric research to stimulate solutions driven collaborations
- to undertake a formal horizon scanning exercise to identify areas of strategic commercial opportunity for Irish-based enterprises, and international benchmarking.[55]

C.1.3 Selected policy support instruments

Since the early 2000s there have been several state funded RDI programmes and other initiatives which influenced the development of the Irish ecosystem. The Department of Jobs, Enterprise and Innovation requested Forfás to carry out an evaluation of the enterprise support programmes provided by the enterprise development agencies (Enterprise Ireland, IDA Ireland and Science Foundation Ireland), under the period 2002-2012. The evaluation included 70 programmes around entrepreneurship and start-up supports, support to research, development and innovation, and support to business development.

The evaluation confirmed that the individual programmes have been found to be appropriate and aligned with government policy at the time of their implementation. On the other hand, the appropriateness and alignment is less clear when existing interventions are modified in response to the changing nature of the economy and market conditions. The evaluation showed that, overall, all programmes have met their goals, and some have been particularly successful. For instance, the Strategic Research Clusters programme (2007–2011), targeted mostly at biotechnology and ICT, has met its objectives and exceeded several of its targets. The evaluation suggested that there was a good level of partnership outcomes in the form of

54 Department of Jobs, Enterprise and Innovation (2014). National Policy Statement on Entrepreneurship in Ireland 2014.

55 Department of Jobs, Enterprise and Innovation (2015). Innovation 2020: Excellence Talent Impact. Ireland's Strategy for Research and Development, Science and Technology Interdepartmental Committee on Science, Technology and Innovation. December 2015.

increasing industry engagement and commercial and technical transfer outcomes.

The overall conclusion from the evaluation indicated a positive change in behaviour from both industry and HEIs. The changes in behaviour and behavioural additionality has been noted across all programmes and display increased academic-industry links, improved research quality, increase in the relevance of the research conducted in the research groups involved, changed behaviours with respect to academic-industry interactions and increased mobility of research staff to industry. The successful Strategic Research Clusters programme was replaced by the Research Centres hub programme (see section A1.2.).[56]

Today, the Irish government emphasises the implementation, policy innovation, monitoring and learning and on active engagement with a diverse range of public and private participants in the finance arena in Action Plan for Jobs. In the future, the government will focus on increase different bank and non-bank finance mechanisms that are available to companies. [57]

In the 2014 report from KPMG, it is stated that Irish companies are rather satisfied with the Irish government's efforts to promote innovation. In the study, 30% of the respondents believe that the State is doing enough. However, 39% believe more needs to be done. 51% of the respondents that believe the government needs to do more want more financial incentives and/or grants. Of the respondents, 86% consider access to funding to be very or somewhat important to the successful completion of an innovation project. Furthermore, 36% would like the government to address different taxation issues. On the other hand, grant funding seems to be more important than the R&D tax credit (see below) among those who are planning to innovate.[58]

Ireland has a range of support measures, see Table 8 for a selection. The Irish state's investment in R&D was €733m in 2013. Investment in R&D by companies based in Ireland increased to 13.6% in 2013. This number is above both EU average (2.6%) as well as globally (4.9%).[59] In Table 8, a selection of different support measures is presented.

In Table 8, several of the organisations' initiatives for start-ups are presented. Another example is the Innovation Partnership Programme that assists companies to access the skills and expertise from research institutes in Ireland. The programme can provide a maximum of 80% of the cost of research work in order to develop new and improved products, processes or services, or generate new knowledge and know-how. The Innovation Voucher initiative aims to build linkage between Ireland's public knowledge providers and small businesses, and vouchers of €5 000 are available to companies to explore business opportunities, or problems, with a registered knowledge provider. SMEs can have a maximum of three vouchers (and if so, one voucher must be a so called fifty fifty co-funded Fast Track voucher).[60]

IDA Ireland provides different funding support. Besides funding, the organisation has several direct support mechanisms, including employment and training grants. In addition, IDA Ireland works with companies to ensure they have the facilities, resources and supports in order to establish and expand their RDI operations. For example, IDA Ireland has a programme of grant aid for RDI projects. This includes a 25% R&D tax credit designed to encourage companies to undertake new or additional RDI activity (carried out in Ireland). Over the years, IDA Ireland has attracted billions of euro in foreign direct investment from companies in hi-tech sectors as ICT and pharmaceuticals.

Already mentioned above is Science Foundation Ireland. It funds oriented basic and applied research in the areas of science, technology, engineering and mathematics and provides grants for researchers in Ireland, and researchers who wish to relocate to Ireland. Funding is provided to academic researchers and research teams in the areas of biotechnology, ICT, and sustainable energy and energy efficient technologies. Except from the centres mentioned in section A.1.1., Science Foundation Ireland has several other programmes, as SFI Partnerships, that support to support research projects of scale between industry and academia, where Science Foundation Ireland matches the investment by industry.

The Irish R&D tax credit scheme was introduced by the Finance Act 2004 and enables a qualifying company or group of companies to claim a tax credit valued at 25% of their expenditure on qualifying R&D activities. Today, the R&D tax credit accounts for approximately 65% of direct government support of R&D in private firms. In the Action Plan for Jobs, the Irish government emphasises the right conditions for entrepreneurship to thrive include fiscal policy, with both tax rates and tax incentives supporting entrepreneurship and influencing investment decisions. Stated in the National Policy Statement on Entrepreneurship in Ireland, the effective tax rate, rather than the nominal rate, is regarded as one of the most important measures of the competitiveness of a country's tax system: *"Ireland's effective corporate tax rate has been a key attrac-*

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56 Forfás, Evaluation of Enterprise Supports for Research and Development and Innovation, 2013.

57 National Policy Statement on Entrepreneurship in Ireland 2014.

58 KPMG (2014). Innovation Monitor 2014/2015. Insights into Innovation & R&D in Ireland.

59 http://www.idaireland.com/business-in-ireland/activities/research-development-and-innovation.

60 https://www.enterprise-ireland.com/en/research-innovation/companies/collaborate-with-companies-research-institutes/innovation-voucher.shortcut.html .

61 National Policy Statement on Entrepreneurship in Ireland 2014. See also Department of Finance, Government of Ireland (2013). Review of Ireland's Research and Development (R&D) Tax Credit 2013.

Table 8. Selection of different support measures 2011-2016.

Name of support measure	Dates	Size m€ (and participating enterprises) 2013	Type of activities supported	Target beneficiaries
Enterprise Ireland High Potential Start-ups (HPSU)	Ongoing	21.7 (104)	Funding	Start-up venture involved in manufacturing or internationally traded services
Enterprise Ireland Competitive Start Fund	Ongoing	4.3 (60)	Funding	Start-up companies (focus on getting investor ready)
Enterprise Ireland Competitive Feasibility Fund	Ongoing	-	Feasibility funding	Business start-ups in various sectors and geographic regions
Enterprise Ireland New Frontiers Entrepreneur Development Programme	Ongoing	-	Funding	Innovative, early-stage start-ups
Enterprise Ireland Mentoring[61]	Ongoing	0.6 (513)	Advice, guidance and support	Start-ups (focus on developing their proposition)
Seed and Venture Capital Scheme	Ongoing (current period is 2013-2018)	55 (186)	Funding	Start-ups
Enterprise Ireland Commercialisation Fund for 3rd Level Researchers	Ongoing	15.7 (64)	Funding for the development of innovations at all stages of the commercial pipeline	Technology based start-up companies
Incubation Centres (26)[62]	Ongoing	2 (355)	Foster entrepreneurship and campus company activity by providing an essential transitional space between the research and business worlds	SMEs, start-ups included

tion for international investment and will continue to be in the future".[63]

On the other hand, OECD considers that support such as tax credit schemes *"not always are well suited to the needs of domestic and young firms"*. OECD also expresses that direct support is important to stimulate innovation, particularly for young innovative firms that lack up-front funds, and that *"a well-designed, competitive and transparent system of direct supports can complement existing tax incentives and can direct public funding to areas of high social and economic returns. It can also help address specific barriers in the Irish innovation system, eg lack of science-industry cooperation, which is particularly important to improve the performance of low-productivity firms"*.[64]

C.1.4 Key learning points

Obstacles are often gathered around the "everyday struggles" for SMEs and start-ups. In order to promote a robust ecosystem, the state should minimise (or fully remove) these obstacles. Below are some learning points:

- Different government policies act as growth accelerators when the government does it right. The *right funding*, particularly at the *right time*, can accelerate early-stage companies and turn them into gazelles. On the other hand, policies can also function as barriers.
- Governments often have a rather strong country specific focus in their ecosystem policies. However, differences between countries are common. If an early-stage

61 An evaluation from 2012 showed that start-ups with mentor support from Enterprise Ireland develop more quickly than start-ups without a mentor.

62 A review of the Incubator programme scheme is currently underway to evaluate the impact of the investment and to identify any unmet industry demands.

63 National Policy Statement on Entrepreneurship in Ireland 2014. See also Department of Finance, Government of Ireland (2013). Review of Ireland's Research and Development (R&D) Tax Credit 2013.

64 OECD (2015). Science, Technology and Industry Scoreboard 2015 – Innovation for Growth, OECD Publishing. See also https://www.oecd.org/policy-briefs/ireland-better-innovation-policies-for-better-lives.pdf.

company wants to expand and go global, there are potential issues for this reason. As stated in the report Entrepreneurial Ecosystems Around the Globe and Company Growth Dynamics, there are more similarities than differences in the issues facing companies, and these issues have an impact on the major growth accelerators as well as the major growth challenges for early-stage companies.[65] Consequently, horizon scanning and international benchmarking are two important futures in building a robust ecosystem. This is also stated in the National Policy Statement on Entrepreneurship in Ireland.

- As highlighted in several reports, large companies can play major roles for early-stage companies in their growth and development. Better access to both R&D, infrastructure (data, software, etc.) and knowledge (for example regarding intellectual property) are valuable for early-stage companies and SMEs. On the other hand, early-stage companies can play important roles as well. They can mentor, inform and even provide investment for other early-stagers.
- There is a need for information about different funding alternatives. In Ireland, the SME State Bodies Group will continue to raise awareness of the schemes by promoting the so called Supporting SMEs online tool. In addition, Enterprise Ireland and the Business Innovation Centres will continue to help clients to become investor ready and guide them in the fundraising process in order to enhance their access of securing funding.[66]

Last but not least, there is a need to review and evaluate previous and existing policy initiatives and instruments to ensure they meet their aims and consequently provide value for money. Moreover, there is no formal process of ex-ante evaluation undertaken.

C2 The Netherlands

C.2.1 Background and strategic vision

The Netherlands is one of the leading economies in the world and the country has strongly emphasised innovation and entrepreneurship. There are several top universities in the Netherlands (four in top 100 according to Shanghai list), and many among the top 200 in the world.[67] The university sector is today facing a more competitive financing situation rather than direct budgetary funding. The situation is similar to that of most universities in the developed countries. The Dutch government emphasises strongly the commercialisation of university research. As a consequence, the university sector has strong links with the industry, and the industry funding is relatively high in the country.[68]

The Dutch government aims at positioning the country among the top five in the world as far as competitiveness is concerned. By the year 2020, the country targets R&D spending of 2.5% of GDP. The country uses "traditional support mechanisms" in order to help indigenous companies. These policies are for example increasing the scope for financing (especially for innovative companies), supporting the collaboration of academia and industry, reducing regulatory burden of entrepreneurs, developing IT tools for entrepreneurs, and assisting in networking access. Interestingly enough, the government is taking online retailing (2015 Retail Agenda) and its consequences seriously.[69] Further discussion on government actions can be found at the following chapter.

The Netherland is considered by some as the start-up capital of Europe. The development started in 1990s with examples as Booking.com and TomTom.[70] According to OECD, Dutch start-ups are slow to grow fast due to a number of reasons. These reasons include, for example, red tape and access to finance.[71] However, according to the recent PwC Innovation survey, most of government actions towards supporting innovation goes to big and established companies, such as Shell and Philips.[72]

In addition, Dutch companies are not too keen to outsource their activities to low cost economies. The most important development issue regarding innovation was named as shortening the time from R&D to market. Nearly 20% of respondents stressed the importance of ecosystem development as process development (38%), strategy development (31%), funding development (28%), and developing suitable business models (27%) were regarded as more important development areas.

In the PwC Innovation survey, entrepreneurs stressed the importance of soft skills of the labour force. This is an interesting finding as usually technical skills, technology related skills as well as some specified skills are sought

65 Foster, G. et al. (2013). Entrepreneurial Ecosystems Around the Globe and Company Growth Dynamics. World Economic Forum.
66 National Policy Statement on Entrepreneurship in Ireland 2014.
67 https://www.innovationpolicyplatform.org/content/netherlands?country=7757
68 http://www.keepeek.com/Digital-Asset-Management/oecd/science-and-technology/oecd-reviews-of-innovation-policy-netherlands-2014_9789264213159-en#page20
69 https://www.government.nl/topics/enterprise-and-innovation/contents/the-government-supports-entrepreneurs
70 https://techcrunch.com/2015/07/05/the-netherlands-a-look-at-the-worlds-high-tech-startup-capital
71 http://www.keepeek.com/Digital-Asset-Management/oecd/science-and-technology/oecd-reviews-of-innovation-policy-netherlands-2014_9789264213159-en#page5
72 https://www.pwc.nl/en/assets/documents/pwc-innovation-survey.pdf

after. Companies stressed the importance of "connecting the dots" of their future employees. Multi-disciplinarity was also strongly emphasised. However, the Dutch government stresses heavily on stimulating technical skills.

Open innovation ideology and further collaboration with external companies and organisations are said to be the key to future innovation. This includes taking customers involved in the innovation process more actively.[73]

C.2.2 Historic trends in the ecosystem creation

The Netherland's government supports companies (that are regarded as innovative) that develop innovative products through tax benefits, innovation credit and grants. There are also a number of EU grant schemes for innovation. Netherlands Enterprise Agency is the key player in selecting and supporting innovative companies.[74] There are big multinationals in the country, such as Phillips in the ICT sector.

There is an old tradition of university-industry collaboration in the country. External evaluators, such as OECD and PwC are suggesting some changes in the government policies. These include, for example, supporting more SMEs rather than established multinational companies, making policy measures less bureaucratic, and make the regulation framework easier for SMEs.[75]

As stated above, the government supports innovative enterprises in a number of ways. Many of the schemes can be found in most developed countries in similar ways.[76]

- **Increasing scope for finance.** The government has various financial schemes for entrepreneurs wanting to expand their businesses quickly, and innovative entrepreneurs.
- **Promoting cooperation between researchers and the private sector.** The government is working with the private sector and knowledge institutions to improve public-private partnership, thus supporting Triple Helix ideology.
- **Reducing the regulatory burden on entrepreneurs.** The government is taking steps to reduce the regulatory burden on entrepreneurs. These include granting permits more quickly – or even automatically – and making greater use of digital technology.
- **Developing IT tools for entrepreneurs.** Providing government services online reduces the regulatory burden on entrepreneurs. IT also offers unlimited scope for new products or for making business processes more efficient.
- **Helping entrepreneurs access networks.** Good networks help businesses grow. The government is using the following tools to help entrepreneurs build solid networks:
  - Trade missions abroad. By conducting trade missions abroad, the Netherlands can access new foreign markets. The focus here is on emerging markets like Brazil and India.
  - Enterprise forum. This is the government's one-stop shop for entrepreneurs, where they can access services from a range of agencies, including the Chamber of Commerce (KvK), the Tax and Customs Administration, the Road Transport Agency (RDW) and Statistics Netherlands (CBS).

Some of the policies presented have been criticised by both OECD as well as entrepreneurs. Entrepreneurs feel that the financial support is more targeted to large organisations rather than SMEs. Additionally, and also stated above, entrepreneurs feel that the red tape is preventing them from taking advantage of these schemes.[77]

In 2011, the government decided to concentrate its support efforts to nine top sectors, which have been growing and developing the best in the past. These nine sectors are:

- Horticulture and propagation materials
- Agri-food
- Water
- Life sciences and health
- Chemicals
- High tech
- Energy
- Logistics
- Creative industries.

The selected nine sectors cover most of the Dutch industries. They are large company dominated sectors, which have a long tradition in the country. The Netherlands has been a global player in the field of trade, transport, and logistics for a long time. Interestingly enough, ICT is not on the list but is included in many of the selected sectors and under the umbrella of high tech.[78]

In OECD's Innovation policy evaluation regarding the Netherlands, there is strong support for the Dutch activities of selecting top sectors for further development. At the same time, OECD stressed the importance of including SMEs into these support activities in a better way.[79]

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73 https://www.pwc.nl/en/assets/documents/pwc-innovation-survey.pdf

74 See http://english.rvo.nl

75 https://www.pwc.nl/en/assets/documents/pwc-innovation-survey.pdf

76 https://www.government.nl/topics/enterprise-and-innovation/contents/the-government-supports-entrepreneurs

77 https://www.pwc.nl/en/assets/documents/pwc-innovation-survey.pdf

78 https://www.government.nl/topics/enterprise-and-innovation/contents/encouraging-innovation

79 http://www.keepeek.com/Digital-Asset-Management/oecd/science-and-technology/oecd-reviews-of-innovation-policy-netherlands-2014_9789264213159-en#page5

The government, the private sector, universities and research centres are working together in the Top Sector Alliance for Knowledge and Innovation (TKI) to make top sectors even stronger. The alliance looks for ways to get innovative products or services onto the market. The government is encouraging innovation in top sectors in the following ways:

- National Icons Competition
- Innovation Expo
- 'Volg Innovatie'
- National Science Agenda
- Innovation Attaché Network
- Smart Industry
- Innovative Future Fund
- A single tax credit scheme for research and development (R&D).[80]

This means that government support is mostly targeted to companies among these nine sectors. This decision is somewhat contradictory to ecosystem development approach.

C.2.3 Selected policy support instruments

Some support measures are worth mentioning.

- **National Icons Competition** takes place every second year when the government selects several projects or products as winners. These projects and products show how Dutch innovations are among the world's best. The winning entries all address major social issues.
- **Innovation Expo** is an event held every second year, which aims at accelerating innovation. The Innovation Expo in spring 2016 will highlight the Netherlands' EU Presidency. The Innovation Expo is also an innovation network comprising 3 000 representatives from the private sector, public bodies and knowledge institutions. They work together on innovations and technological breakthroughs.[81]
- **'Volg Innovatie' database** is managed by the Netherlands Enterprise Agency and provides information on the money the Ministry of Economic Affairs spends on various projects.
- **National Science Agenda** of the Ministry of Economic Affairs identifies focus themes for scientific research in the years ahead. It asks questions like: What areas hold promise for the Dutch science sector? How can science help find solutions to social issues? How can science create economic opportunities for innovation?
- **Innovation Attaché Network** covers Dutch embassies and consulates. The attaches assist Dutch companies doing business abroad. For instance, by introducing them to potential partners, like research institutions or other companies.
- **Smart Industry** initiative aims to strengthen Dutch industries by promoting the use of cutting-edge IT and technology, like 3D printing, nanotechnology and robots.
- **Innovative Future Fund** through which the government is making additional money available for innovative SMEs and vital research for the future. From 2018 the fund will make €5m available annually. Its initial capital will be €200m. This money is included in the Ministry of Economic Affairs' 2016 budget.
- **A single tax credit scheme for research and development (R&D):** In 2016, the two main tax arrangements for commercial research and development will be combined. The RDA and WBSO research and development tax credits will be brought together in one scheme that will offset R&D tax credits against salaries tax. The government hopes this will make the scheme more effective and simplify the application procedure for businesses. The budget for this scheme will be increased by €100m in 2016 and by €115m in 2017. This money is included in the Ministry of Economic Affairs' 2016 budget.

According to EU the key development in the R&D policies and systems in the Netherlands were the following:

- In 2015, the Ministry of Economic affairs set up an Additional Action plan SME funding to supplement a 2014 action plan, which was part of the new growth agenda. The plan includes various actions aimed at extending existing measures like the recently established Netherlands Investment Institute and the Future Funds (continuation of the SME Innovation Funds). The total package of interventions has the potential of creating €2.5b of extra funding. In order to help firms find the most appropriate type of financial support, contact points were streamlined into one single "Enterprise Point" and a National Funding Guide was released.
- From September 2015, the basic grant system for students was replaced by an extended loan system. This change occurs as part of broader reforms of the educational system, which also includes performance contracts between universities and the ministry of ECS.
- In November 2015, the new National Research Agenda was presented, following up on the Science Vision 2025 of November 2014. In this agenda a knowledge coalition of universities, research institutes and governmental organisations consolidated a list of research questions that fit with the scientific strengths, societal challenges and economic opportunities in the Netherlands. This list of questions is supposed to be a basis for strategic allocation of public resources for research.[82]

[80] https://www.government.nl/topics/enterprise-and-innovation/contents/encouraging-innovation

[81] For further information, see http://www.innovatie-estafette.nl/About-us

[82] https://rio.jrc.ec.europa.eu/en/library/rio-country-report-netherlands-2015

C2.4 Key learning points

The Dutch government has targeted to develop the economy in such a way that the Dutch economy will become one of the top five economies in the world by 2020. In order to achieve the goal, the Dutch government is increasing its R&D investments, thus believing that innovation is the key for future success of the nation.

The Netherlands' government is active in supporting innovative companies. It has analysed potential developments and selected nine targeted sectors for policy support. Selection was based on the economic history and future aspirations in the selected sectors. This selective policy has gained support from the OECD. At the same time, active start-up scene as well as established SMEs feel that they are being left out in most of the innovation initiatives. It must be said that these nine selected sectors cover most of the business sectors. They are overlapping, too.

The Dutch start-up scene started early (in the 1990s). There have been a number of success stories among the start-ups. However, most of the start-ups are not growing. This might reflect a global phenomenon where more and more of specialised jobs are being outsourced. Companies are more willing to buy services from other companies rather than employing more people. This started among construction and shipbuilding sector in 1980s and has spread to other industries. If the trend continues it has an important effect on ecosystem development agendas and open innovation approach usage. Triple Helix approach becomes more important. Consequently, sectorial support policies may not be the answer for future.

C.3 Sweden

C.3.1 Background and strategic vision

Sweden's economy has grown faster than the economy of several other OECD countries after the financial crisis in 2008. Over time, the country has advanced in the ranking for **innovation-driven economies**. In order to ensure Sweden's position as a leader regarding research and innovation, the Swedish government's Research and Innovation Bill 2013-2016 introduced a selective and quality-based funding approach with a significantly **increased government budget for R&D**. Since, the Swedish government has been investing considerable resources in R&D in relation to the size of its economy. Sweden has one of the highest rates of R&D investment globally and at present, it counts for almost 4% of the country's' GDP on R&D. In 2009, Swedish investments in R&D comprised about SEK 112b, 3.6% of GDP (in 2005, R&D amounted to SEK 104b).[83] **A larger share of the R&D is performed in the industry.** In 2005, approximately 74% of R&D activity was carried out by companies. In 2009, industrial investments amounted to SEK 77b, accounting for almost 70% of all R&D. Companies mostly finance their own R&D, while R&D at universities are mainly funded from public funding bodies.[84]

Today, Swedish **companies are among the most innovative and export-oriented in the world**, and the country ranks among the top economies in global innovation indexes. According to the Bloomberg Innovation Index, Sweden is on the top ten list over the world's most innovative countries. In addition, it has more scientific publications and patents per capita than most OECD countries. However, Swedish patents are mainly owned by few (five to ten) R&D intensive large companies. In the European Innovation Scoreboard 2016, Sweden ranks as number one.[85]

In Sweden, **entrepreneurial activity has increased during the last decade**. The share of the Swedish population involved in entrepreneurial activity has increased from approximately 4% in 2004 to about 7% in 2014. Consequently, Sweden has improved its position in the Global Entrepreneurship Monitor ranking since the 2000s. Moreover, the scientific quality of research carried out in Sweden is high, especially in life sciences (biomedicine and clinical medicine).[86]

Collaboration between companies and higher education institutions has been a key area for the Swedish government for several years. In addition, the Swedish government has **invested in infrastructure to support various thematic areas**, for example life science research, both in academia and industry, and in research carried out in collaboration between private and public organisations. As stated in the *National Innovation Strategy*, one goal is to continue to develop incentives and structures for collaboration between universities and the surrounding society, including long term collaboration with a view to develop knowledge and solutions to address societal challenges as well as key enabling technologies with wide applications in many areas of society.

In Sweden, research institutes are often organised in order to facilitate cooperation between industries, sectors and different thematic fields. They have extensive collabo-

83 Prop. 2012/13:30. *Forskning och innovation.* A new Research and Innovation Bill will be presented in autumn 2016.

84 Data from Vinnova.

85 http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

86 OECD (2014), "Sweden", in OECD Science, Technology and Industry Outlook 2014, OECD Publishing. International Bank for Reconstruction and Development/World Bank (2015). *Sweden's Business Climate. A Microeconomic Assessment.* See also Ministry of Enterprise and Innovation (2012). *Den nationella innovationsstrategin.*

rations with both national and foreign universities, as well as international research organisations and companies (both SMEs and large companies). Also stated in the latest innovation strategy, one goal is to further develop the role of research institutes in providing facilities for test and demonstration of new solutions, including collaboration with users, and enhance collaboration of research institutes with universities, industry and the public sector on national and regional levels.[87]

Several Swedish universities and university colleges have so called innovation offices. An innovation office is a unit in the university administration that supports the utilisation of R&D. The office provides, for example, information, guidance and advice in issues relating to utilisation of R&D, innovation, entrepreneurship and business collaboration. In addition, the office often supports cooperation between researchers and companies (strategic alliances, projects, etc.). Sweden is, together with Italy and Poland, the three EU member countries where researchers at the universities (or university colleges) own the rights to any intellectual property resulting from their research. The rule is general, and thus does not apply specifically to researchers.[88]

The Swedish Research Council finances long-term plans for an effective research infrastructure that provides a positive climate for research. In this context, **several national research centres** have been established. Sweden has also many state-of-the-art research centres, such as The Chemical Biology Consortium Sweden. Since the 1980s, the Swedish government has been focusing on science-based entrepreneurship and in this light, the first science parks were created. However, since the early 2000s, Swedish policies emphasis on incubators (and later also accelerators) instead. Currently, Sweden has 43 incubators and over 33 science parks, several focusing on ICT and life sciences.

Industrial research institutes are not a part of the higher education institutions sector. Instead, they are classified as so called knowledge intensive firms. They are organised under one umbrella organisation, RISE Research Institutes of Sweden, a publicly owned company. RISE consists of four corporate groups with a total of 16 research and technology organisations (and their subsidiaries), as well as **test beds and demonstrator facilities** such as Swedish ICT. A test bed aims at giving innovators the opportunity to test and develop their innovation or product in a real life setting. The largest sponsor of test beds in Sweden is Vinnova. For example, the agency granted a total of SEK 40m to 16 test beds within the healthcare sector between 2012-2013.

In addition, Vinnova has founded a programme called VINN Excellence Center. The programme aims at strengthening the **link between academic research groups and industrial R&D** in the long term in order to create new knowledge and new technologies. The centres are not focused on R&D in specific thematic areas. The creation of so called competence centres has a long tradition in Sweden. In the early 1990s, former NUTEK started Competence Research Centres. Under the period 1995-2005, the Swedish government, universities and the industry invested approximately SEK 4.9b in 30 centres at eight universities.

Venture capital investments in Swedish companies reached SEK 2.6b in 2014. The corresponding figure for 2013 was SEK 2b. The increase came mostly from private funds (total investments increased by 57%). On the other hand, the public funds decreased their investments by approximately 16%. In 2010, there were 51 different Swedish private funds investing in Swedish companies. The corresponding figure for 2014 was 20. Divided into development phases, the annual venture capital investments show a shift towards investments in the later stages. This shift has occurred at the expense of investments in companies in the early-stages, which has decreased in recent years. While venture capital investment as a share of GDP in Sweden is at the OECD middle range, there are still gaps in the supply of early-stage venture capital· Seed-stage capital is still limited in Sweden. In this context, several reports highlight the need for more initiatives that ensure access to capital from venture capital, as well as public funding programmes.[89]

There are a number of **business angel networks** in Sweden. In addition to the official business angel networks, some of the business angels invest their own private equity in different early-stage companies. The share of business angel investment declined between 2011 and 2012. However, it appears to have increased in 2013 and 2014. Several business angels act in specific thematic areas, such as tech and life sciences.[90]

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87 The Swedish Ministry of Enterprise (2012). The Swedish Innovation Strategy. N2012.33.

88 See Ownership of research results – the Swedish Research Council, http://www.codex.vr.se/en/agande1.shtml

89 For example Braunerhjelm, P. (2012). *Ett ramverk för innovationspolitiken - Hur göra Sverige mer entreprenöriellt?* Stockholm: Samhällsförlaget. Adenfelt M. et al. (2015). *LEVEL UP Internationaliseringsfrämjande av företag med hög tillväxtpotential - en kartläggning av initiativ och program i Norden.* Entreprenörskapsforum. Laufer M., et al. (2014). *Affärsängelnätverk och investeringar. Svenska tillväxtföretag kan andas ut – affärsänglar har kapitalet.* Ratio and Connect Sverige. Braunerhjelm P., et al. (2012). *2012 Entreprenörskap i Sverige – Nationell rapport Entreprenörskapsforum and GEM.*

90 Laufer M., et al. (2014). *Affärsängelnätverk och investeringar. Svenska tillväxtföretag kan andas ut – affärsänglar har kapitalet.* Ratio and Connect Sverige. Braunerhjelm P., et al. (2012). *2012 Entreprenörskap i Sverige – Nationell rapport Entreprenörskapsforum and GEM.*

C.3.2 Historic trends in the ecosystem creation

Between 2002 and 2004, only a smaller percentage of small companies were involved in innovation activities; 44% in comparison with 64% for medium-sized companies and 77% for large companies.[91]

Main policy changes in the last five years (from 2011 until today) include, for example:

- A pilot project on support for the development of science parks
- The decision to initiate a programme for innovation in the construction industry
- The publication of the 2013-2016 Research and Innovation Bill[92] and the National Innovation Strategy in 2012
- The introduction of call for identification of strategic innovation areas
- The decision to increase the share of performance based institutional funding
- The finalisation of funding for, for example, European Spallation Source (ESS)
- The proposed models for research funding and impact
- The initiation of preparation of a new national energy bill as well as research bills (will be published in late 2016)
- The evaluation of the strategic research initiative.[93]

Stated in the latest innovation strategy, the Swedish government intends to continue to develop good conditions, incentives and framework conditions, promote positive attitudes to entrepreneurship and innovation in society, by, for example, highlighting good examples and role models and developing forms of mentoring.

Introduced in 2014, the aim of the recent Swedish enterprise and industrial policy is to **strengthen the competitiveness and create good conditions for more jobs in growing companies**. This area includes improved conditions for entrepreneurship and enterprises, such as issues concerning regulatory simplification and supplementary funding, and developing and strengthening the innovative capacity of Swedish companies.

The Swedish government argues that a well-functioning policy framework for capital supply is an important factor for creating new firms and making them expand. The state funding is complementary to the market in areas where the private market is limited.[94] Today, the Swedish government focuses on horizontal actions stimulating entrepreneurship. Examples of priority areas are increased focus on young entrepreneurs and internationalisation. In comparison with other OECD countries, Sweden has few initiatives targeted at growth companies, companies with high growth potential and young innovative companies that promote internationalisation.

In the latest research and innovation bill, life sciences was one thematic area that was highlighted. In this light, the bill includes a number of investments in the life science industry. Examples of investments resulting from the latest research bill are European Spallation Source (ESS) in Lund, MaxIV in Lund, a new centre for clinical trials in Gothenburg, and the SciLifeLab in the Stockholm-Uppsala region. Per capita spending on life science research is the highest in Europe.[95]

In 2015, the Swedish government published the proposition for a reform of the venture capital sector. The proposition was presented by the government to the parliament in spring 2016.[96]

As stated above, the strategic research areas were evaluated by an international expert panel in 2015. The expert panel was mainly positive. For example, one identified strength was the long-term focus of the investment. According to the expert panel, this focus enabled research groups to engage in a higher degree of risk taking than that associated with project funding.

C.3.3 Selected policy support instruments

Several reports state that innovation and entrepreneurship will be of importance for future growth in Sweden. A fruitful innovation and business policy must build mechanisms to transform knowledge into benefits which requires initiatives that promote both innovation as well as entrepreneurship.

Since the early 1980s, Sweden has been one of the leading countries of the world in terms of government investment in R&D in proportion to GDP. Between 1993 and 1999, Sweden invested the most resources in R&D in the world in relation to GNP. The investments in R&D investments increased in the 1990s, but after 2001 the investments in relation to GNP declined, and in 2005, it was approximately 3.9% of GNP (as stated in A.1.1., approximately SEK 104b).[97]

Today, the Swedish government has an important role in funding. Data from the Enterprise Surveys (published by

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91 The Royal Swedish Academy of Engineering Sciences (IVA) (2008). Research and innovation in Sweden - an international comparison.

92 Although data are not available for 2015 yet, the goals have been met.

93 Jacob, M. et al. (2016). RIO Country Report 2015: Sweden.

94 Prop. 2009/10:148. Företagsutveckling – statliga insatser för finansiering och rådgivning. The Ministry of Enterprise, Energy and Communications (2007). A national strategy for regional competitiveness, entrepreneurship and employment 2007-2013.

95 The life science sector has been prioritised since 2012as a result of Astra Zeneca's decision to reduce the size of the company's R&D investment portfolio in Sweden.

96 See Prop. 2015/16:110

97 The Royal Swedish Academy of Engineering Sciences (IVA) (2008). Research and innovation in Sweden - an international comparison.

the World Bank) show that Swedish authorities have been successful in creating an environment conducive to private companies' getting access to credit.[98]

The Swedish approach to RDI governance is decentralised and the RDI ecosystem in Sweden has several different support and funding arrangements. In addition, the ecosystem has low diversity in terms of categories of research performing organisations.

Direct government funding and R&D funding from the Swedish Research Council, Vinnova, the Swedish Energy Agency, FAS, Formas, and the Swedish National Space Board was approximately 80% of all government R&D funding in 2009.[99] Between 1993-2012, direct government funding and funding from the Swedish Research Council are the two sources which have grown the most. When comparing with other countries, research at Swedish universities and university colleges receive a relatively large part of the government R&D funds. Over time, the share has increased. On the other hand, the share going to the industry has decreased.

There have been several measures focused on an incremental industrial restructuring to reduce economic dependence on a few larger companies by improving framework conditions for SMEs (start-ups and entrepreneurs included) in Sweden during the last two decades. Yet, direct government R&D funding to SMEs is small compared to several other countries.[100]

Vinnova is the central coordinating actor for innovation and the agency has a special programme for innovation-driven growth in SMEs, see Table 9.

Tax legislation in Sweden is designed to support the purpose of the Swedish economic policy and provide good conditions for business and investments. On the other hand, Sweden has the second highest personal income tax rates in the world (28%) and a corporate tax rate of 25%. For small companies, there are special tax rules called the 3:12 rules. The rules apply to active owners in corporations where four or less owners control at least 50% of the shares. Only dividends within the dividend allowance are taxed as dividend income. Dividends exceeding the dividend allowance are taxed as labour income. The 2006 reform of the 3:12 rules was intended to stimulate entrepreneurship and employment in family owned businesses; the tax rate on dividends within the dividend allowance was reduced and the dividend allowance was increased.[101]

As stated above, Sweden scores high regarding direct government support to R&D. Until recently, Sweden's ecosystem did not include any form of tax credits. In January 2014, the Swedish government introduced a scheme for reduction of social security contributions for commercial R&D activity.[102]

Table 9. Selection of different support measures.

Name of support measure	Dates	Size (m€)	Type of activities supported	Target beneficiaries
Vinnova Innovation vouchers	Ongoing	Approx. €3.2m per year	Smaller amounts (€11,000) to invest in an idea. Support is passed through Almi, IUC and Companion Cooperative Development	SMEs, start-ups included
Vinnova Verification support in early stages	Ongoing	€6.4m (€3.2m allocated by a Vinnova grant, the remaining is allocated by the agency through innovation offices	Support grant (up to €0.2m per grant)	Early-stage companies
Vinnova Innovation projects in enterprises	Ongoing	Approx. € 19.2m per year	Support for innovative development projects	Mostly SMEs
EUREKA/Eurostars	Ongoing	Approx. €11m	Support for small and innovative companies to participate in EU programmes for innovation and development	SMEs, start-ups included

98 OECD (2014), "Sweden", in OECD Science, Technology and Industry Outlook 2014, OECD Publishing. International Bank for Reconstruction and Development/The World Bank (2015). *Sweden's Business Climate. A Microeconomic Assessment.*

99 In 2014, the Swedish government added another actor in the ecosystem - the Innovation Council.

100 Data from Vinnova. See also Jacob, M. et al. (2016). RIO Country Report 2015: Sweden.

101 SOU 2015:64 En fondstruktur för innovation och tillväxt. See also Alstadsæter A et al. (2012*). Income Shifting in Sweden. An empirical evaluation of the 3:12 rules.* 2012:4 ESO-report.

102 https://www.skatteverket.se/foretagorganisationer/arbetsgivare/socialavgifter/forskningsavdrag.4.8dcbbe4142d38302d7cb4.html

C.3.4 Key learning points

In an international comparison, the Swedish government invests a relatively large amount of public resources in R&D. However, the Swedish innovation system is rather fragmented, and consequently rather ineffective in some areas. A fragmented system can result in, for example, excessive administrative costs. Another problem due to a fragmented system is that innovators and entrepreneurs do not know where to find the *right* funding.

A number of financial constraints are identified as barriers for the development of early-stage companies. According to a recent study by The Swedish Federation of Business Owners, the access to finance is overall not seen as a big problem in Sweden. However, seed-stage capital is still rather limited in Sweden.

Despite various initiatives, the share of industry-funded research at Swedish universities and university colleges is rather small from an international perspective.[103] There is a need for more collaboration between public and private actors, especially for companies in the early stage.

Swedish companies pay 49.4% of commercial profit in taxes, a higher amount than EU28 and OECD high income countries. Statistics from several OECD countries indicate that lowering statutory corporate tax rates can result in large productivity gains by increasing the profitability. The tax rates have not prevented Swedes from starting new companies, resulting in well-known gazelles and unicorn. However, data shows that Swedish companies relocate when they have moved away from the initial start-up phase.

C4 Switzerland

C.4.1 Background and strategic vision

Switzerland is one of the leading countries in the world as far as GDP per capita, infrastructure or living standards are concerned. In the field of innovation, Switzerland scores high due to the high ranking of its universities and research facilities (such as CERN), academic publications per capita or the number of applied patents[104] as well as due to large R&D spending of the Swiss companies (see Table 10). Switzerland uses around 3% of its GDP (or CHF 16b) to fund R&D activities of which two third are generated by private sector and one third by the public sector.[105]

Swiss governance is based on bottom-up processes and federalism, with the Confederation and cantons sharing responsibility for research and higher education policy. Since 1 January 2013, the Federal Department of Economic Affairs (FDEA) has become the Federal Department of Economic Affairs, Education and Research (EAER), reflecting the integration of training, research and innovation as an economic policy issue. The State Secretariat for Education, Research and Innovation (SERI) at the EAER serves as the federal government's specialised agency for national and international matters concerning education, research and innovation policy.

The federal government's strategy document, Promotion of Education, Research and Innovation (ERI Dispatch) 2013-2016, aimed to reinforce the high level of competition based public R&D investment, to increase the provision of well-qualified human resources and to ensure framework

Table 10. R&D in Switzerland. Source: Federal Statistical Office, 2012

	R&D financed by (CHF millions)	%	R&D performed by (CHF millions)	%
Government	4,705	25.4%	140	0.8%
Confederations	*2,835*	*15.3%*	--	
Cantons	*1,870*	*10.1%*	--	
Industry	11,250	60.8%	12,820	69.3%
Other national sources	320	1.7%	--	
Abroad	2,235	12.1%	--	
Higher education	--	--	5,210	28.1%
Private non-profit sector	--	--	340	1.8%
Total	**18,510**	**100%**	**18,510**	**100%**

[103] http://www.vinnova.se/en/About-Vinnova/Vinnova-and-the-outside-world/Swedens-innovation-system/Cooperation-between-universities-and-industry/

[104] Higher Education and Research in Switzerland, State Secretariat for Education Research and Innovation, SERI 2015

[105] http://www.sbfi.admin.ch/themen/01367/index.html?lang=en

conditions that are helpful to innovation and help maintain Switzerland's position in international competition.

The ERI Dispatch gives priority to strengthening Switzerland's international reputation as a competitive location for research and economic activities by increasing the amount of grant funding awarded on a competitive basis for research and innovation. The Swiss National Science Foundation (SNSF)'s Council initiated an evaluation of SNSF with a view to assessing and improving the SNSF's evaluation procedures in terms of their fairness and transparency and the extent to which they promote research excellence, increase the competitiveness of Swiss research and of researchers in Switzerland, and promote young researchers. The largely positive evaluation recommended a reform of the processes and procedures for external evaluations of funding applications, greater transparency through better documentation and information provision, and regular, systematic reviews and possible revisions of funding schemes.[106]

The ERI guidelines and targets for three areas (Education, Research and Innovation, and the Innovation system) 2013-2016 are:

Education

- Ensuring a wide range of diverse and permeable education and training programmes through balanced funding of general education and VET/PET pathways
- Ensuring the high quality and solid international reputation of the Swiss higher education sector, particularly by creating adequate professor-student ratios
- Consolidating the national and international position of VET/PET by giving equal value to general education and VET/PET pathways, as required by the Federal Constitution
- Improving the learning capabilities and employability of young people by ensuring that at least 95% obtain upper-secondary level qualifications
- Ensuring that the education system is open to the rest of the world by encouraging the international mobility of VET learners, baccalaureate students, university students and teaching staff
- Maintaining the quality of baccalaureates by ensuring that baccalaureate holders have acquired the requisite academic skills
- Coordinating introduction of the new Federal Act on Funding and Coordination of the Higher Education Sector
- Creating the general conditions for continuing education and training (CET), among other things by improving the level of transparency and quality of CET courses

Research and Innovation

- Positioning Switzerland's international reputation as a competitive location for research and economic activities by increasing the amount of grant funding awarded on a competitive basis for research and innovation
- Ensuring that Switzerland holds a top position in promising fields through targeted measures to improve research, development and innovation capabilities, while leaving enough room for unconventional research approaches
- Investing in strategically important research infrastructures at the national and international levels
- Maintaining the strategic importance of international cooperation and networking with European and non-European countries
- Improving cooperation between research institutes and the private sector.

Targets for innovation system

- Strengthening social cohesion through the production, dissemination and use of knowledge
- Allocating greater funding to train the next generation of researchers and qualified workers
- Promoting equal opportunities by ensuring that education allows all individuals to achieve their full potential
- Fostering sustainable development by ensuring that the structures and content of the ERI system serve social, economic and environmental interests.[107]

In Switzerland, basic research mainly takes place at the federal institutes of technology and at universities. Applied research and development and the transfer of knowledge into marketable innovations, however, is primarily the domain of the private sector and universities of applied sciences.

The public sector finances research according to liberal principles. This means that funds are awarded on the basis of the researchers' individual initiative on a competitive basis, where the decisive factor is the quality of the proposals submitted. Promotion of international cooperation is another cornerstone of this policy. Switzerland participates also in EU Framework programmes while being a non-EU country.

Under the Research and Innovation Promotion Act (RIPA), the Confederation is responsible for providing grant funding for research and innovation through the Swiss National Science Foundation (SNSF) and the Commission for Technology and Innovation (CTI). It also provides the necessary funding for the Association of Swiss Academies and supports nearly 30 non-university research institutions. Fi-

106 https://www.innovationpolicyplatform.org/content/switzerland
107 http://www.sbfi.admin.ch/org/01645/index.html?lang=en

nally, the Confederation provides funding for teaching and research at institutions in the ETH domain. The cantons in turn are committed to promoting research in their role as funding bodies of the universities and universities of applied sciences.

The Swiss government promotes scientific research and innovation activities as follows:

- the Confederation supports independent basic research by financing the Swiss National Science Foundation to promote scientific research and the academies of science as institutions promoting science
- the Federal Council commissions the Swiss National Science Foundation to carry out programme research in areas where structural weaknesses in the scientific system call for a concentrated approach or where economic and social requirements demand specific scientific results: National Centres of Competence in Research NCCR and National Research Programmes NRP
- the Confederation grants funds to research institutions outside the university sphere
- the federal administration finances numerous research proposals in the framework of departmental research
- the Confederation supports international cooperation in research by the public and private sectors in Switzerland in international research programmes, international research organisations and bilateral programmes with priority countries
- the Confederation manages and finances the Commission for Technology and Innovation (CTI) as an agency for the promotion of applied research and development (R&D), the promotion of entrepreneurship and the development of start-up companies.[108]

C.4.2 Historic trends in the ecosystem creation

Switzerland has been investing heavily in education and research. Many Swiss universities rank among the top 100 best universities in the world according to various rankings (such as Shanghai, QS and Times). Especially, the basic research has gained a lot of attention and financial support. At the same time, Switzerland has been seen as investment heaven for safe and peaceful business environment and secure banking sector. This has led to many multinational companies to establish their headquarters in Switzerland. This is especially noticeable in the life sciences field, where large pharma companies have traditionally had close ties with universities and research organisations.

The start-up scene is evolving. It can be seen as a late-runner compared to many western nations due to the fact that sectors that have dominated in Switzerland (sectors linked with life sciences) are not linked with lean start-up approach. In life sciences you cannot always test your product or service as fast as in other sectors.[109]

Switzerland is investing heavily in research infrastructures in 2017-2020 (Roadmap for Research Infrastructures). It follows the tradition of supporting institutions as well as basic research. The results of this policy remain to be seen as the process is on-going. Another interesting initiative is National Initiative for Personalised Medicine, which is coordinated by two federal universities of technology (EHT in Zurich, EPF in Lausanne), and university research centres. At the first stage in the initiative, the focus is on universities and patient data in hospitals. Therefore, bioinformatics and biobanking are seen as key areas in order to develop personalised medicine. At a later stage the structured data will be used to more personalised medicine and treatment methods. Again, university (institution) involvement is evident. The Initiative for Personalised Medicine is very recent and indicates a slow start in Switzerland compared to many other developed countries where an emphasis on combining IT and life sciences research has been mainstream activities for years.

Innovation Park Initiative aims at securing Switzerland's position on the top of competitiveness game as well as improving the country's position as an attractive location for innovation (or investors). Swiss Innovation Park consists of five innovation parks (plus their networks) around the country in various cantons. The aim of the Swiss Innovation Park is to secure and develop private research and development investment in Switzerland. This represents a valuable addition to the established funding instruments in Switzerland. The new approach seeks to make Switzerland attractive to international research and development players by providing developed parcels of land and floor space with expansion potential in the vicinity of existing higher education institutions and businesses.[110]

The innovation ecosystem in Switzerland consists of strong university sector, large corporations and federal/regional financial instruments. There has been a movement from institutional support to more competitive project-based funding recently.

According to the Startup Monitor database 2015/2016, start-ups are distributed as follows: ICT (29.9%), Consulting & Services (12.3%), MedTech and Diagnostics (10.6%), Engineering (9.7%), Biotech and Pharma (8.4%), Consumer products (5.4%) and then various other industries with 5% or less.[111]

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[108] http://www.sbfi.admin.ch/themen/01367/01675/index.html?lang=en

[109] For further information, see http://www.startup.ch

[110] See https://www.switzerland-innovation.com for further information

[111] http://startupmonitor.ch/wp-content/uploads/reports/SSM_Report_2015-2016_Final.pdf

Aggregating the regions into four main areas, namely the Greater Zurich Area (GZA), the Greater Basel Area (GBA), the Greater Geneva Bern Area (GGBA) and the St. Gallen Bodensee Area (SBA), there are several patterns discernible with regards to the distribution of the most important sectors. In the GZA and GGBA there is a particularly strong basis of ICT bases companies (GZA: 33%, GGBA: 30%). This result is plausible, considering the fact that in these areas well-known companies from the IT sector have clustered within these regions. In these two areas, engineering companies are highly represented as well, which can be traced back to the fact that the two leading Swiss technical institutes ETH Zurich and EPFL are located in these areas. The greater Basel Area has strong prevalence of Biotech & Pharma (26%) and MedTech (14%) companies. This is due to the fact that Northwest Switzerland is home to a unique life sciences cluster. In this area Consulting and Services (24%) also makes up a solid basis. The St. Gallen Bodensee Area displays a strong prevalence of ICT, Consulting & Services, and Consumer Products.

C.4.3 Selected policy support instruments

As many of the building blocks of ecosystem development have been introduced quite recently there are no policy support instruments to evaluate in the case of Switzerland. For the future, The Roadmap for Research Infrastructure, National Initiative for Personalised Medicine, and Innovation Park Initiative are ones to follow.

One of the key reasons for the difficulty of evaluating policy support instruments in Switzerland is the fact that Federal Government has decided not to favour certain industries or sectors (cluster policy). Cantons are different. The Federal Government trusts Cantons to take care of the regional development. As a consequence the Federal Government has invested in infrastructure and basic research.

C.4.4 Key learning points

Switzerland is a neutral country with a long tradition of having a banking sector. Thus, the stable political and economic environment and infrastructure can attract foreign investments to a country. Legal environment is supportive for promoting business investments in innovation and R&D. IP protection, favourable taxation, and highly developed financial system attracts foreign investments in the R&D sector. Pharmaceutical companies need such a stable environment for investments in R&D are massive and the process from discovery to medical drug is a long one (10 years a minimum).

Nowadays, the Swiss system of promoting innovation is based to a large extent on competitive projects. This is a fairly recent phenomenon. Previously, Switzerland used to finance institutions and especially basic research and infrastructure. There is a need for entrepreneurship education in universities and other educational institutions in order to develop Swiss start-up scene.[112]

There is more or less centralised system in place to coordinate R&D&T activities in the country. Universities work closely with industry. As the Federal Government has invested heavily on research infrastructures and universities companies have become interested in joining forces with research facilities especially in sectors in which you need massive investments to carry out research (for example life science). Swiss R&D system is evaluated to be open due to the wide usage of Triple Helix.

Swiss start-up scene is evolving. This is a result of a combination of things. Switzerland has emphasised university and research development more heavily than entrepreneurship education. Many important sectors in Switzerland are large company dominated. Educated workforce has had job opportunities in these global companies. As the education system is selective and small it cannot produce enough skilled workforce for high tech companies. Therefore, there are a lot of foreign employees in companies making the Swiss system one of the more open R&D systems globally. The Federal Government is just recently starting to put more efforts on developing the start-up scene.

The participation of private sector in R&D activity is notable. The reason for this is the fact that there are many multinational corporations in Switzerland especially in the life sciences sector. The Swiss companies have a tradition in collaborating with top universities. This is due to the fact that openness has been supported by the federal government.

[112] See Marxt & Brunner (2013). Analyzing and improving the national innovation system of highly developed countries – The case of Switzerland. Technological Forecasting and Social Change, 80:6, 1035-1049, and http://www.startupmonitor.ch

Appendix D. Survey questionnaires

Evaluation of Tekes' **Combio** programme

Introduction

This questionnaire is part of an independent study of the Combio (2003-2007) programme, commissioned by the Finnish Funding Agency for Technology and Innovation, Tekes. The evaluation assesses the results, impacts and efficiency achieved under the programme. In addition, the study will also benchmark international best practices for experimental R&D and innovation policies so that valuable input can be provided to the design of future Finnish R&D and innovation programmes. The evaluation is carried out by Technopolis Group, an independent policy research and consulting organisation.

You have received this invitation to complete the questionnaire because you have received funding through the Combio (2003-2007) programme. Your input in the evaluation will be very valuable. We would therefore be grateful if you could complete this questionnaire. The information you provide will be treated confidentially and will be presented to Tekes at an aggregate level only. Your individual information will not be shared outside the independent evaluation team, and will not be used for any other purposes. The final evaluation report will be made available by Tekes.

We anticipate the questionnaire will take no more than 20 minutes to complete. Your answers will be saved as you proceed through the questionnaire.

Tekes and the evaluation team would like to thank you for your cooperation in supporting this important work. For any question about the evaluation or the survey, please contact Dr Jelena Angelis by emailing at jelena.angelis@technopolis-group.com or Pekka Pesonen at pekka.pesonen@tekes.fi

Thank you for your contribution!

Evaluation of Tekes' **Combio** programme

About you

First, we would like to learn about your organisation and your involvement with the programme so that we understand better the responses in the following sections

1. What type of organisation did you represent during the Combio programme?

- ○ a. SME
- ○ b. Large enterprise
- ○ c. University
- ○ d. Research organisation
- ○ e. Other (please specify)

2. What project funded under the Combio programme were you involved in?

3. What was the role of your organisation during the project?

- ○ Project leader
- ○ Project participant

Evaluation of Tekes' **Combio** programme

Project partners

In this section, we would like to learn about your partner organisations during the project

4. How many project partners (national and international) were involved in your Combio-funded project? Please, specify which of them were new to you when the programme started.

	National	...of them new	International	...of them new
a. SMEs				
b. Large enterprise				
c. University/research institute				
d. Other (please specify)				

Please specify the 'other' category

5. With how many of these national/international project partners did you continue to work with 1-5 years after the project?

	National	International
a. SMEs		
b. Large enterprise		
c. University/research institute		
d. Other (please specify)		

Please specify the 'other' category

6. Are you still working with some of your project partners today?

- a. Yes, our partnership is related to the *same activities* as during the project.
- b. Yes, our partnership is related to *other activities.*
- c. No, even though our organisations still work in the same sector, we don't work together anymore.
- d. No, neither my partners nor I work in the biomaterial sector anymore.

Please explain your answer

Evaluation of Tekes' **Combio** programme

Project's outcomes and impacts on your organisation

In this section, we would like to learn about the long term effects the project had on your organisation's activities and success.

7. What were the effects of your Combio-funded project on your organisation's activities?

	No	No, although these were planned/expected in the project	Yes, but not because of Combio programme	Yes, Combio support here was instrumental	Not relevant
a. We increased our know-how as a *result of the business education* activities	○	○	○	○	○
b. We increased our know-how as a *result of other activities* (not only education)	○	○	○	○	○
c. We produced new peer-reviewed publication(s) and/or academic dissertations	○	○	○	○	○
d. We created new patent(s)	○	○	○	○	○
e. We developed new prototype(s)	○	○	○	○	○
f. We launched a commercial product or service to the market	○	○	○	○	○
g. We launched a new start-up and/or spin-off company	○	○	○	○	○
h. Our revenue grew	○	○	○	○	○
i. New talented people got employed	○	○	○	○	○
j. We got researchers/students who moved from our research partner(s) to the company	○	○	○	○	○
k. We established a new national network	○	○	○	○	○
l. We became part of a new (to us) national network	○	○	○	○	○

	No	No, although these were planned/expected in the project	Yes, but not because of Combio programme	Yes, Combio support here was instrumental	Not relevant
m. We established of a new international network	○	○	○	○	○
n. We became part of a new (to us) international network	○	○	○	○	○
o. Combio helped us to get funding from other sources	○	○	○	○	○

Other (please specify)

8. Did any other national or international cooperation opportunities or business opportunities arise for your organisation following your participation in the Combio-funded project? Please explain and provide some examples

9. Can you think of any unplanned or unexpected results of the project (e.g. impact on new policy, standards or regulation)?

○ Yes

○ No

Please bring examples

10. Did your participation in Combio programme change the operating practices of your organisation *after the project*? Please provide examples

○ Yes

○ No

Other (please specify)

11. If the company you worked for during the Combio programme was subsequently sold/merged with a foreign company, does it still continue activities in Finland?

- ◯ Yes
- ◯ No
- ◯ Not relevant (e.g. our organisations isn't a company)

Please explain your answer:

12. What efforts could Tekes have made during/after the programme to keep such companies in Finland?

During the programme:

After the programme:

Not relevant (e.g. our organisations isn't a company)

13. If your research team doesn't study biomaterials anymore, what were the reasons for you to change the research field? Please provide examples

14. What efforts could Tekes have made during/after the programme to keep your biomaterials research going?

During the programme:

After the programme:

Not relevant:

15. In case your project did not 'succeed' or continue after Combio, what were the main reasons for that? Tick ALL that apply.

- [ ] a. Technological difficulties
- [ ] b. Quality and/or regulatory restrictions
- [ ] c. Lack of business know-how
- [ ] d. Lack of further funding
- [ ] e. Lack of capable partners to bring the innovation to market
- [ ] f. International competition

Other (please specify)

Evaluation of Tekes' **Combio** programme

Project's impacts on the Finnish innovation ecosystem

In this section we would like to learn about the long-term effects and impacts of the Combio projects on Finnish innovation system that you find significant.

Finland has been aiming to transform itself from a resource-based economy into innovation ecosystem where the flow of technology and information among people, enterprises and institutions is key to an innovative process.

16. How would you rate the contribution of your project towards establishing this innovation ecosystem in the biomaterials field in Finland?

- ◯ Very high
- ◯ High
- ◯ Moderate
- ◯ Low
- ◯ None

Please explain your answer

17. Who in your opinion are the key players in the system that 'orchestrate' this innovation ecosystem in the biomaterials field in Finland?
Please list players that come to your mind:

18. What have been (in your view) your project's effects on the Finnish innovation system?

	Not at all	Not very much	To an average extent	Quite a lot	To a large extent	Not applicable
a. The project contributed to the creation of *national networks* in the biomaterials field	◯	◯	◯	◯	◯	◯
b. The project contributed to the creation of *international networks* in the biomaterials field	◯	◯	◯	◯	◯	◯

	Not at all	Not very much	To an average extent	Quite a lot	To a large extent	Not applicable
c. The project contributed to Finland taking a bigger role in the *international* biomaterials market	○	○	○	○	○	○
d. The project contributed to increasing the income and profit of the project participants	○	○	○	○	○	○
e. The project contributed to the growth of participating organisations	○	○	○	○	○	○
f. The project led to important innovations and new business practices in Finland	○	○	○	○	○	○
g. The project led to important innovations and new business practices in Europe	○	○	○	○	○	○
h. The project contributed to the development of Finland's R&D system	○	○	○	○	○	○
i. The project increased competitive ability of Finnish R&D ecosystem	○	○	○	○	○	○
j. The project gave a possibility for academic researchers and students to get a glimpse of business life.	○	○	○	○	○	○

Please explain your answer:

19. Can you provide some other long-term effects and impacts of your Combio project on the Finnish innovation ecosystem that have not been mentioned previously? Please elaborate

Project support from Tekes

In this section, we would like to learn about the support your organisation received from Tekes during your project.

20. What should be improved in the future if a similar programme is launched in Finland? (for example to grow and retain companies in Finland, enhance university-industry collaboration, etc.)

21. How beneficial has the information/education received from Tekes been to your project and organisation?

	Not at all useful	Not so beneficial	Moderate	Beneficial	Very beneficial	We didn't receive it
a. Information about the thematic area	○	○	○	○	○	○
b. Licensing know-how	○	○	○	○	○	○
c. Regulatory know-how	○	○	○	○	○	○
d. Quality know-how	○	○	○	○	○	○
e. Distribution strategies know-how	○	○	○	○	○	○
f. Information about funding possibilities	○	○	○	○	○	○
g. information on patenting	○	○	○	○	○	○
h. Help in establishing national networks	○	○	○	○	○	○
i. Help in establishing international networks	○	○	○	○	○	○
j. Help in getting involved in national networks	○	○	○	○	○	○
k. Help in getting involved in international networks	○	○	○	○	○	○
l. Business education (i.e. seminars, workshops)	○	○	○	○	○	○
m. Biomaterial market evaluation reports and other market information	○	○	○	○	○	○
n. Other? Please, specify what	○	○	○	○	○	○

Other (please specify)

22. How would you rate the importance of Combio programme in the following?

	Not important at all	Not very important	Moderately important	Quite important	Very important	Not applicable
Achieving project results your organisation was involved in	○	○	○	○	○	○
Revenue growth in your organisation	○	○	○	○	○	○
Growth of your organisation in terms of employees	○	○	○	○	○	○
Production of more value-added goods, services, innovation	○	○	○	○	○	○
Improving recruitment opportunities	○	○	○	○	○	○
Enhancing international visibility of your organisation	○	○	○	○	○	○
Facilitating changes in your organisation's practices	○	○	○	○	○	○
Providing opportunities for organisations to pursue research and innovation	○	○	○	○	○	○
Establishing national networks for research and innovation	○	○	○	○	○	○
Establishing international networks for research and innovation	○	○	○	○	○	○
Increasing the competitiveness of the Finnish biomaterials sector	○	○	○	○	○	○

Please explain your answer:

23. Please rate your experience of working with Tekes

	Poor	Fair	Good	Very good	Excellent	Not relevant
a. Working with Tekes advisors on project application	○	○	○	○	○	○
b. Working with Tekes advisors on project reporting	○	○	○	○	○	○
c. Getting support to find project partners in industry in Finland	○	○	○	○	○	○
d. Getting support to find project partners in industry outside Finland	○	○	○	○	○	○
e. Getting support to find project partners in research in Finland	○	○	○	○	○	○
f. Getting support to find project partners in research outside Finland	○	○	○	○	○	○
g. Help with dissemination activities	○	○	○	○	○	○
h. Working within the constraints of the funding size	○	○	○	○	○	○
i. Any other support (please specify)	○	○	○	○	○	○

Please explain your answer:

24. How would you rate your overall satisfaction with your organisation's participation in the Combio programme?

- ○ Very satisfied
- ○ Moderately satisfied
- ○ Neutral
- ○ Moderately dissatisfied
- ○ Very dissatisfied
- ○ Please explain your answer:

25. Please provide any additional comments related to your experience with the Tekes programme or services with other innovation actors:

26. If you could recommend somebody else who should fill in this survey, please leave their e-mail address(es) or forward this survey link to them.

This is the end of our survey.
We thank you for your contribution!
Please click "Submit" below.

Evaluation of Tekes' **BioIT** programme

Introduction

This questionnaire is part of an independent study of the BioIT (2013-2014) programme, commissioned by the Finnish Funding Agency for Technology and Innovation, Tekes. The evaluation assesses the results, impacts and efficiency achieved under the programme. In addition, the study will also benchmark international best practices for experimental R&D and innovation policies so that valuable input can be provided to the design of future Finnish R&D and innovation programmes. The evaluation is carried out by Technopolis Group, an independent policy research and consulting organisation.

You have received this invitation to complete the questionnaire because you have received funding through the BioIT programme. Your input will be very valuable in the evaluation. We would therefore be grateful if you could complete this questionnaire. The information you provide will be treated confidentially and will be presented to Tekes at an aggregate level only. Your individual information will not be shared outside the independent evaluation team, and will not be used for any other purposes. The final evaluation report will be made available by Tekes.

We anticipate the questionnaire will take no more than 20 minutes to complete. Your answers will be saved as you proceed through the questionnaire.

Tekes and the evaluation team would like to thank you for your cooperation in supporting this important work. For any question about the evaluation or the survey, please contact Dr Jelena Angelis by emailing at jelena.angelis@technopolis-group.com or Pekka Pesonen at pekka.pesonen@tekes.fi

Thank you for your contribution!

Evaluation of Tekes' **BioIT** programme

About you

First, we would like to learn about your organisation and your involvement with the programme so that we understand better the responses in the following sections

1. Select the title of your project from the following list

Other (please specify)

2. The project is...

- ...ongoing
- ...completed

3. What is the type of your organisation? Tick one:

	Biosector	ICT
Small or medium sized enterprise (SME)		
Large enterprise		
Higher Education Institution		
Research organisation		
Public body		
Other		

Other (please specify)

4. What was the role of your organisation in this project?

- Project leader
- Project participant

Evaluation of Tekes' **BioIT** programme

Project partners

In this section, we would like to learn about the partner organisations and their roles in your project

5. How many project partners (national and international) were involved in the following roles in this project?

	National	International
Businesses		
Higher Education Institution		
Research organisations		
Public body		
Other		

Please specify the 'other' category

6. Please indicate the countries of international partners involved in the project

	Please select a country	Enter the number of partners
Country 1		
Country 2		
Country 3		
Country 4		
Country 5		

Other (please specify)

Evaluation of Tekes' **BioIT** programme

Project partners

In this section we would like to know your views on the importance of the project partners and how you continued or plan to continue working with them

7. How would you rate the importance of partners in achieving the project's results?

	National	International
Businesses		
Higher Education Institutions		
Research organisations		
Public bodies		
Others		

Other (please specify)

8. How many project partners have you continued to work (or plan to work) with after the project end?

	National partners	International partners
Businesses		
Higher Education Institutions		
Research organisations		
Public bodies		
Others		

Other (please specify)

9. Please provide any other comments on how the project team's composition could have been improved

Evaluation of Tekes' **BioIT** programme

Programme's goals

The aim of the BioIT programme was to help small and medium enterprises (SMEs) in the biosector to develop their business activities and to bring players in the biosector and ICT together so that new industries and business models can be developed. Specific goals were (1) Growth & international success for SMEs; (2) New networks; and (3) New enterprises from academia. In this section, we would like to learn about your views on the programme's goals

10. Please indicate how strongly you agree or disagree with the following statements on the overall programme?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly Agree	Don't know
Programme's objectives were *relevant*	○	○	○	○	○	○
Programme's objectives were *challenging*	○	○	○	○	○	○
Programme was *mainly technology-focussed*	○	○	○	○	○	○
Programme was *suitably multi-disciplinary*	○	○	○	○	○	○
Programme *supported the implementation of my organisation's strategies*	○	○	○	○	○	○
Programme *supported the implementation of Tekes' strategies*	○	○	○	○	○	○
Programme *supported the implementation of Finland's strategic needs*	○	○	○	○	○	○

Project's results

In this section, we would like to learn about the results you (and your partners) achieved in your project

11. What were the results of your project? Select all that apply:

- [ ] We are now part of a new network/ partnership
- [ ] We produced new peer-reviewed publication(s)
- [ ] We created new patent(s)
- [ ] We developed new prototype(s)
- [ ] We launched a commercial product or service to the market
- [ ] We launched a new start-up and/or spin-off company
- [ ] Other (Please specify below)

Please explain your answer

12. For which of these results was the support from Tekes essential? Select all that apply:

- [ ] We are now part of a new network
- [ ] We produced new peer-reviewed publication(s)
- [ ] We created new patent(s)
- [ ] We developed new prototype(s)
- [ ] We launched a commercial product or service to the market
- [ ] We launched a new start-up and/or spin-off company
- [ ] Other (Please specify below)

Please explain your answer:

Evaluation of Tekes' **BioIT** programme

Project's results

In this section, we would like to learn about the results you (and your partners) achieved in your project

13. How did your organisation benefit from this programme? The programme…

- ☐ ...provided access to new business partners *in Finland*
- ☐ ...provided access to new business partners *outside Finland*
- ☐ ...provided access to new academic partners *in Finland*
- ☐ ...provided access to new academic partners *outside Finland*
- ☐ ...provided access to new public sector partners *in Finland*
- ☐ ...provided access to new public sector partners *outside Finland*
- ☐ ...contributed to revenue growth
- ☐ ...contributed to further recruitment
- ☐ ...contributed to enhanced international visibility
- ☐ We have benefited from knowledge exchange
- ☐ Other (please specify)

14. Has the project resulted in students and/or academic researchers moving to work in business?

- ○ Yes, students
- ○ Yes, researchers
- ○ Yes, both
- ○ No

Please explain your answer (reason, number of researchers or students, etc):

15. Can you think of any unplanned or unexpected results of the project *(e.g., impact on new policy, standards or regulation, obtained follow-on funding, etc*)?

- ○ Yes
- ○ No

Please provide examples

Project's results

Finland has been aiming to transform itself from a resource-based economy into innovation ecosystem where the flow of technology and information among people, enterprises and institutions is key to an innovative process. Finland seeks to achieve functioning business ecosytems through a culture of experimentation.

16. Do you believe your project contributed to establishing a business ecosystem in your thematic area?

- ◯ Yes
- ◯ No

Please explain your answer

17. How would you rate the contribution of your project towards establishing an 'experimental' culture in Finland?

	None	Low	Moderate	High	Very high	Don't know
Please rate	◯	◯	◯	◯	◯	◯

Please explain your answer:

Evaluation of Tekes' **BioIT** programme

Project support from Tekes

In this section, we would like to learn about the support your organisation received from Tekes during your project

18. Please rate the support you received from Tekes with...

	Poor	Fair	Good	Very good	Excellent	Not relevant
Project application	○	○	○	○	○	○
Project reporting	○	○	○	○	○	○
Finding Finnish project partners	○	○	○	○	○	○
Finding international project partners	○	○	○	○	○	○
Getting market research insight	○	○	○	○	○	○
Getting specialised training	○	○	○	○	○	○
Promotion and visibility activities	○	○	○	○	○	○
Any other support (please specify below)	○	○	○	○	○	○

Please explain your answer

19. How well did the utilized funding model serve your needs?

	too short/ small	about right	too long/ large	don't know
Project duration	○	○	○	○
Funding size (€)	○	○	○	○

Please explain your answer

20. Please rate your overall satisfaction with the Tekes programme?

- ○ Very satisfied
- ○ Moderately satisfied
- ○ Neutral
- ○ Moderately dissatisfied
- ○ Very dissatisfied

Please explain your answer

Evaluation of Tekes' **BioIT** programme

Your suggestions

This is the last section of the survey and we would appreciate your suggestions in improving Tekes programmes

21. Please provide any additional comments related to your experience with the Tekes BioIT programme

22. How could Tekes deliver improved programmes in your thematic area in future? (*for example how to grow and retain companies in Finland or enhance university-business collaboration, etc*)

23. We would like to understand better the needs of programme participants. If you are willing to take part in a short telephone interview, please provide your name and email address. Your details will only be seen by the independent study team.

Name

Email address

This is the end of our survey.
We thank you for your contribution!
Please click "Submit" below.

Evaluation of Tekes' **Trial** programme

This questionnaire is part of an independent study of the Trial (2011-2014) programme, commissioned by the Finnish Funding Agency for Technology and Innovation, Tekes. The evaluation assesses the results, impacts and efficiency achieved under the programme. In addition, the study will also benchmark international best practices for experimental R&D and innovation policies so that valuable input can be provided to the design of future Finnish R&D and innovation programmes. The evaluation is carried out by Technopolis Group, an independent policy research and consulting organisation.

You have received this invitation to complete the questionnaire because you have received funding through the Trial programme. Your input will be very valuable in the evaluation. We would therefore be grateful if you could complete this questionnaire. The information you provide will be treated confidentially and will be presented to Tekes at an aggregate level only. Your individual information will not be shared outside the independent evaluation team, and will not be used for any other purposes. The final evaluation report will be made available by Tekes.

We anticipate the questionnaire will take no more than 20 minutes to complete. Your answers will be saved as you proceed through the questionnaire.

Tekes and the evaluation team would like to thank you for your cooperation in supporting this important work. For any question about the evaluation or the survey, please contact Dr Jelena Angelis by emailing at jelena.angelis@technopolis-group.com or Pekka Pesonen at pekka.pesonen@tekes.fi

Thank you for your contribution!

Evaluation of Tekes' **Trial** programme

About you

First, we would like to learn about your organisation and your involvement with the programme so that we understand better the responses in the following sections

1. Select the title of your project from the following list

Other (please specify)

2. What is the type of your organisation? Tick one:

- ◯ Small or medium sized enterprise (SME)
- ◯ Large enterprise
- ◯ Higher Education Institution
- ◯ Research organisation
- ◯ Public body
- ◯ Other

Other (please specify)

3. What was the role of your organisation in this project?

- ◯ Project leader
- ◯ Project participant

Evaluation of Tekes' **Trial** programme

Project partners

In this section, we would like to learn about the partner organisations and their roles in your project

4. How many project partners (national and international) were involved in the following roles in this project?

	National	International
Businesses		
Higher Education Institution		
Research organisations		
Public body		
Other		

Please specify the 'other' category

5. Please indicate the countries of international partners involved in the project

	Please select a country	Enter the number of partners
Country 1		
Country 2		
Country 3		
Country 4		
Country 5		

Other (please specify)

Project partners

In this section we would like to know your views on the importance of the project partners and how you continued or plan to continue working with them

6. How would you rate the importance of partners in achieving the project's results?

	National	International
Businesses		
Higher Education Institutions		
Research organisations		
Public bodies		
Others		

Other (please specify)

7. How many project partners have you continued to work (or plan to work) with after the project end?

	National partners	International partners
Businesses		
Higher Education Institutions		
Research organisations		
Public bodies		
Others		

Other (please specify)

8. Please provide any other comments on how the project team's composition could have been improved

Evaluation of Tekes' **Trial** programme

Programme's goals

The aim of Tekes' Trial Environment for Cognitive Radio and Network programme was to transform Finland into a globally attractive cluster of expertise and unique trial environment for cognitive radio and networks. Specific goals were (1) Finland is at global top level in the research and development of cognitive radio and networks (2) Finnish companies utilise the business potential of the cognitive radio and networks (3) National and international co-operation is created (4) Finland is a tempting trial environment for foreign companies

9. Please indicate how strongly you agree or disagree with the following statements on the overall programme?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly Agree	Don't know
Programme's objectives were *relevant*	○	○	○	○	○	○
Programme's objectives were *challenging*	○	○	○	○	○	○
Programme was *mainly technology-focussed*	○	○	○	○	○	○
Programme was *suitably multi-disciplinary*	○	○	○	○	○	○
Programme *supported the implementation of my organisation's strategies*	○	○	○	○	○	○
Programme *supported the implementation of Tekes' strategies*	○	○	○	○	○	○
Programme *supported the implementation of Finland's strategic needs*	○	○	○	○	○	○

Evaluation of Tekes' **Trial** programme

Project's results

In this section, we would like to learn about the results you (and your partners) achieved in your project

10. What were the results of your project? Select all that apply:

- [ ] We are now part of a new network/ partnership
- [ ] We produced new peer-reviewed publication(s)
- [ ] We created new patent(s)
- [ ] We developed new prototype(s)
- [ ] We launched a commercial product or service to the market
- [ ] We launched a new start-up and/or spin-off company
- [ ] Other (Please specify below)

Please explain your answer

11. For which of these results was the support from Tekes essential? Select all that apply:

- [ ] We are now part of a new network
- [ ] We produced new peer-reviewed publication(s)
- [ ] We created new patent(s)
- [ ] We developed new prototype(s)
- [ ] We launched a commercial product or service to the market
- [ ] We launched a new start-up and/or spin-off company
- [ ] Other (Please specify below)

Please explain your answer:

Evaluation of Tekes' **Trial** programme

Project's results

In this section, we would like to learn about the results you (and your partners) achieved in your project

12. How did your organisation benefit from this programme? The programme…

- [ ] ...provided access to new business partners *in Finland*
- [ ] ...provided access to new business partners *outside Finland*
- [ ] ...provided access to new academic partners *in Finland*
- [ ] ...provided access to new academic partners *outside Finland*
- [ ] ...provided access to new public sector partners *in Finland*
- [ ] ...provided access to new public sector partners *outside Finland*
- [ ] ...contributed to revenue growth
- [ ] ...contributed to further recruitment
- [ ] ...contributed to enhanced international visibility
- [ ] We have benefited from knowledge exchange
- [ ] Other (please specify)

13. Has the project resulted in students and/or academic researchers moving to work in business?

- ○ Yes, students
- ○ Yes, researchers
- ○ Yes, both
- ○ No

Please explain your answer (reason, number of researchers or students, etc):

14. Can you think of any unplanned or unexpected results of the project (*e.g., impact on new policy, standards or regulation, obtained follow-on funding, etc*)?

- ○ Yes
- ○ No

Please provide examples

Project's results

Finland has been aiming to transform itself from a resource-based economy into innovation ecosystem where the flow of technology and information among people, enterprises and institutions is key to an innovative process. Finland seeks to achieve functioning business ecosytems through a culture of experimentation.

15. Do you believe your project contributed to establishing a business ecosystem in your thematic area?

- ◯ Yes
- ◯ No

Please explain your answer

16. How would you rate the contribution of your project towards establishing an 'experimental' culture in Finland?

	None	Low	Moderate	High	Very high	Don't know
Please rate	◯	◯	◯	◯	◯	◯

Please explain your answer:

Evaluation of Tekes' **Trial** programme

Project support from Tekes

In this section, we would like to learn about the support your organisation received from Tekes during your project

17. Please rate the support you received from Tekes with...

	Poor	Fair	Good	Very good	Excellent	Not relevant
Project application	○	○	○	○	○	○
Project reporting	○	○	○	○	○	○
Finding Finnish project partners	○	○	○	○	○	○
Finding international project partners	○	○	○	○	○	○
Getting market research insight	○	○	○	○	○	○
Getting specialised training	○	○	○	○	○	○
Promotion and visibility activities	○	○	○	○	○	○
Any other support (please specify below)	○	○	○	○	○	○

Please explain your answer

18. How well did the utilized funding model serve your needs?

	too short/ small	about right	too long/ large	don't know
Project duration	○	○	○	○
Funding size (€)	○	○	○	○

Please explain your answer

19. Please rate your overall satisfaction with the Tekes programme?

- ◯ Very satisfied
- ◯ Moderately satisfied
- ◯ Neutral
- ◯ Moderately dissatisfied
- ◯ Very dissatisfied

Please explain your answer

Evaluation of Tekes' **Trial** programme

Your suggestions

This is the last section of the survey and we would appreciate your suggestions in improving Tekes programmes

20. Please provide any additional comments related to your experience with the Tekes Trial programme

21. How could Tekes deliver improved programmes in your thematic area in future? (*for example how to grow and retain companies in Finland or enhance university-business collaboration, etc*)

22. We would like to understand better the needs of programme participants. If you are willing to take part in a short telephone interview, please provide your name and email address. Your details will only be seen by the independent study team.

Name

Email address

This is the end of our survey.
We thank you for your contribution!
Please click "Submit" below.

Appendix E. Survey results

E.1. Survey of the BioIT programme's participants

Members of the 21 projects funded under the BioIT programme responded to the online survey. One of these projects had two responses. Most of the projects are completed (15 projects) while five are still ongoing. Almost all of the respondents represented SMEs, three of which are from biosector and 11 are active in ICT. There were also two large biosector enterprises represented in the survey, one higher education institution specialising on biosector and five research organisations (four in biosector, one in ICT). In 19 cases the project leaders filled in the survey and in two cases a project participant responded.

E.1.1 Project partners

When asked about the project partners, almost all of the participants (18 in total) had Finnish **business partners** in the project. While the majority had only one partner (9 respondents), others had two or more partners, one respondent reported having six partners and another one marked having had seven partners. In addition, the respondents added that they had lots of collaborative links with business partners throughout the project, although most of these were not official partners. The second most important group among the national partners were research organisations with nine respondents having at least one partner in this group. Among other national partners, three respondents mentioned having a higher education institution as a partner and two noted a public body.

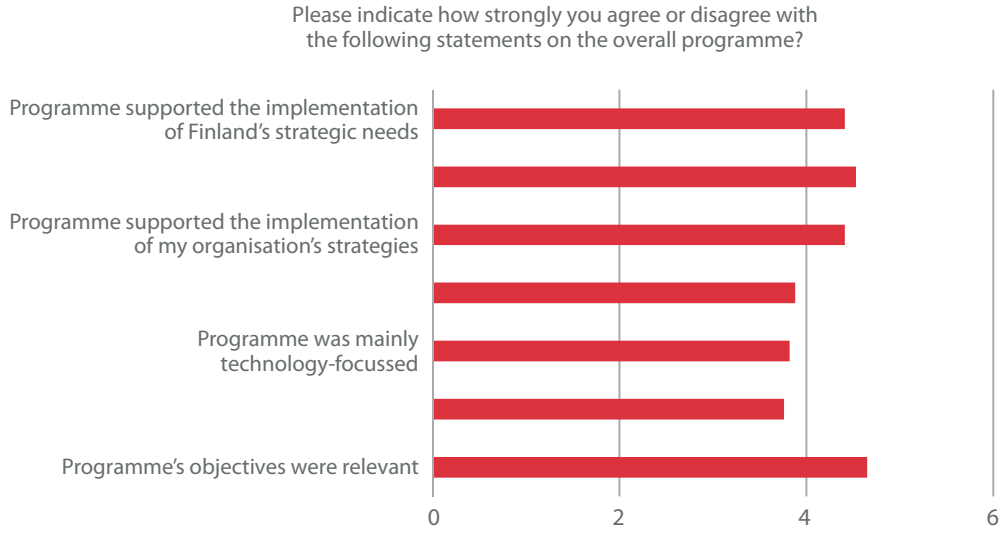
There were fewer international partners, yet they were still represented. One respondent mentioned having an international business partner and three had two international business partners involved in their projects. Two respondents reported having had an international research organisation as their partner. These various partners came from the USA (4), Germany (3), France (1), China (2), Switzerland (2), United Kingdom (2), and Singapore (1).

Programme participants marked that both national and international **business partners** had a high importance on achieving project's results. Out of national partners, one respondent mentioned that higher education institutions were of high importance and two respondents claimed this in case of research organisations. On the other hand, no other types of organisations were seen as highly important in case of international partners. The importance of partners and collaborative activities is shown also by the fact that 13 respondents have continued to work with their national business partners and 7 with their international business partners. On the national level, the collaboration has also continued with higher education institutions (three respondents), research organisations (two respondents) and public bodies (one respondent). At the same time, two respondents claimed to continue working with international HEIs and one has a continued partnership with a foreign public body.

> *"For us, it was highly important to collaborate with business and public organisations in order to learn about technology, market and future trends as well as commercial potential of the idea."*

E.1.2 Effectiveness of the programme

When assessing the **effectiveness of the BioIT programme** in general, the responses were mostly positive. Most of the respondents strongly agreed that the programme's objectives were relevant. 12 out of 18 respondents also strongly agreed that the programme supported implementation of their organisation's strategies. On average there was a strong belief that the programme supported the implementation of Finland's strategic needs. At the same time, there was less agreement on whether the programme's objectives were challenging (seven did not agree nor disagree).



E.1.3 Results of the programme

The majority of the respondents (15) mentioned that they launched a commercial product or service to the market; developed a prototype (13 respondents); and/or became part of a new network/partnership (10 respondents). Some of the respondents also mentioned creating new patents (4) and two had produced new peer-reviewed publications. The open ended questions on the project results revealed also that one of the companies had to change their result and business model as a result of the project. In reaching these aims, the support of Tekes was essential mostly for launching new products and services (13 respondents) and developing new prototypes (10 respondents).

When outlining **how organisations benefitted from the programme**, 13 respondents mentioned that it contributed to their enhanced international visibility, 9 found that it contributed to revenue growth, 9 got access to new business partners in Finland, and seven benefited from knowledge exchange. One of the respondents mentioned that the programme *"... provided access to companies and research institutes in Finland and outside Finland. Unfortunately, these did not realise to "new business partners".*

Seven respondents did not observe that the project would have resulted in **students or academic staff of their project moving to work in a business** as a result of the project. However, five respondents claimed that researchers have moved to work in business, two mentioned that this happened to students and in three cases both students and researchers had moved to work in business from the organisation. However, open-ended questions also revealed the following cases:

"International researcher exchange."

"The project did not result in business that would have provided employment for someone."

"We have made new recruitments who were formerly working in academic positions, but made redundant."

"Researchers are working part time in business. Understanding the importance and processes of commercialisation of innovations improved a lot."

Three quarters of respondents (12) could not think of any **unplanned or unexpected results** of the projects. However, others brought some examples:

"Project is ongoing, and the testing of the built data-analysis platform with clinical data and data from a clinical stem cell trial is commencing."

"Many laboratories were not digitising as fast as we thought."

"The change of our company strategy and business model was unplanned."

"New ideas for the future products/services that we did not realise before starting this project."

"Every international project is an eye opener. Market knowledge was gathered and new ideas were generated."

"The results from the new methods were not exactly as expected when starting the project."

E.1.4 Contribution to the ecosystem

At the same time, 13 respondents believed that their project contributed to establishing a **business ecosystem** in their thematic area while five did not find that. The open-ended questions revealed that:

"Full contribution, with the project ongoing in the IT-platform testing phase, is still early to evaluate. However, we have already expanded the research and business network aiming to further develop the project's platform internationally (Finland, China)."

"We failed in developing new business in this area. At best, we have been indirectly contributing by discussing with lots of people."

"Ecosystem is a buzzword with insufficient definition. Nobody works in a vacuum. The question cannot be answered."

"We are a very active player in our field in Finland and internationally. We are open and actively seek collaboration, and we have developed good relationships with several important international partners. That is not very typical in Finland, therefore we see that our role is much larger than our size."

"Or there probably was an ecosystem for physiological sport measurement but it grew bigger and stronger."

"Our interpretation services and gene account supports marketing new genetic tests by clinical laboratories."

All respondents believed that their project had made some **contribution towards establishing and "experimental" culture in Finland**, even if low. One respondent believed that the project had a very high contribution, six found that there was a high level of contribution, 6 found it moderate, three thought that the level of contribution was low. Two of the respondents could not respond.

"We were brave in trying this, and we tried extremely hard. I think that is appreciated and it will promote 'experimental' culture. However, we have now a big problem with the loan which, at its worst, can ruin our new business model. Thus, if the loan cannot be negotiated we are a good example that people should not be 'experimental'. Negotiation process is ongoing, hoping for the best..."

"Our project has gathered international interest, but very limited interest in Finland."

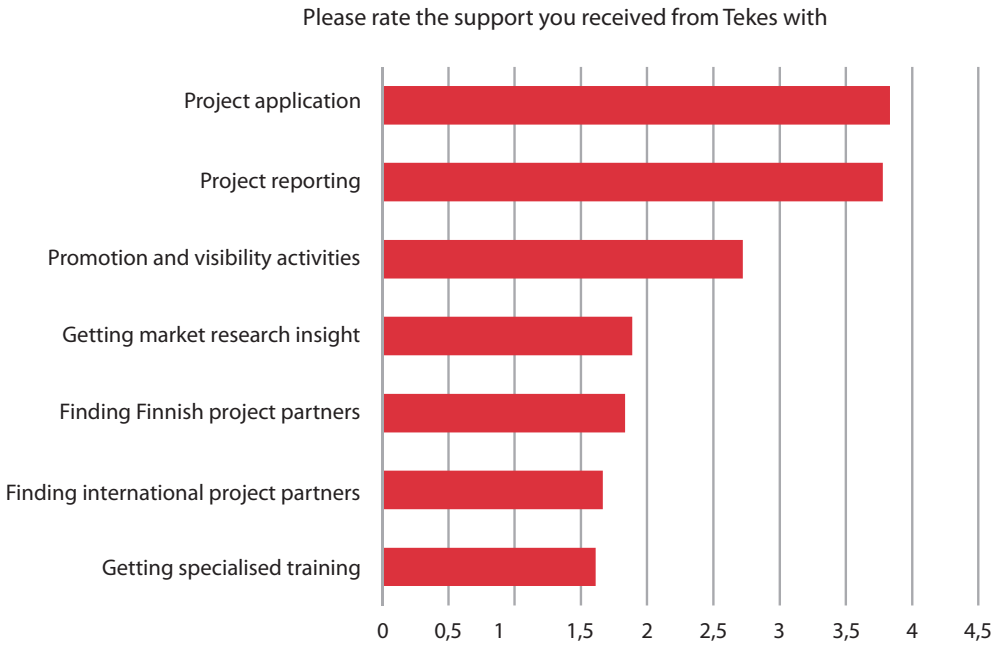
"Considering the scale of our business, we have set an example to other businesses to develop new products via innovation."

E.1.5 Support from Tekes

The respondents were also asked to **rate the support received from Tekes in different areas**. The highest general score was received regarding the project application support (3.9), followed by project reporting (3.8) and support for promotion and visibility activities (2.7). At the same time, getting specialised training was most often marked as fair and was thus ranked the lowest (1.6) together with the support received for finding international project partners (1.6 points on average). At the same time, the two latter ones were also mentioned a lot as not being relevant which reflects that the respondents also may not have expected extensive support on these activities.

One respondent added:

"Generic support has been available, but more specific support has been absent (poor). We have not expected Tekes to be able to provide such support, hence "poor" in certain cases is expected. We operate in a new field, about which Tekes or its contractors have almost no knowledge."



The majority of the respondents found that the **funding size and the project duration** was about right (respectively 14 and 10). 6 respondents believed that the duration was too short and one thought that it was too long. At the same time, four people noted that the funding was too small but none mentioned that it would have been too large.

"There should be a possibility to apply for follow-up or additional funding during the project, based on the project's success."

"With respect to our goal we were not as close to the final solution as we expected."

"The project duration estimation is difficult. Operating abroad brings a lot of delay due to the physical distance to the pilot users"

"We suffer from being a big enterprise due to partial ownership of Finnish state."

E.1.6 Overall satisfaction with the programme

On average, the **overall satisfaction** with the BioIT programme was very good. 12 respondents mentioned that they were very satisfied, 6 were moderately satisfied, and none claimed to be dissatisfied. Additional comments on the BioIT programme included:

"Tekes BioIT programme has made it possible for us to address a true medical IT unmet need."

"Challenging area in general."

"Fine programme, perhaps separate track or specified programme for Health IT software would have offered better networking possibilities for the IT SMEs."

"It ended two years ago, I cannot any more provide feedback. Since then we have had other useful Tekes projects supporting us."

"It is important that the Tekes advisors are experienced in business. In this project, we were lucky in this respect, and our business model and business objectives in the field were understood. This can be much more challenging with less experienced people or people whose work-life experience is in science or it is otherwise too superficial."

E.1.7 Future support

Discussing the **future prospects of Tekes' activities in their thematic area**, the respondents expressed their opinion on what else could be done:

"More 'too close to market' support."

"More matchmaking internationally between IT companies in Bio and Health software."

"Once the product is available, Tekes support about ends. Risk capital is the next step that is needed."

"Tekes should embrace internationalisation and not set national barriers. Otherwise the development may lead to a situation where the companies with less readiness to international competition are the ones which do best in Finland."

"Industrial post-doc programmes would be highly recommended."

"Tekes should even stronger require universities to collaborate with SMEs. On a statement level it works, but practical collaboration is poor, eg between biobanks and the Finnish SMEs."

E.2 Survey of the Trial programme's participants

In total, 18 Trial programme projects were responded for in the survey. Three of those projects had more than one respondent. The largest part of the respondents (eight respondents) represented research organisations while six respondents were representing higher education institutions and six – either small or large enterprises. Approximately two thirds (or 13 respondents) of the respondents were project leaders while seven were project participants.

E.2.1 Project partners

Trial projects had many project partners. On the **national level**, a total of 17 respondents mentioned that their project had at least one business project partner, the largest number of business project partners noted was seven. It was common to have either one (six respondents) or two (eight respondents) higher education institutions as project partners. Seven respondents mentioned having research organisations as project partners and 12 partnered with Finnish public bodies. Internationally, three claimed to have partnered with foreign businesses, three with foreign higher education institutions, three with research organisations and one with a public body. Foreign project partners originated from Italy, Sweden, United Kingdom, USA, Japan, and India.

When describing the **importance of national partners,** business partners were seen as the most important ones (with 13 respondents marking them as highly important and three as moderately important). This was followed by higher education institutions (11 respondents found them to be highly important), public bodies (six marked as highly important), and research organisations (five mentioned them as highly important). On the international level, only two respondents found business partners highly important and two thought the same about higher education institutions.

As Trial is a fairly recent programme, the respondents claimed to have close **cooperation** ties or are planning to continue working with many of their national project partners. A total of 15 respondents mentioned that they are still cooperating with at least one business project partner while 12 claimed the same about higher education institutions, nine about public bodies, and seven about research organisations. On the international level, five of the respondents are working together or would be willing to continue their partnership with at least one business partner, while two people mentioned the same about working together with higher education institutions, research organisations, and public bodies respectively.

The respondents were asked to comment on how the team composition could have been improved and the results were following:

> *"Composition in CORE+ project was very good (research, cellular operators, mobile infra vendors, SME, etc.). In ATRIAL II parallel project there was no direct partners, just partners in CORE+ project."*
>
> *"Excellent co-operation across regulation, business and research domains."*
>
> *"…more co-creation with foreign business partners."*
>
> *"…more close and close co-operation with universities in USA."*
>
> *"…more close and concrete co-operation with top university in USA."*
>
> *"Now optimum team."*

E.2.2 Effectiveness of the programme

The respondents were asked to rate different statements regarding the Trial programme in general. Most of the respondents agreed that the programme's objectives were relevant as well as challenging. While the results were to a large extent homogenous with the respondents somewhat agreeing or strongly agreeing to the statements, the statements on the programme supporting the implementation of Finland's strategic needs and the strategies of the respondents' organisation, received the lowest general score.

The respondents mentioned that their **organisation mainly benefitted from the Trial programme** as it provided access to new business partners in Finland and they have benefitted from the knowledge exchange. Contributing to enhanced international visibility and providing access to new business partners outside Finland was also mentioned a lot. While providing access to new public sector partners outside Finland and contributing to revenue growth were not as important as other aspects, there were still quite a few respondents for whose organisations it mattered.

Figure 33. How the organisations of respondents benefited from the Trial programme.

E.2.3 Results of the programme

The question on the **results of the programme** indicates that almost all (16 respondents) are now part of a new network or partnership, 14 produced new peer-reviewed publications or dissertations and 12 developed new prototypes. Advancements were seen also in other areas with five respondents claiming having produced new patents, and three bringing a commercial product to the market. The respondents described their results in the following way:

"The project opened the door to new partnerships in new projects. The project published a large number of peer-reviewed publications. The project developed the world's leading spectrum sharing trial prototypes."

"Commercial product features based on technology developed in ATRIAL II are launched."

"The CORE project continued with new partners. Developed expertise made (in its part) new international cooperation possible in some WIFIUS projects."

"…contributions to regulation process."

"Our position in regulation forums and related eco-system became much stronger. We did world's first LSA/ASA demonstrator."

"We strengthened our position in regulation forums and involved organisations and companies."

"It was possible to strengthen our co-operation with NICT/ Japan and Japan wireless communication research eco system."

"Patent application is pending, so do not know yet the result."

"We showed demonstration on high profile venues (Mobile World Congress)."

"The EECRT project was a first phase project that lead directly to a second phase one."

When discussing for which of these results the **support of Tekes was essential,** the respondents mainly brought out being part of a new network (15), producing new publications (11) and developing new prototypes (10). The respondents commented:

"None of this would have been possible without the funding from Tekes."

"In CORE+ project we get networked with the partners that and contact with them has continued after the project, also related to the prototype developed in ATRIAL II. We were able to develop prototype faster than what was possible without Tekes."

"It is impossible to achieve real new results without enough funding."

"We took a new advanced technology into use in our products."

"Our project is very technology specific (narrow area), so Tekes' main function is funding."

"The TRIAL framework enabled all work in the project, and all results."

There was some movement of academic researchers going to work in business sector observed by the respondents. Four mentioned that students went to work in businesses and in three cases the researchers went to work in businesses. Three people claimed that both had changed their jobs while seven respondents had not observed this kind of phenomenon.

Approximately half (eight respondents) could think of an **unexpected result of their project** with the following examples:

"Standardisation and regulation"

"The project strongly contributed to European and international spectrum policy making. It presented world's first and leading trials of new Licensed Shared Access (LSA) spectrum sharing concept introduced by the European Commission. "

"Standards"

"Spectrum sharing high on the EC and FCC agenda. CRB with CORE showcased first field trials. Nokia active in regulation and standardisation."

"Change of regulation could have changed our business environment."

"Perhaps more steps towards service business, instead of buying pure technology (that is a current habit)."

"The demonstration platform designed in the project became the main demonstration platform of the 25-million European FP7 project METIS. This lead to unpredicted visibility."

"Impact to standards and regulation."

E.2.4 Contribution to the ecosystem

All of the respondents believed that their project contributed to **establishing a business ecosystem** in their thematic area. Furthermore, there was a strong belief that the project helped to establish an **experimental culture** in Finland with seven respondents claiming to have made a high contribution and ten claiming to have made a very high contribution. The explanations to this understanding are as follows:

The business ecosystem

"The project strongly contributed developing a national trial environment for spectrum sharing trials for mobile communications and incumbent wireless systems."

"There has been business contacts after the project that are based on the technology (and contacts) created in the project."

"This was starting of developing spectrum sharing in mobile radio networks."

"Spectrum sharing is a systemic disruptive change impacting ecosystem."

"Active and regular information and knowledge sharing with partners."

"Close and continuous co-operation knowledge sharing with companies related technologies, regulation and standards."

"Project team has regular and innovative discussion with business partner and NICT/Japan about possible impact and utilisation of the project results."

"Our solution needs many partners to have an end-to-end solution and service, eg university level organisation(s), smaller technology companies having deep narrow knowledge, telecom operators and device vendors, application developers and providers etc."

"The partner companies acquired the developed technology and the project fostered cooperation."

"The one start up involved has been consolidating itself."

"In the ecosystem surrounding the project, one startup partner has become more established."

Experimental culture in Finland

"The role of CORE+ project was fundamental in creating experimental culture in trials and presented the results in international regulation, standardization, industry and academic forums with success."

"We developed trial platforms in the projects that are still used though updated."

"Lead and agile techniques and processes leveraged in networked research."

"Very developed complex state-of-art testbed."

"We created one of the first state-of-art cognitive network."

"Project focused on building on realistic simulation models instead of physical prototypes. The reason was limited funding."

"An experimental culture within fault diagnostics and low voltage power quality measurements."

"The project lead to a shift in focus of the university towards more experimentation based research. This has also reflected directly to a change in the teaching curriculum of the university, with new courses, and novel experimental objectives."

E.2.5 Support from Tekes

Giving **feedback on the project implementation and the role of Tekes as such**, the respondents brought out that the project application as well as promotion and visibility activities were mostly excellent (according to ten respondents). The respondents were also content with project reporting (seven excellent and seven very good ratings) and finding Finnish project partners (five excellent and five very good) as well as getting market research insights (five excellent

and four very good). While there were none of the activities which would have received a poor rating, three of the respondents thought that the market research insights would receive a fair rating from them. Among all of the activities, nine people found that finding international project partners was not really relevant as an activity. The respondents commented:

"Tekes contact person was professional and with good skills to support research."

"As explained earlier the project scope is very narrow technological product and service, although it requires wide many partners to be a complete solution."

"The main forum for the programme was the interest group. The meetings of the interest group were seen as very important for disseminating information inside the program, for coordinating the actions etc. TEKES was very active in promotion of program results."

Regarding the **budget and the project timeline**, the project respondents mostly mentioned that the project duration as well as the funding size were about right (15 and 12 respondents respectively). Two respondents believed that the project was too short and five mentioned that the funding size was too small.

E.2.6 Overall satisfaction with the programme

The overall satisfaction with the Trial programme was positive with 13 respondents mentioning being very satisfied, three noting that they are moderately satisfied and one person being neutral. The respondents explained:

"This programme gave a great opportunity to do world class research and present it to the world."

"We are satisfied, just thinking was it possible to achieve even more."

"For a research organisation all goals are not the best, but that why we have different partners."

"The programme enabled a paradigm shift in the research and education at Aalto University related to wireless networks. Funding for development of testbed activities significantly boosted the experimental way of work at Aalto".

Providing **additional comments** related to their experience with the Tekes Trial programme, the respondents mentioned the following:

"Without Tekes' Trial Fairspectrum could not have started."

"Helped networking between companies and institutions."

"Good job done. In particular CORE and WISE clusters really created and leveraged Finnish e2e ecosystem in a whole."

"TRIAL interest group work was active and useful way to exchange ideas within the programme."

"As an umbrella name 'Trial' programme seemed to had the right focus, since main part of our project was trialing..."

E.2.7 Future support

Finally, the respondents commented on **how Tekes could deliver improved programmes in their thematic area in future**:

"Tekes is already doing a great job in the 5thGear programme."

"More funding for basic radio technology research based on industry needs."

"Encourage further e2e ecosystem type consortia projects with cross disciplinary participants."

"University-business collaboration is possible but making public research from business topics that could increase competitive edge is difficult if research results are published during the project."

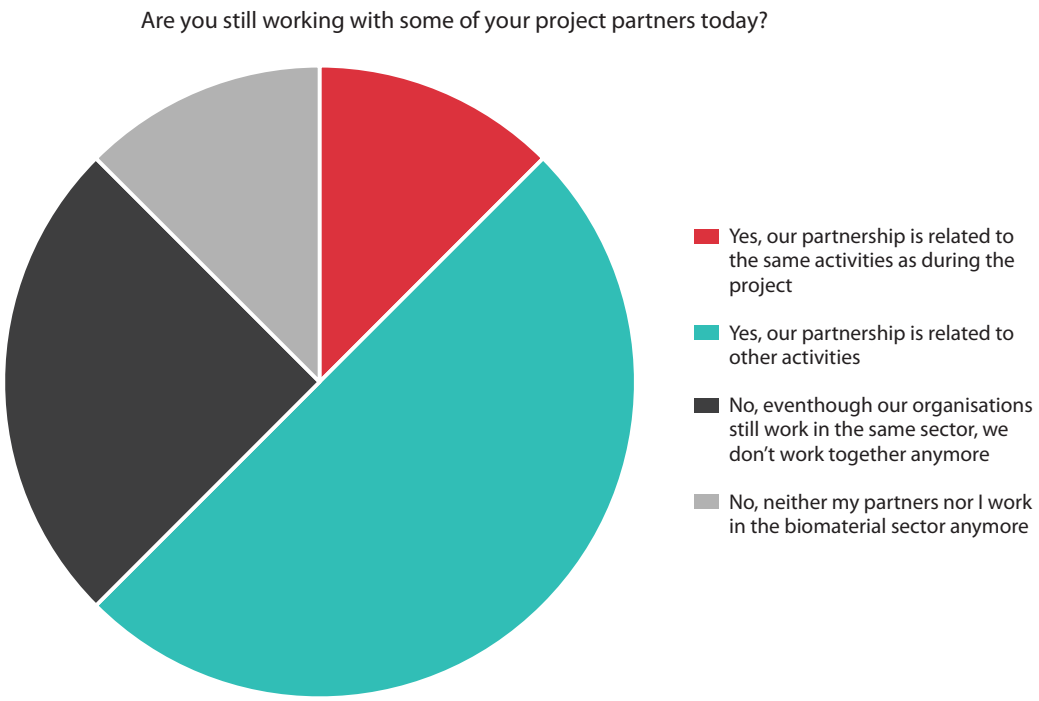
"Tekes had right direction (SHOKS), but state cancelled them. Similar type of research network is needed."

"The field is very challenging, as the technologies are extremely complicated. It takes significant time to develop business based on these technologies. A long perspective is necessary for that, nothing happens in two years."

E.3 Survey of the Combio programme's participants

A total of 9 respondents filled in Combio survey questionnaire. Two of the respondents represented SMEs, 6 were part of an university and one from a research organisation. Two thirds of the respondents were project leaders and the rest participated in the projects. The projects that were responded for, had in five cases at least one project partner among SMEs, in two cases a partner of a large enterprise and in 8 cases were partnering with a university or a research institute. There were no international partners mentioned. According to the respondents, the cooperation ties were long term as the partnership was continued with 7 university partners, all of the large enterprises and SMEs. In four cases the partnership is related to other activities.

Figure 34. Continued partnerships of the Combio programme.



E.3.1 Results of the programme

In general, Combio programme participants noted that there were few project **effects on their organisation's activities**. While the most common ones where the support of Combio programme was instrumental was producing peer-reviewed publications (six respondents), increasing know-how and establishing national networks (all acknowledged by five respondents), the sudden cutting of funding made it difficult for companies to bring their products to market as it was difficult to find further funding:

> *"Tekes funding for biomaterials stopped abruptly around 2009 and left several projects in the air. We did not have time, money and experience to finish the projects into products."*

The respondents could bring some examples of **unexpected results** of their project, for example:

> *"Another distantly related technology that we have and are investigating with the Academy, Tekes and EU funding."*
>
> *"Apatite coating did not help bone formation in cellulose or polycaprolactone sponges as expected. Ca-doped bioactive glass composites were superior to other products in the market as bone substitutes, but we could not finish the project because of cuts in the funding. Modified stem cells could be administered by intraperitoneal injection."*
>
> *"Results can be applied also outside of medical applications such as in functional surfaces and smart porous structures."*
>
> *"Funding from Tekes completely stopped. It forced us to do other kinds of research and other areas in which we are not dependent on Tekes anymore."*

Three respondents mentioned that participating in Combio programme changed the **operating practices** of their company. Examples of the change include change in laboratory practices which became more routine, strengthening collaboration with companies, learning about the materials that the respondents worked with and also learning from the collaborators.

The feedback to Tekes in terms of keeping the companies of this sector in Finland included understanding more thoroughly the product development cycle, where sufficient funding and time should be allowed for the results to be properly tested. The respondents commonly agreed that in order for keeping biomaterials research groups from re-specialising to other research areas, Tekes should have planned a smoother transition period of cutting the funding. As such, one of the respondents wrote that *"the discontinuation of the Combio programme had significant negative effects for R&D&I within the area"*. The discontinuation of the Combio funding is the main reason why many of the research groups have moved away from the biomaterials' field and why their projects did not succeed.

> *"Funding of biomaterial research was nearly stopped, thus I also retired two years earlier as I had planned."*
>
> *"Volume of research with Finnish partners has decreased significantly and research is done now with foreign partners in EU projects or project drafts."*

E.3.2 Contribution to the ecosystem

The respondents believed the contribution of their project towards **establishing Finland's experimental culture** was either high (three responses) or moderately high (three responses). None of the respondents thought it would have been a very high contribution. The respondents explained:

> *"Both projects in which we were involved were very interdisciplinary in their nature and combined know-how from very different research areas. Innovation happens often in interfaces..."*

> *"Stem cell based technologies will gradually come to all areas of regenerative medicine. It would be extremely important to maintain the knowledge level and feed spinoff companies with the newest knowledge. We need more people who have the skills and are willing to go to the commercial side of the biomaterials and stem cell use."*

According to the respondents, the actors important in "orchestrating" the biomaterials field in Finland are the universities of Turku, Tampere, Helsinki, hospitals and doctors involved in R&D, bigger industry players, research groups and universities with spin-offs, Tekes/Sitra and Academy of Finland, Bayer.

The respondents were mostly modest when assessing the **effects of their projects on the Finnish innovation ecosystem**. One person believed that the project contributed to the development of Finland's R&D system to a large extent and the same level of effect was believed by one participant regarding the effect of the project on the competitive ability of the Finnish R&D ecosystem. Three respondents brought out that the project helped the Finnish researchers to get a glimpse of the business life to quite a large degree. The effect was believed to be small or average when assessing the creation of national networks, international networks, Finland taking a bigger role in international biomaterials market, increasing income and profit, important innovations and business practices. Regarding other effects, one of the respondents wrote:

> *"Benefits of research results for other research and business areas was very important."*

E.3.3 Support from Tekes

When discussing the **benefits of information/education received from Tekes**, on average, the respondents found information about the thematic area the most beneficial, which was followed by the biomaterials market evaluation reports and market analyses and information concerning the funding opportunities. On the other hand, licensing know-how, distribution strategies know-how, help in establishing international networks and help in getting involved in international networks received the lowest scores.

When rating the importance of Combio regarding various aspects, five respondents found that the programme had quite an important role in increasing the competitiveness of the Finnish biomaterials sector and the same number found Combio either quite important or very important in achieving the project results of the organisation. For other roles (revenue growth, employee number growth, value-added etc.) three people found it quite or very important, thus the distinction in the results cannot be made. On the opposite side, only one person found that the programme was somewhat important in facilitating change in the organisation's operating practices and three mentioned that it was not very important.

Working with Tekes mostly received good or very good feedback, in some cases excellent. Working with Tekes people on project application and project reporting was most often noted as good, very good or excellent (five respondents for both). On the other hand, one person noted that getting support for finding project partners in the industry outside Finland was poor as well as finding project partners in research outside Finland was noted poor one time. Also, help with dissemination activities received one poor grade.

E.3.4 Overall satisfaction with the programme

None of the respondents were very dissatisfied with the Combio programme. Two respondents were very satisfied, two were moderately satisfied, one was neutral and one was moderately dissatisfied. A comment left to the question mentioned: "Very happy with Tekes cooperation as such."

> *"Advisors were helpful and necessary for us. The funding was absolutely important but stopped quite abruptly when animal experiments were almost at the end."*

E.3.5 Future support

When talking about the future, some respondents stated the following:

> *"Why cannot Tekes arrange a network of people like myself (who's done it, have experience) to consult and connect. When I need advice, I call groups which I recognise as players in the field. I call and ask if they'd like to be involved as advisors. I pay them a little for once a month to have a teleconference call or a meeting. I am flying to Miami to meet a guy who took a company to the stock market, then sold a company, retired."*

> *"When we were introduced to Combio, I had a difficulty at the beginning to understand what it was about and what was its purpose. Not to make it too tight of course."*

> *"They should rethink about funding this kind of research area in Finland again and put some more effort in funding this research area and companies in this area. All the governmental sources are brought more closely together. If one is supporting research the others should support the startup companies. If we think about the fact that how many biomaterials companies exist in Finland. All the research in Turku was cut out of funding. That was quite dramatic decision which we were wondering from … they were left without funding and this is the only area where we also had some functioning companies. If you compare Finland and Sweden there are many companies. Gothenburg they manage and they have 30-40 companies."*

Tekes' Reports in English

5/2016 Striving toward a vibrant ecosystem – Evaluation of Tekes' Combio, BioIT and Trial programmes. Peter Varnai, Jelena Angelis, Marja Tähtinen, Sofie Pollin, Pasi Malinen and Tomas Åström. Evaluation Report. 120 p.

4/2016 Towards material excellence – Evaluation of Tekes' programmes on materials. Juhani Timonen, Markku Antikainen, Amit Das, Essi Sarlin and Jyrki Vuorinen. Evaluation Report. 59 p.

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