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The Impact of Tekes Activities on Wellbeing and Environment

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A study by Technopolis B.V., VTT and Statistics Finland

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Tekes – the Finnish Funding Agency for Technology and 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

Finnish wellbeing is based on the wealth and jobs created by the success of Finnish companies on the global market. In terms of wellbeing, Finland ranks among the top countries according to several different indicators.

The impact of Tekes activities on the wellbeing in society, the environment and climate change can often only be noticed after a long time and through indirect mechanisms. The preconditions for the positive impacts that are now visible were established years or decades ago, and today's activities will create the preconditions for future development. This makes it challenging to set impact targets and to assess the impacts, which accordingly requires additional investments.

As an example, the long-term and still increasing investments in energy and health technology are reflected in Finland's strong role in the export of these technologies. In a comparison of the EU countries, Finland is one of the leading exporters of energy technology. Moreover, the export of health technology is increasing rapidly.

This impact study was carried out by Technopolis Group and VTT. The main question of the study is how Tekes activities have practically succeeded to improve well-being and environment in Finland? Impact assessment showed that societal impacts perceived higher from projects in which Tekes had a significant role. Moreover, the role of Tekes in producing societal impacts strongly relates to Tekes ability to create networks, add relevant partners to project consortiums and to enable the usage of relevant outside resources. Also case studies present innovations, developed and commercialized by companies receiving Tekes support, which have significant impacts on environment and wellbeing.

Tekes wishes to thank the evaluators for their thorough and systematic approach. Tekes expresses its gratitude to steering group, those who were interviewed, and all others that have contributed to the evaluation.

Helsinki, April 2014

Tekes

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Long summary in English

Introduction

This report presents results of an impact assessment of Tekes on environment and wellbeing, performed by Technopolis Group, VTT and Statistics Finland. This study has a focus on the societal contribution of Tekes, and tries to identify long-term societal impacts of research and innovation.

Positive contribution on the state of environment and human wellbeing is one the three principal impacts Tekes aims to generate. According to its mission statement "Tekes promotes the development of industry and services by means of technology, innovations and growth funding. This helps to renew industries, increase the value added and productivity, improve the quality of working life, as well as boost exports and generate employment and wellbeing."

The main focus of Tekes is economic ("development of industry and services"), but over the years environment and wellbeing have become explicit objectives in the Tekes strategy and Tekes has a long track record in developing programmes with some kind of other societal goal. The strategic considerations were a mix between 'supporting companies in grasping commercial opportunities that societal issues offer' and 'tackling social challenges'. Tekes not only provides grants and loans to reduce the risks of R&D and innovation, but also has much attention for improving the capabilities within the Finnish society to initiate and achieve successful innovations.

In the figure on page 9 Tekes mission, goals and activities are schematically represented.

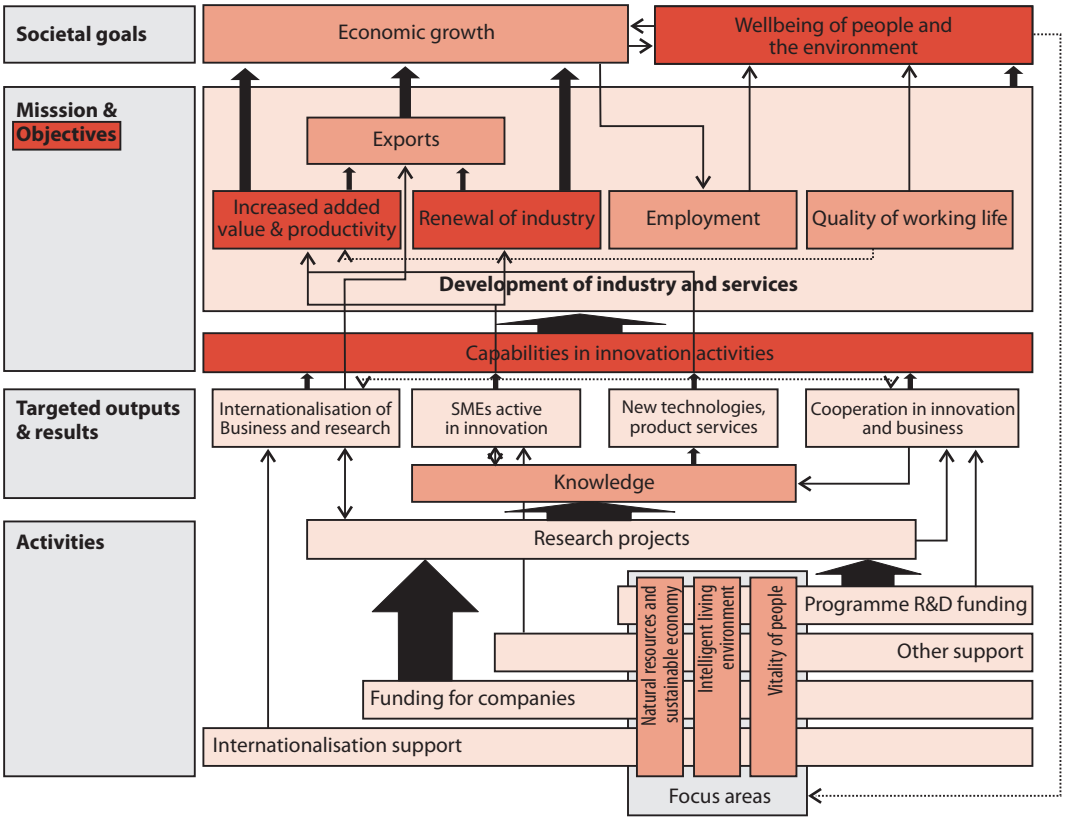
Tekes' activities are focused around 6 focus areas 'in which Finnish companies and research carried out in Finland have significant potential on the horizon', 3 of these areas directly relate to environment and wellbeing: 'Natural resources and sustainable economy' (environment), 'Intelligent living environment' (environment and wellbeing) and 'Vitality of people' (wellbeing). The focus areas in their turn are 'guiding programme activities', i.e. they play a large role in the development of and choice for research programmes with participation of research groups from industry as well as from the research world.

Environment has been an important topic for Tekes since the 1990s. Environmental projects were supported both inside focused programmes as well as in normal Tekes support outside the programmes.

Between 2000 and 2011, Tekes invested approximately €75 million in the area of wellbeing, esp. in the development of medical devices and the pharmaceutical industry. From 2008 Tekes' focus in wellbeing was broadened to social and health services. This reflects the transition in the health sector that is currently taking place: innovation is approached more from an open or collaborative model than the closed internal models of the past. The Tekes 'Innovations in Social and Healthcare Services programme' (2008-2013) is an early example of this change.

In this study the focus was on 7 programmes from the period 2006–2015 in the area of environment (BioRefine, Fuel Cell, Functional Materials, Groove, Sustainable Community, Symbio and Water) and two programmes with a specific wellbeing focus (Innovations in Social and Healthcare Services, Pharma).

Somewhat surprisingly maybe, all these programmes (the environment and wellbeing programmes), except one (the Innovations in Social and Health care services programme), have no explicit goals for environment or wellbeing. The programme goals of the environment and wellbeing programmes are all related to knowledge and networks for new products and services, new business concepts and new business. Other Tekes programmes (without specific focus in this area) might also have impacts on Finnish environment and/or wellbeing. The focus in this study was on the effects of this specific set of programmes, but comparison was made with other programmes where possible.



Approach and methodology

In the assessment we have used a systems perspective of innovation. The systems character of innovation makes it difficult to measure impacts from innovation programmes: innovation is not always straightforward and innovation pathways are often indirect, especially when one wants to determine impact at the level of society, and from the perspective of societal value. There are many indicators and indices available on society and wellbeing and research and innovation activities and their results are well described by RDI-indicators, however the link between these two worlds seems to be missing. Challenging issues are **attribution** of innovations to a specific source or programme; **timing** since it generally takes a long time for value (impact) to be created as a result of innovation and innovation programmes and **additionality** of Tekes activities Finally there is an issue of **comparability**: How to make the approach suitable for comparisons of different situations?

This study builds on a social impact assessment model for Tekes activities developed in a previous study. The model describes the various possible outputs and impacts well, but does not explicitly describe the links between inputs, outputs, outcomes and impacts (i.e. the innovation pathways) either. In order to further elaborate the impact assessment model we used four research methods in this study.

- In the first place we analysed the self-reporting data from post-completion questionnaires of projects supported by Tekes. In these questionnaires the respondents are requested to assess (among other things) whether the project has had societal impacts.
- Furthermore we made a comparison (statistical analysis) of innovation expenditures, innovation results and company growth between companies in the field of environment and wellbeing that were supported by Tekes, companies that were outside the field of environment and wellbeing that were supported by Tekes and companies not supported by Tekes.

- In the third place we have conducted case studies to examine the magnitude of impact per innovation in absolute terms (e.g. tons of CO2 reduced, or size of population receiving cure to a particular health issue) and the role of Tekes (impact mechanisms).
- Finally we compared the performance of Finland in the area of environment and wellbeing by looking at international composite indices for these fields. This does directly relate to the efforts of Tekes, but places the data on environment and wellbeing in a global perspective.

Results

Post-completion questionnaires

The statistical analysis (logistic regression) of post-completion project questionnaires highlights that societal impacts were perceived higher from projects in which Tekes had a significant role. Particularly for industry projects the intervention of Tekes increased the probability that the project had perceived societal impacts. The Tekes impact variables included were:

- All projects: Tekes impact on project challenge level, Tekes impact on project using outside resources, Tekes impact on the number of project partners and Tekes impact on project overall.
- Industry projects: Tekes impact on project using outside resources, Tekes impact on the number of project partners and Tekes impact on project overall.
- For research projects the impact of Tekes was found statistically irrelevant.

We may conclude that the role of Tekes in producing societal impacts strongly relates to Tekes ability to create networks, add relevant partners to project consortiums and to enable the usage of relevant outside resources. This suggests that Tekes has impacted firm behaviour (Behavioural additionality) through its intervention and created positive changes in how networks are created. This behavioural additionality appears to be positively linked with generation of societal impacts.

Statistical comparison of company performance

In the statistical analysis the unit of study is the company, not the programme or the project, because broader statistical data are only available for companies. The performance of companies that received Tekes support in the environment and wellbeing programmes was compared with performance of firms that received support from Tekes outside the environment and wellbeing programmes (including individual support) and with companies not being Tekes clients in 1992-2012.

The statistical data include the following company level data:

- R&D Surveys: in-house R&D, R&D persistence; 2000-2011
- Patent data: Domestic patent applications; 1985-2011
- Patent data: Patents granted by the United States Patent and Trademark Office, USPTO; 1985-2009
- Business register: number of employees, turnover, sector, exporting; 2000-2011
- Innovation Survey CIS2010: new-to-market innovations; 2008-2010

Comparison was done with various advanced statistical techniques, comparing different periods (2004-2007 and 2008-2011) and different support modes (loans and grants)

A significant positive effect of Tekes support on companies has been found within samples studies. Tekes support improves or increases supported companies' innovation input (the share of R&D expenditures in turnover), innovation output (new-to-market innovations) and growth rates. These results are in line with earlier impact studies.

The effects of grants and loans may, in some time periods, have opposite effects, which may hinder the finding of the effects of total support. The main conclusion concerning the impact of grants and loans is that grants contribute to the creation of new technological inventions (proxy: patents and new-to-market innovations), and loans have a more direct impact on the economic success on the market (growth, profit). Because markets are hit by the economic crisis from 2008 onwards, loans rather than grants have a significant effect on the R&D intensity and growth rates of supported companies. This should not be interpreted so that grants have lost their economic impact. Grants and loans are complementary instruments over the innovation process. Large firms receive mostly grants through their participation in collaborative research projects. But a large majority of SME's use both instruments anyway: the combination of loans and grants probably varies depending on which innovation phase supported projects are at a specific point of time. A more detailed analysis should be made on the effects of their different combinations.

The main target of this study was to analyse whether Tekes support has innovation input and output additionality for companies participating in environmental and welfare programmes. Because of the small size of observations of companies in welfare programmes and at the same time in the R&D Surveys, these companies had to be dropped from the analysis. By using a matching procedure based on the propensity scores of the predicted probability mass function, we found evidence of the effect of Tekes support on supported companies' R&D intensities, growth rates, patents granted and innovations. Often these findings can be seen just after a few years. We used two period treatment effect models (probit models) where the mean performance in the latter period was explained with the earlier and the latter period treatments. Because treatments are shown to have a measurable impact on companies R&D intensities, growth rates and innovations, they with a high probability also affect the environmental impacts of these companies.

Case study results

The purpose of the case study analysis has been to create information which complements the statistical analysis with more qualitative view on the mechanisms through which Tekes can generate impacts on wellbeing and environment. The cases have been selected to cover (1) environmental and wellbeing related innovations, (2) tangible products and services, and (3) stand-alone innovations and more system level concepts. The table below summarises the cases and key findings.

Innovation	Characteristics	Impacts on wellbeing / environment	Tekes contribution
Lactose-free milk by Valio	Product innovation by a large firm Stand-alone technological innovation	Wellbeing impacts: health benefits within a population group with specific dietary limitations (lactose intolerance) Impacts with international scale covering Northern Europe	Financial support through SymBio programme Tekes contributed to improvement of collaboration with research organisations Support from top management to continue R&D work with help of Tekes funding
Net zero energy building by Järvenpään Mestariasunnot	System-level ("architectural") innovation by a small firm Enabled demonstration of supplier innovations upstream	Environmental impacts: improved energy efficiency at the local scale High potential to diffuse due to regulatory drivers (energy efficiency in buildings directive)	Financial support to concept development (input additionality) through Sustainable Community programme Tekes support enabled subcontracting of external expertise (output additionality) Co-contribution with other public funding agencies
Biodiesel by Neste Oil	Radical product and process innovation by a large corporation	Environmental impacts: significant reduction of CO_2 emissions on a global scale	Financial support to technology development through BioRefine programme Tekes contribution to technology development, search for raw material options, testing and verification
Kotitori home care service integrator by City of Tampere	Service innovation by a municipality Novel concept for integrating public and private services Public procurement of service innovation	Wellbeing impacts: improved accessibility and productivity of social services Local scale, little cross-sectoral or geographical diffusion so far	Financial support to concept development through FinnWell programme (input additionality) Expert support during the process (output additionality) Tekes the main external contributor
Water quality monitoring system by Liqum	Technology-based service innovation by a small firm	Environmental impacts: improved monitoring capability of environmental risks Small user base on a national scale within several industrial sectors, nascent export activities	Financial support through Water programme The contribution of Tekes is mainly input additionality
Traumakine™ by Faron Pharmaceuticals	Development of a new medicine by a small firm	No impacts yet, medicine is in phase of clinical trials	Financial support (loans) for clinical trails, and YIC grant. Support also enabled international networking necessary for further (EC) financing

The case study analysis provides the following observations:

- It is possible to identify innovations, developed and commercialised by companies receiving Tekes support, which have significant impacts on environment and/or wellbeing. In each case analysed, Tekes support was perceived to have played an important role. As the cases were intentionally selected to represent innovations with a strong link with Tekes it is not possible to generalise from them about the frequency of the impacts in statistical terms. However, cases provide valuable insight into identification of plausible mechanisms through which impacts may occur.
- The primary mechanisms through which Tekes activities contribute to wellbeing and environmental impacts are financial support to generation and diffusion of technological knowhow and innovation capabilities in firms. These capabilities transform to impacts through creation, development and commercialisation of innovative products and services with positive effects on environmental sustainability and individual wellbeing and adoption of these innovations by users.
- For large companies the financial support from Tekes does not appear to be equally important as to SMEs. Tekes support however gives credibility to a project, which in its turn increases the likelihood that such a project is funded and supported internally. It also has provided external credibility among potential users, stakeholders, and public authorities responsible for environmental regulation and public social and health care service provision.
- Tekes financial support is important for realising long-term research collaboration (financing of academic or institute research). Tekes support to long-term research programmes and collaboration with research organisations have played a key role in building necessary capabilities for innovation. This has contributed to renewal of Finnish industry towards more ecologically sustainable products.
- For SMEs the Tekes funding is more important for complementing insufficient financial resources, thus generating input additionality.
- Financial support alone is generally not enough to realise fast growth and important societal impacts. This is related to the barriers for market access, immature markets and innovation diffusion. Even if SMEs are able to overcome risks of failure it takes more time for them to grow to a sufficient scale. Tekes market pull support, especially in the semi-public markets of environment and wellbeing could be important. Supporting public procurement of innovation is becoming an established approach. Sophisticated use of other forms of demand-side innovation policies (regulation, standards) are still in a nascent stage.
- The total magnitude of impacts is largely a function of the number of users adopting a particular innovation with positive impacts on environment or wellbeing. With their large production capacity, delivery channels and marketing capabilities large companies are in a better position to diffuse innovation successfully to a large user base than SMEs, thus generating larger total magnitude of impacts.
- Tekes impacts on wellbeing and environment are dependent on the success of new products, processes and organizing models not only being developed but also adopted in significant scale. Two cases analysed, biodiesel by Neste Oil and lactose-free milk by Valio, have been successfully commercialized and their production scaled up to the level where they have a significant and measurable impact on environment and wellbeing.
- In the area of environment and wellbeing the necessary capabilities needed might even be larger than outside these domains because there are in these domains significant institutional barriers (care sector), financial barriers (costs of clinical trials in pharmaceuticals) and regulatory barriers (or lack of regulatory drivers for environment).
- The scale and speed of innovation adoption is largely dependent on whether a market for an innovative product readily exists or not. Within the cases analysed, only one innovation had a rather direct route to existing markets with well-articulated user needs (Valio). In other cases the market for innovative product did not exist but it had to shape up before diffusion was possible, thus delaying generation of impacts. For one case the diffusion is still at a very early stage (Kotitori) and it remains to be seen how broadly it will eventually become scaled-up.
- For environmental innovations the key driver for new market creation has been introduction of new or tighter regulation. For wellbeing it was not possible to identify any single key driver for market emergence. The dynamics appear to be rather different for consumer demand (e.g. food with health claims), regulated demand (pharmaceuticals), or institutional demand (public and private health and social care services).

International comparison

According to various international indices Finland is among the top performing countries in the world in the area of well-being. Wellbeing has however only recently become an area of specific attention for Tekes and in the past ten years only a limited number of projects with (positive) wellbeing effects has been found. In most of these projects SMEs have been supported, and more recently also the public health and social services have become eligible for support. Tekes attention for this is welcomed but the optimal role of Tekes is not yet clear. Effects on a macro-level can, because of present small size of the Tekes activity and lack of data not be attributed to Tekes.

In the field of environment high material consumption, fairly low energy-efficiency and high GHG emissions, which result from energy intensive industrial sectors, freight transportation and traffic as well as extensive earthworks and hydraulic engineering, put large pressure on ecosystems in Finland. Finland has however been placing a lot of emphasis on solving this issue. There have been a large number of Tekes-programmes in this area. The analysis of projects supported by Tekes highlighted the positive impact of Tekes intervention on the probability that the project had perceived societal impacts. In recent years, at project level, impact on energy efficiency and materials efficiency becomes apparent. This effort is apparent in the European eco-innovation index where Finland ranks no 1, especially because of strong eco-innovation inputs. From innovation to environmental impact is however a long process and a relation between Tekes projects and the state of the environment in Finland cannot (statistically) be made.

Switzerland and Sweden are countries that are consistently in high positions in all rankings. Although these kind of composite index scores are always open for debate, we have looked at innovation policies in Switzerland and Sweden.

It is striking to see that the systems for innovation support in these two well-performing countries are so different. Where Switzerland has small agencies, with fairly small budgets that do not follow strong thematic policies, Sweden is more like Finland with strong agencies with fairly large budgets and thematic agendas. In both countries (and in contrast with Finland) the attention of government policy for the interaction between companies and knowledge infrastructure is limited. If there is a theme that is supported in both countries it is environment/sustainability. Wellbeing has received significant attention in Sweden. In Sweden there are a set of demand side policy measures to support eco-innovative activities, products and services. Several regulations, performance standards, tax incentives, tax reductions and demand subsidies are in place to help consumers to purchase more environmentally efficient products.

Tiivistelmä

Johdanto

Raportissa arvioidaan Tekesin toiminnan vaikutuksia ympäristöön ja hyvinvointiin. Vaikutusarvioinnin ovat suorittaneet Technopolis Group, VTT ja Tilastokeskus. Siinä pyritään tunnistamaan, miten Tekesin tuki tutkimukselle ja innovaatiotoiminnalle tuottaa pitkänä aikavälin yhteiskunnallisia vaikutuksia.

Myönteiset ympäristö- ja hyvinvointivaikutukset ovat yksi kolmesta Tekesin vaikutustavoitteesta. Toiminta-ajatuksensa mukaisesti "Tekes edistää teollisuuden ja palvelujen kehittymistä teknologian, innovaatioiden ja kasvurahoituksen keinoin. Tämä uudistaa elinkeinoja, kasvattaa jalostusarvoa, tuottavuutta ja työelämän laatua, lisää vientiä sekä luo työllisyyttä ja hyvinvointia."

Vaikka Tekesin toiminnan pääpaino on taloudellisissa vaikutuksissa ("teollisuuden ja palveluiden kehitys"), ovat myös ympäristö ja hyvinvointi määritelty strategisiksi tavoitteiksi. Tekesillä on jo pitkään ollut ohjelmia, jotka pyrkivät edistämään yhteiskunnallisia päämääriä. Yhtäältä on tuettu yrityksiä tarttumaan ympäristöön ja hyvinvointiin liittyviin kaupallisiin mahdollisuuksiin. Toisaalta on pyritty vastaamaan yhteiskunnallisiin haasteisiin. Tutkimus- ja innovaatiotoiminnan riskejä jakavan rahoituksen lisäksi Tekes on pyrkinyt parantamaan suomalaisen yhteiskunnan kyvykkyyksiä innovaatioiden synnyttämiseen ja käyttöönottoon.

Tekesin toiminta on painottunut kuuteen sisällölliseen painopisteeseen, joista kolme liittyy suoraan ympäristöön ja hyvinvointiin: luonnonvarat ja kestävä talous, älykäs elinympäristö sekä elinvoimainen ihminen. Painopisteet suuntaavat Tekesin ohjelmia, joiden sisältö kehitetään yhdessä yritysten ja tutkimusyhteisön kanssa.

Ympäristö on ollut tärkeä teema Tekesille 1990-luvulta lähtien. Ympäristöön liittyviä hankkeita on tuettu sekä aiheeseen liittyvien ohjelmien puitteissa että Tekesin ohjelmien ulkopuolella rahoitettavissa hankkeissa.

Vuosien 2000 ja 2011 välillä Tekes investoi noin 75 miljoonaa euroa hyvinvointiin. Alkuvaiheessa painopiste oli erityisesti terveysteknologiassa ja lääkekehityksessä. Vuoden 2008 jälkeen Tekesin fokus laajentui myös palveluihin. Muutos heijastelee laajempaa siirtymää terveyssektorilla suljetuista kehitysmalleista avoimeen yhteiskehittelyyn. Innovaatiot sosiaali- ja terveyspalveluissa -ohjelma (2008–2013) on esimerkki uudenlaisesta panostuksesta hyvinvointisektoriin.

Tässä selvityksessä analysoitiin aikajaksolta 2006–2015 seitsemää ympäristöön liittyvää ohjelmaa (BioRefine, Polttokennot, Toiminnalliset materiaalit, Groove, Kestävä yhdyskunta, Symbio ja Vesi) sekä kahta hyvinvointiin kohdistunutta ohjelmaa (Innovaatiot sosiaali- ja terveyspalveluissa, Pharma).

Ohjelmien tavoitteita koskevasta analyysistä käy ilmi, että yhtä lukuun ottamatta (Innovaatiot sosiaali- ja terveyspalveluissa) ohjelmille ei ole asetettu eksplisiittisiä ympäristöön tai hyvinvointiin liittyviä tavoitteita. Ympäristö- ja hyvinvointiohjelmien tavoitteet liittyvät osaamisen, verkostojen, liiketoimintakonseptien ja liiketoiminnan kehittämiseen. Kuitenkin myös muilla Tekes-ohjelmilla ja rahoituksella voi olla vaikutuksia ympäristöön ja hyvinvointiin. Tässä selvityksessä päähuomio oli hyvinvointiin ja ympäristöön kohdistuneiden ohjelmien vaikutuksissa, mutta niitä on vertailtu muihin ohjelmiin siltä osin kuin mahdollista.

Lähestymistapa ja menetelmät

Arvioinnissa on hyödynnetty innovaatiojärjestelmiä koskevaa lähestymistapaa. Innovaatiotoiminnan systeeminen luonne vaikeuttaa ohjelmien vaikutuksen mittaamista: innovaatioprosessit eivät aina etene suoraviivaisesti ja niiden kehityskulut ovat usein epäsuoria. Erityisesti yhteiskunnallisten vaikutusten ja lisäarvon määrittely on haastavaa. Lukuisia ympäristöön ja hyvinvointiin sekä tutkimus- ja innovaatiotoimintaan liittyviä

indikaattoreita on olemassa, mutta niiden väliset linkit eivät ole selviä. Haasteellisia kysymyksiä ovat innovaatioiden **yhdistettävyys** tiettyyn tuki-instrumenttiin tai ohjelmaan; **ajoitus** johtuen vaikutusten syntymisen pitkästä aikajänteestä; Tekesin toimenpiteiden **lisäarvon** (additionaliteetti) todentaminen; sekä **vertailtavuus** eri tilanteiden välillä.

Tässä vaikutusarvioinnissa kehitetään edelleen aiemmassa selvityksessä luotua Tekesin ympäristö- ja hyvinvointivaikutuksia koskevaa mallia. Alkuperäisessä mallissa kuvataan tuotokset ja vaikutukset, mutta linkkejä panosten, tuotosten ja vaikutusten välillä innovaatioprosessien mukaisesti ei ole määritelty kovin tarkkaan. Mallin edelleen kehittämiseksi tässä vaikutusarvioinnissa hyödynnettiin neljää rinnakkaista tutkimusmenetelmää.

- Ensiksi analysoitiin Tekesin rahoittamien hankkeiden jälkiraportointiaineistot. Jälkiraportointikyselyissä on muiden kysymysten ohessa tiedusteltu vastaajien arviota hankkeen yhteiskunnallisista vaikutuksista.
- Toisessa analyysiosiossa on tehty tilastollinen vertailtu innovaatiorahoituksen, innovaatiotoiminnan tulosten sekä yritysten kasvun osalta. Tarkastelussa on vertailtu Tekesin tukea saaneita ympäristö- ja hyvinvointialojen yrityksiä, Tekesin tukea saaneita muita yrityksiä sekä yrityksiä, jotka eivät ole saaneet Tekesin tukea.
- Kolmas aineisto koostuu tapaustutkimuksista, joissa on otettu huomioon myös yhteiskunnallisten vaikutusten suuruus (esim. CO_2-päästöjen vähennys tonneina, väestön koko joka on saanut hoidon terveydelliseen ongelmaan) sekä Tekesin rooli (vaikutusmekanismit).
- Viimeisenä on tarkasteltu Suomen suorituskykyä ympäristöä ja hyvinvointia kuvaavissa kansainvälisissä vertailuissa. Vaikka näillä arvioilla ei olekaan suoraa yhteyttä Tekesin toimintaan, asettavat ne ympäristön ja hyvinvoinnin kehitystä koskevat tiedot kansainväliseen kontekstiin.

Tulokset

Jälkiraportointikysely

Jälkiraportointiaineistosta tehty tilastollinen tarkastelu (logistinen regressioanalyysi) osoittaa, että yhteiskunnalliset vaikutukset koetaan korkeina projekteista, joissa Tekesillä on ollut merkittävä rooli. Erityisesti yrityshankkeissa Tekesin interventio lisäsi todennäköisyyttä myönteisten yhteiskunnallisten vaikutusten syntymiselle. Tekesin vaikutusta kuvaavat muuttujat olivat:

- Kaikki hankkeet: Tekesin vaikutus hankkeen haasteellisuuteen, Tekesin vaikutus ulkopuolisten resurssien hyödyntämiseen, Tekesin vaikutus yhteistyökumppanien määrään ja Tekesin merkitys hankkeelle.
- Yrityshankkeet: Tekesin vaikutus ulkopuolisten resurssien hyödyntämiseen, Tekesin vaikutus yhteistyökumppanien määrään, Tekesin merkitys hankkeelle.
- Tutkimushankkeiden osalta Tekesin vaikutus ei ollut tilastollisesti merkitsevä.

Tulosten pohjalta voidaan päätellä, että Tekesin rooli yhteiskunnallisten vaikutusten synnyttämisessä liittyy vahvasti sen kykyyn luoda verkostoja, tuoda relevantteja kumppaneita mukaan hankekonsortioihin sekä mahdollistaa ulkopuolisen osaamisen hyödyntäminen. Tämä viittaa siihen, että Tekesin toimenpiteet ovat vaikuttaneet yritysten käyttäytymiseen (behavioural additionality) ja myönteisesti vaikuttaneet verkostojen syntymiseen. Tämä käyttäytymisen muutos näyttää olevan yhteydessä myönteisten yhteiskunnallisten vaikutusten syntymiseen.

Yritysten suorituskyvyn tilastollinen vertailu

Tilastollisen analyysin perusyksikkönä käytettiin yritystä (ei ohjelmaa tai hanketta), sillä laajapohjainen tilastoaineisto on saatavilla vain yritysten osalta. Siinä vertailtiin Tekesin ympäristö- ja hyvinvointialan ohjelmiin osallistuneiden yritysten suorituskykyä sellaisiin yrityksiin, jotka eivät osallistuneet näiden alojen ohjelmiin sekä yrityksiin, jotka eivät ole saaneet Tekesiltä rahoitusta vuosina 1992–2012.

Tilastoaineisto sisältää seuraavat yrityskohtaiset tiedot:

- T&k-kyselyt: yrityksen suorittama t&k, t&k-toiminnan jatkuvuus; 2000–2011
- Patenttiaineisto: kotimaiset patenttihakemukset; 1985–2011
- Patenttiaineisto: Yhdysvalloissa myönnetyt patentit, USPTO; 1985–2009
- Yritysrekisteri: työntekijämäärä, liikevaihto, toimiala, vienti; 2000–2011
- Innovaatiokysely CIS2010: markkinoille uudet innovaatiot; 2008–2010

Tarkastelu suoritettiin hyödyntäen tilastollisia menetelmiä vertaillen eri aikajaksoja (2004–2007 ja 2008–2011) sekä eri tukimuotoja (lainat, avustukset).

Tekesin tuella havaittiin olevan merkittävä myönteinen vaikutus otoksen yrityksiin. Tekesin tuki parantaa tai lisää tuettujen yritysten innovaatiotoiminnan panoksia (t&k-panosten osuus liikevaihdosta), innovaatiotoiminnan tuloksia (uudet tuotteet) sekä kasvuvauhtia. Nämä havainnot ovat yhdenmukaisia aiempien vaikutusarviointien tulosten kanssa.

Avustuksilla ja lainoilla havaittiin joinain ajanjaksona olevan vastakkaisia vaikutuksia, mikä vaikeuttaa tuen kokonaisvaikutusten havainnointia. Avustusten ja lainojen vaikutusten vertailua koskeva johtopäätös on, että avustukset vaikuttavat uusien keksintöjen syntymiseen (patenttien ja innovaatioiden määrällä mitaten), kun taas lainoilla on suorempi vaikutus yrityksen taloudelliseen menestykseen (kasvu ja kannattavuus). Koska vuoden 2008 jälkeen taloudellinen taantuma on vaikuttanut voimakkaasti markkinoihin, lainoilla on ollut avustuksia vahvempi vaikutus tuettujen yritysten t&k-intensiteettiin ja kasvuvauhtiin. Avustukset ja lainat ovat toisiaan täydentäviä instrumentteja innovaatioprosessissa. Suuret yritykset ovat saaneet Tekesiltä pääosin avustuksia osallistuessaan tutkimusyhteistyöhön. Valtaosa pk-yrityksistä käyttää molempia instrumentteja: avustusten ja lainojen yhdistelmä kunakin aikana riippunee siitä, missä vaiheessa innovaatioprosessia tuetut hankkeet ovat. Jatkossa on tarpeen suorittaa yksityiskohtaisempia tarkasteluja tukiyhdistelmien vaikutuksista.

Tämä selvityksen päätavoite on ollut analysoida, onko Tekesin tuella innovaatiotoiminnan panoksiin ja tuotoksiin liittyvää lisäarvoa (additionaliteetti) yrityksille, jotka osallistuvat ympäristö- ja hyvinvointialan ohjelmiin. Johtuen hyvinvointialan ohjelmiin osallistuneita yrityksiä koskevien havaintojen pienestä määrästä nämä yritykset jouduttiin jättämään pois tilastollisesta analyysistä. Soveltamalla vastaavuuspisteiden (propensity scores) perusteella suoritettua parivertailumenetelmää löytyi näyttöä Tekesin tuen vaikutuksista yritysten t&k-intensiivisyyteen, kasvunopeuteen, patentointiin ja innovaatioihin. Usein nämä vaikutukset näkyvät vain muutaman vuoden kuluttua. Selvityksessä käytettiin kahden havaintokauden vaikutusmallia (probit), jossa jälkimmäisen kauden keskimääräistä suorituskykyä selitettiin aiemman ja jälkimmäisen vaiheen tuki-interventiolla. Koska interventioilla osoitettiin olevan mitattavissa olevia vaikutuksia yritysten t&k-intensiteettiin, kasvunopeuteen ja innovaatioihin, niillä on suurella todennäköisyydellä myös vaikutus näiden yritysten ympäristövaikutuksiin.

Tapausanalyysin tulokset

Tapausanalyysin tavoitteena on tuottaa laadullisiin menetelmiin pohjautuvaa tietoa Tekesin ympäristö- ja hyvinvointivaikutusten syntymisen mekanismeista, joka täydentää tilastollista analyysiä. Tapaukset on valittu siten, että ne kattavat (1) ympäristöön ja hyvinvointiin liittyviä innovaatioita, (2) konkreettisia tuotteita ja aineettomia palveluita, sekä (3) itsenäisiä innovaatioita ja järjestelmätason toimintakonsepteja. Seuraavalla sivulla olevassa taulukossa on yhteenveto tapauskohteista ja analyysin päähavainnoista.

Tapausanalyysien perusteella voidaan tehdä seuraavia päätelmiä:

- On löydettävissä merkittäviä ympäristöön ja/tai hyvinvointiin vaikuttavia innovaatioita, jotka ovat Tekesin tukea saaneiden yritysten kehittämiä. Kaikissa analysoiduissa tapauksissa Tekesin tuella oli ollut merkittävä rooli. Koska tapaukset oli tarkoituksella valittu edustamaan innovaatioita, joilla on vahva linkki Tekesiin, ei näiden havaintojen pohjalta voida tehdä yleistyksiä vaikutusten yleisyydestä tilastollisessa mielessä. Tapausanalyysit tarjoavat kuitenkin arvokasta tietoa mekanismeista, joiden kautta vaikutukset voivat syntyä.
- Pääasiallinen mekanismi, jonka kautta Tekesin toiminta tuottaa hyvinvointiin ja ympäristöön liittyviä vaikutuksia, on taloudellinen tuki uuden teknologisen tietotaidon ja innovaatiokyvykkyyksien luomiseen ja leviämiseen. Nämä kyvykkyydet muuntuvat hyvinvointi- ja ympäristövaikutuksiksi innovatiivisten tuotteiden ja palveluiden kehittämisen, kaupallistamisen ja käyttöönoton avulla.
- Suurille yrityksille Tekesin taloudellinen tuki ei ole ollut yhtä tärkeää kuin pk-yrityksille. Tekesin tuki antaa tuotekehitysprojektille kuitenkin uskottavuutta, mikä parantaa sen menestysmahdollisuuksia yrityksen sisällä. Se voi myös lisätä ulkopuolista uskottavuutta potentiaalisten käyttäjien ja sidosryhmien keskuudessa sekä ympäristölainsäädännöstä ja julkisista hyvinvointipalveluista vastaavien viranomaisten tahoilla.
- Tekesin taloudellinen tuki on tärkeää pitkän aikavälin tutkimusyhteistyön toteutukselle yliopistoissa ja tutkimuslaitoksissa. Tekesin tuki tutkimusohjelmiin ja yhteistyöhön tutkimusorganisaatioiden kanssa on ollut tärkeässä roolissa keskeisten osaamisten rakentamisessa. Tämä on edesauttanut suomalaisen teollisuuden uudistumista kohti ekologisesti kestävämpiä tuotteita.

Innovaatio	Ominaispiirteet	Vaikutukset hyvinvointiin / ympäristöön	Tekesin kontribuutio
Laktoositon maito, Valio	Suuren yrityksen tuote-innovaatio Itsenäinen teknologinen innovaatio	Hyvinvointivaikutukset: terveys-hyödyt ruoka-ainerajoitteita omaaville ihmisille (laktoosi-intoleranssi) Kansainväliset vaikutukset Pohjois-Euroopan tasolla	Tekesin taloudellinen tuki SymBio-ohjelmasta Tekesin tuki edesauttoi yhteistyön kehittymistä tutkimusorganisaatioiden kanssa Tekesin tuki lujitti yrityksen sisäistä tukea t&k-toiminnan jatkamiseen
Nollaenergiatalo, Järvenpään Mestariasunnot	Pienen yrityksen järjestelmätason innovaatio Mahdollistanut toimittajayritysten innovaatioiden demonstroinnin	Ympäristövaikutus: energiatehokkuuden parantuminen paikallisella tasolla Korkea leviämispotentiaali johtuen lainsäädännöllisistä ajureista (rakennusten energiatehokkuusdirektiivi)	Taloudellinen tuki konseptikehitykseen Kestävä yhdyskunta -ohjelmassa Tekesin tuki mahdollisti ulkopuolisen asiantuntemuksen alihankinnan Yhteisvaikutus muiden julkisten rahoittajien kanssa
Biodiesel, Neste Oil	Suuren yrityksen radikaali tuote- ja prosessi-innovaatio	Ympäristövaikutukset: merkittävä hiilidioksidipäästöjen vähennys globaalilla tasolla	Taloudellinen tuki teknologian kehitykseen BioRefine-ohjelmassa Tekesin kontribuutio kohdistui teknologian kehitykseen, uusien raaka-aineiden etsimiseen, testaukseen ja verifiointiin
Kotitori palvelu-integraattori, Tampereen kaupunki	Kunnan kehittämä palveluinnovaatio Julkisia ja yksityisiä palveluita integroiva toimintamalli Palveluinnovaation julkinen hankinta	Hyvinvointivaikutukset: palveluiden parempi saatavuus ja sosiaalipalveluiden tuottavuus Paikallisen tason vaikutukset, ei levinnyt vielä alueellisesti eikä toimialojen välillä	Taloudellinen tuki konseptikehitykseen FinnWell-ohjelmassa Valmisteluprosessin aikainen asiantuntijatuki Tekes pääasiallinen ulkopuolinen rahoittaja
Vedenlaadun seuranta-järjestelmä, Liqum	Pienen yrityksen teknologiapohjainen palveluinnovaatio	Ympäristövaikutukset: ympäristöriskien parempi seurantavalmius Pieni käyttäjäkunta kansallisella tasolla, useita teollisia sektoreita, orastavaa vientiä ulkomaan markkinoille	Taloudellinen tuki Vesi-ohjelmassa Tekesin pääkontribuutio oli lisätä kehitystoiminnan panostuksia (input additionality)
Traumakine™, Faron Pharmaceuticals	Pienen yrityksen tuote-innovaatio	Hyvinvointivaikutukset: Potentiaaliset vaikutukset merkittävät; ei vielä vaikutuksia, tuotteen kliiniset testit kesken	Taloudellinen tuki (lainat) kliinisiin testeihin ja liiketoiminnan kehitykseen (YIC) Tuki mahdollisti myös kansainvälisen verkostoitumisen eurooppalaisen jatkorahoituksen saamiseksi

- Pienille ja keskisuurille yrityksille Tekesin rahoitus on tärkeä rahoituksenlähde, jolla on lisäarvovaikutus innovaatiotoiminnan panostuksiin (input additionality).
- Lainat ja avustukset eivät yksin ole riittäviä nopean kasvun ja yhteiskunnallisten vaikutusten aikaansaamiseksi. Tämä liittyy markkinoille pääsyn ja innovaatioiden leviämisen esteisiin sekä kypsymättömiin markkinoihin. Vaikka pk-yritykset pystyvät ylittämään kehitystoiminnan riskit, vie aikaa kasvattaa liiketoiminta riittävään mittakaavaan. Erityisesti ympäristö- ja hyvinvointialoilla, joilla julkisen sektorin ja sääntelyn rooli on merkittävä, Tekesin kysyntäpuolen tuki voi olla tärkeä. Innovatiivisten julkisten hankintojen tukemisesta on muodostumassa vakiintunut lähestymistapa. Muiden kysyntälähtöisten instrumenttien (regulaatio, standardit) hyödyntäminen innovaatiopolitiikan välineenä on vielä alkuvaiheessa.
- Vaikutusten kokonaislaajuus on riippuvaista niiden käyttäjien määrästä, jotka ottavat myönteisiä ympäristö- tai hyvinvointivaikutuksia tuottavan innovaation käyttöön. Suuremman tuotantokapasiteettinsa, jakelukanaviensa ja markkinointikykynsä ansiosta isot yritykset pystyvät pk-yrityksiä paremmin levittämään innovaation laajalle käyttäjäkunnalle tuottaen siten myös suurempia kokonaisvaikutuksia.

- Tekesin vaikutukset hyvinvointiin ja ympäristöön riippuvat uusien tuotteiden, prosessien ja organisointimallien onnistuneen kehittämisen lisäksi myös niiden käyttöönotosta riittävässä mittakaavassa. Kaksi analysoiduista tapauksista, Neste Oilin biodiesel ja Valion laktoositon maito, on menestyksekkäästi kyetty kaupallistamaan ja niiden tuotanto skaalaamaan tasolle, jossa syntyy merkittäviä ja mitattavissa olevia ympäristö- ja hyvinvointivaikutuksia.
- Hyvinvointi- ja ympäristöaloilla tarvittavat kyvykkyydet innovaation skaalaamiseksi ovat erityisen vaativia, sillä niihin kohdistuu merkittäviä institutionaalisia esteitä (hyvinvointipalvelut), rahoituksellisia esteitä (lääkkeiden kliinisten testien kustannukset) ja lainsäädännöllisiä esteitä (tai lainsäädännöllisten ajurien puute ympäristöliiketoiminnassa).
- Innovaation käyttöönoton nopeus ja laajuus on pitkälti riippuvaista siitä, ovatko markkinat uudelle tuotteelle jo olemassa. Analysoiduista innovaatioista vain yksi (Valio) eteni melko suoraviivaisesti olemassa oleville markkinoille, joilla käyttäjien tarpeet tunnettiin hyvin. Muissa tapauksissa markkinat innovatiiviselle tuotteelle eivät vielä olleet olemassa, vaan sen muodostuminen oli edellytyksenä innovaation leviämiselle ja siten vaikutusten syntymiselle. Yhdessä tapauksessa leviäminen on yhä varhaisessa vaiheessa (Kotitori) ja jää nähtäväksi, kuinka laajalle se lopulta tulee skaalautumaan.
- Ympäristöinnovaatioissa pääajuri uusien markkinoiden muodostumiselle on ollut uusi tai kiristyvä lainsäädäntö. Hyvinvointiin liittyvässä liiketoiminnassa ei ollut tunnistettavissa yhtä yksittäistä ajuria markkinoiden muodostumiselle. Dynamiikka näytti vaihtelevan suuresti kuluttajamarkkinoilla (esim. terveysvaikutteiset elintarvikkeet), tarkkaan säädellyillä markkinoilla (lääkkeet), tai institutionaalisen kysynnän alueella (julkiset ja yksityiset sosiaali- ja terveyspalveluorganisaatiot).

Kansainvälinen vertailu

Kansainvälisten vertailuindikaattorien perusteella Suomi on hyvinvoinnin osalta parhaiten menestyvien maiden joukossa. Hyvinvointi on melko äskettäin tullut Tekesin painopistealueeksi ja viimeisten kymmenen vuoden ajalta oli tunnistettavissa vain rajallinen määrä hyvinvointiin vaikuttaneita projekteja. Useimmissa niistä on tuettu pk-yrityksiä, mutta viime aikoina myös julkiset sosiaali- ja terveyspalvelujen tuottajat ovat voineet saada rahoitusta. Tekesin huomio tälle alueelle on tervetullutta, mutta sen optimaalinen rooli ei ole vielä selvä. Johtuen pienestä otoskoosta Tekesin toimenpiteiden vaikutuksia ei ollut mahdollista luotettavasti arvioida makrotasolla.

Ympäristön osalta raaka-aineiden runsas käyttö, melko matala energiatehokkuus, energiaintensiivisestä teollisuudesta johtuvat korkeat kasvihuonepäästöt, kuljetus- ja liikennesektori sekä maa- ja vesirakentaminen asettavat Suomen ekosysteemille suuria paineita. Ympäristökysymysten ratkaisuun on panostettu paljon Suomessa. Tekesillä on ollut useita ympäristöön liittyviä ohjelmia. Tekesin tukemien hankkeiden analyysi osoittaa, että Tekesin interventio lisäsi todennäköisyyttä myönteisten ympäristövaikutusten syntymiselle. Viime vuosina vaikutukset energia- ja materiaalitehokkuuteen korostuvat hanketasolla. Nämä ponnistelut näkyvät myös Euroopan ekoinnovaatioindeksissä, jossa Suomi on ensimmäisellä sijalla johtuen juuri voimakkaista panostuksista ympäristöinnovaatioihin. Innovaatioiden muuntuminen ympäristövaikutuksiksi on kuitenkin pitkä prosessi ja yhteyttä Tekes-projektien ja Suomen ympäristön tilan kehityksen välillä ei voida (tilastollisesti) todistaa.

Sveitsi ja Ruotsi ovat johdonmukaisesti johtavilla sijoilla kansainvälisissä vertailuissa. Vaikka yhdistelmäindeksien käyttöön aina liittyy haasteita, on raportissa vertailtu innovaatiopolitiikan toteutusta Sveitsissä ja Ruotsissa.

Näiden kahden menestyvän maan innovaatiotoiminnan tukijärjestelmien erot ovat silmiinpistäviä. Siinä missä Sveitsissä on pienet innovaatiotoiminnan tukiorganisaatiot, vaatimattomat budjetit eikä vahvoja temaattisia tavoitteita, Ruotsissa on Suomen tavoin vahvat organisaatiot isoine budjetteineen ja teemakohtaisine strategioineen. Toisin kuin Suomessa molempien vertailumaiden kansallisessa politiikassa kiinnitetään vähän huomiota vuorovaikutukseen yritysten ja tietoinfrastruktuurin välillä. Ympäristö ja kestävä kehitys ovat molemmissa maissa vahvasti esillä olevia teemoja. Hyvinvointi on merkittävän huomion kohteena Ruotsissa. Siellä on myös käytössä kysyntälähtöisiä politiikkainstrumentteja ympäristöinnovaatioiden kehittämiseen. Lainsäädäntö, ympäristönormit, verokannusteet ja kysyntäpuolen avustukset kannustavat kuluttajia ympäristöystävällisten tuotteiden hankintaan.

1 Introduction

This report presents results of an impact assessment of Tekes on environment and wellbeing. Following up earlier assessments (e.g. Riipinen et al. 2012) of Tekes impacts on productivity and innovation capacities, this study has a focus on the societal contribution of Tekes.

Positive contribution on the state of environment and human wellbeing is one the three principal impacts Tekes aims to generate. According to its mission statement "Tekes promotes the development of industry and services by means of technology, innovations and growth funding. This helps to renew industries, increase the value added and productivity, improve the quality of working life, as well as boost exports and generate employment and wellbeing."

The main focus of Tekes is economic ("development of industry and services"), but over the years environment and wellbeing have become explicit objectives in the Tekes strategy and Tekes has a long track record in developing programmes with some kind of other societal goal. The strategic considerations were a mix between 'supporting companies in grasping commercial opportunities that societal issues offer' and 'tackling social challenges'. Tekes not only provides grants and loans to reduce the risks of R&D and innovation, but also has much attention for improving the capabilities within the Finnish society to initiate and achieve successful innovations.

In its monitoring and evaluation system Tekes is evaluating not only at project and programme level, but is also paying attention to the effects of Tekes at societal level in the three target areas (productivity and renewal of industries; capabilities; wellbeing and environment). Every year impact assessments and studies are assigned for one area to monitor Tekes success and impacts. This year the study had the aim to figure out how The Finnish Funding Agency for Technology and Innovations (Tekes) has contributed to wellbeing and environment fields in Finland. It was assigned to the combination of Technopolis, VTT and Statistics Finland. This report presents the results of the study.

2

Measuring impact of innovation on environment and wellbeing

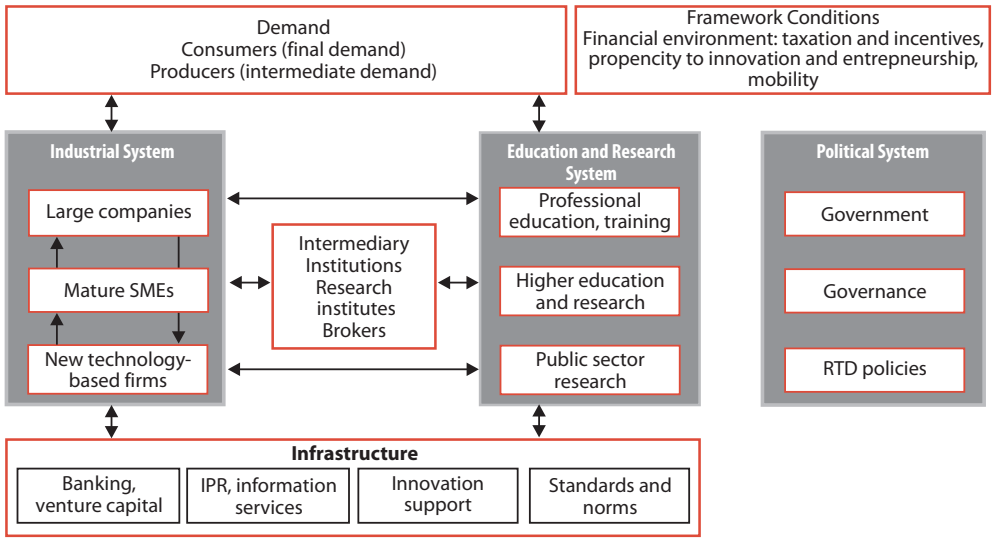
This chapter addresses the following methodological questions defined in the work plan:

1. What are the findings from international literature on how public RDI funding and innovation activities in general improve wellbeing and environment?
2. What types of methods for continuous monitoring, measurement and indicators can be identified to support Tekes management in this target area? What kind of national level indicators can be found?
3. How can the Tekes Social Impact Model developed by Hjelt, 2012 be further developed, based on current international practice?
4. What new indicators can be suggested for measuring results and impacts of Tekes and innovation activities in Finland?

2.1 Innovation processes

For many years a linear model of emerging science and technology together with a view of innovation process as autonomous development was the prevailing perspective on innovation. Research was done in universities and research institutes and the knowledge then used by companies who developed products and processes that were introduced to the market. This view has changed quite drastically over the last four decades. Now the vision prevails that technological innovation is the result of social and economic processes, and thus not a deterministic process. In innovation processes there are numerous and frequent interactions and feedback processes between users and producers. This led to the rise of a systemic perspective, which starts with two related basic assumptions.

Figure 1. Actors in an innovation system. Arnold & Kuhlmann 2001



First, innovation is a multi-actor process that depends on the interaction between different actors. Second, innovation has a systemic character, and is a result of complex interaction between various actors and institutions. Often these actors and stakeholders interact at several levels (Geels 2002).

The most well known type of innovation system is the national innovation system. It captures the importance of the geo-political and policy aspects of processes of innovation. The interest in geographically delimited systemic analyses is primarily based on political considerations such as international or interregional competitiveness.

Arnold & Kuhlmann (2001) developed a typology of players to create insights in the actors (including industrial actors, educational actors, consuming actors, intermediary actors, political and policy/regulatory actors and infrastructural actors) and factors that may shape innovation processes - Figure 1 shows the heuristic map of all actors and factors in an innovation system.

The rationale behind the public intervention in research and innovation lies in the presence of "systems failures" that impede creativity, effectiveness and efficiency of research and innovation systems and market failures that hamper private investments in socially desirable research and innovation.

2.2 Impact assessment

The systems character of innovation makes it difficult to measure impacts from innovation programmes: innovation is not always straightforward and innovation pathways are often indirect, especially when one wants to determine impact at the level of society, and from the perspective of societal value. A lot of literature is available on economic results of research and innovation at the firm level. These economic results and the pathways to these results are researched and described. This literature often refers to societal results as *long-term spillovers*. But here it stops: how RDI-activities lead to these societal impacts isn't described, at least not in detail. Now that in the past decade a shift has taken place in RDI policy thinking from (mostly) economic value to wider societal value[1] it has become important to identify long-term societal impacts of research and innovation. There are many indicators and indices available on society and wellbeing and research and innovation activities and their results are well described by RDI-indicators, however the link between these two worlds seems to be missing. In *Better Results, More Value* (Tekes, 2011) the authors also state that "there are very few indicator-activities that genuinely link socio-economic impact factors to research and innovation and there are even less activities linking socio-economic impacts in specific areas to RDI activity. Furthermore, if you also want to determine the role of specific actors in achieving the societal impact it implies identifying *how* research and innovation lead to societal impact.

Linking RDI-activities and societal impacts is faced by numerous challenges[2]. Innovation also often has not one but various sources of knowledge/inspiration. It is therefore difficult to **attribute** innovations to a specific source or programme. The challenge of attribution is to eliminate the effects of other research and external factors on the impact.

Furthermore the complexity of the system makes it difficult to determine the **additionality** of a specific action or programme: the difference in effect between doing nothing and performing the action. Determining *input additionality* (in Tekes' case firm's own RDI investment behaviour), *output additionality* (the proportion of outputs which is created by public RDI support) and *behavioural additionality* (how public RDI funding has changed firm's subsequent behaviour to the desired direction). can to some extent be determined quantitatively, and qualitative methods have been developed to obtain additional insight. However there is no real counterfactual situation to compare with. Both qualitative and quantitative methods suffer from **time lag**. It generally takes a long time for value (impact) to be created as a result of innovation and innovation programmes. Some pathways may even take 15–20 years. It is hard to assess the value that is created at a certain point of time when not all types of value are apparent yet. For measuring socio-economic impacts furthermore a clear definition is needed to know "how to really capture impacts in meaningful terms": Defining what to assess and developing adequate **indicators**. Also, various types of impact might overlap. Finally there is an issue of **comparability**:

1 At EU-level this is reflected in the orientation of Horizon 2020, based on the grand challenges.

2 Frank & Nason (2009), Bornmann (2013), Tekes review (2011)

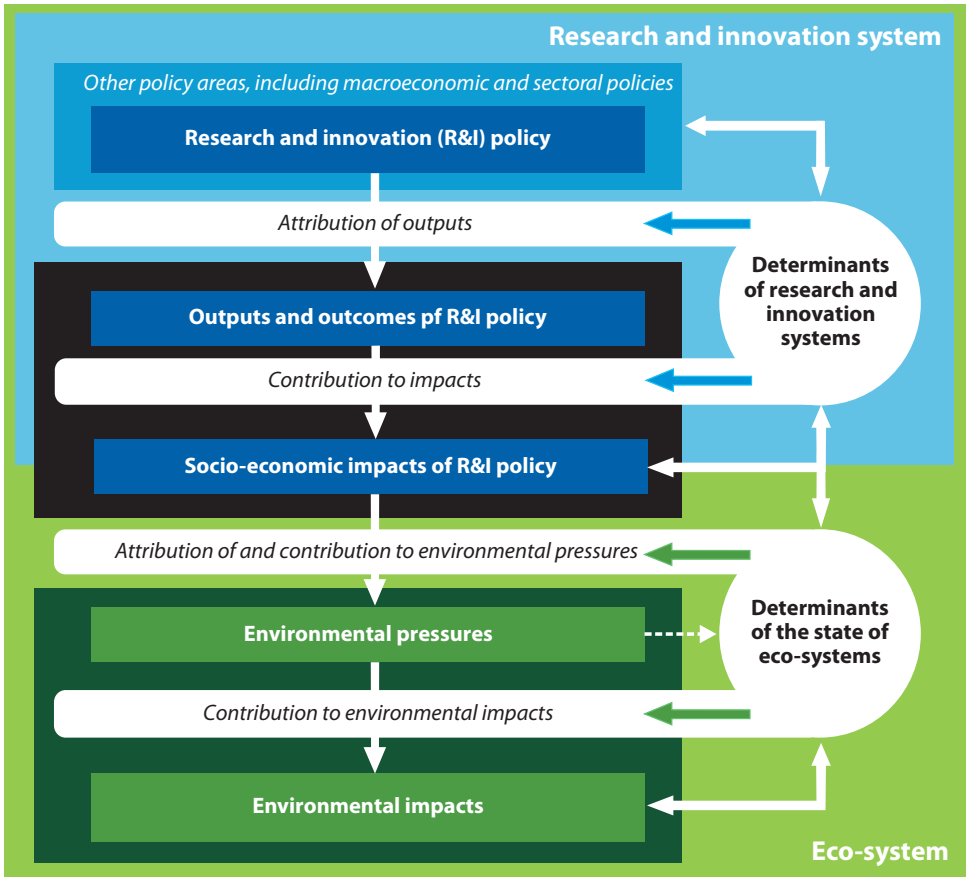
How to make the approach suitable for comparisons of different situations? This requires similar data collection methods, but in contrast to this standardisation, it is also important for an approach to be flexible and adaptable to the context of assessment and to specific goals and standards of the research to be assessed.

2.3 Innovation impacts on environment and national indicators for this

Miedzinski et al (2014, forthcoming) present an overall framework for determining the impact of innovation on environment (Figure 2). Core of this framework is that R&I lead first to socio economic results and only then (after the innovations have been implemented) to (increase or reduction of) environmental pressures that in turn have environmental impacts: the research and innovation system is separated from the ecosystem.

Information of impacts at macro-level becomes more and more available, with indicators on materials (use, consumption, waste), water, land and carbon and air as well as for biodiversity. However attributing the impacts to (policy) actions is less clear because outcomes from the R&I system impact the ecosystem by ways of various **pathways**. These pathways may have many different forms, from fairly linear to extremely complex, ranging from (new) products and production systems to regulation (which may be a source for new innovation) and social practice and consumption patterns.

Figure 2. Environmental impact framework. Miedzinksi et al, 2014



2.4 Indicators for impacts on wellbeing

In 2005 the Canadian Centre for the Study of Living Standards published an extensive overview of indicators and indices of wellbeing used in Canada, the U.S., OECD countries and internationally (CSLS, 2005). These include both comprehensive sets of indicators as well as composite indexes. The researchers defined wellbeing as an umbrella concept. It included economic, health, social, cultural and environmental indicators. Historically, indicators of wellbeing were based on objective data, but in recent years the importance of subjective wellbeing has grown. Output indicators appear to be much more appropriate than input indicators in the measurement of wellbeing, given that wellbeing itself is an outcome. Many measuring organizations explicitly recognise this by only including outcome variables.

Composite indexes may capture headlines, but they cannot by their nature shed light on specific problems that only individual indicators can elucidate (CSLS, 2005). International indices are a popular area of impact indicators, but they are also problematic since they hide actual data and individual indicators. Also, they often lack a clear conceptual and theoretical framework, which means they are not suitable for using time series or studying causal relationships. Therefore indices are less useful for an impact framework for a specific intervention; like in the area of environment there is a need for more detailed indicators that can be linked to inputs, activities and outputs of research and innovation activities.

Where the innovation system and the eco-system are for a large part separate from each other, the innovation system and the health system seem more entangled. Especially in the care market innovation processes are very hands-on, and often focused on removing institutional barriers more than technical or financial ones (Whether this is influenced by the fact that environment is a public good that is realised with public means (regulation, investment) where health is private (individual) good that is largely realised with public means but partially also with private means, is an interesting topic for further research).

In 2009 the European Commission initiated the 'Beyond GDP' initiative (http://www.beyond-gdp.eu) contributing to the Europe 2020 strategy. The initiative focuses on presenting an overview of the approaches to developing indicators that include environmental and social aspects of progress in addition to GDP. Wellbeing indicators are used to broadly illustrate people's general satisfaction with life, or give a more nuanced picture of wellbeing in relation to their jobs, family life, health conditions, and standards of living.

By means of the Better Life Initiative the OECD (www.oecd.org/betterlifeinitiative) is also contributing to the debate on measuring wellbeing. This results from the fact that macroeconomic statistics do not portray the right image of what ordinary people perceived about the state of their own lives. Addressing these concerns is crucial, not just for the credibility and accountability of public policies, but for the very functioning of our democracies. A report, entitled "How's Life?", has been released in October 2011 and looks at issues such as people's health, their education and competencies, the quality of their daily work activities, the state of their local environment, their personal security, the richness of their community ties, and whether people are satisfied with their lives. In 2011 also Compendium of OECD wellbeing indicators was published. In terms of scope, the indicators are developed with a distinction between current material living conditions and quality of life, on the one hand, and the conditions required to ensure their sustainability over time, on the other hand. In total 11 dimensions are defined which form the basis for the overall Better Life Index allowing people to compare the wellbeing across 34 countries (see Figure 3)

2.5 Tekes impact model

In the previous study to determine the impact of Tekes activities on environment and wellbeing the consultancy firm Gaia developed the Tekes social impact assessment model (Figure 4, Hjelt et. al., 2012). The model is comparable to the models from literature previously discussed. It describes the various possible outputs and impacts well, but does not explicitly describe the links between inputs, outputs, outcomes and impacts (i.e. the innovation pathways). Impacts on environment and wellbeing are not defined in more detail in this model.

Case studies should illustrate the link between Tekes inputs and impacts. When reconstructing the Tekes influence on societal developments however problems of attribution and additionality remain.

Figure 3. Measuring human wellbeing. OECD

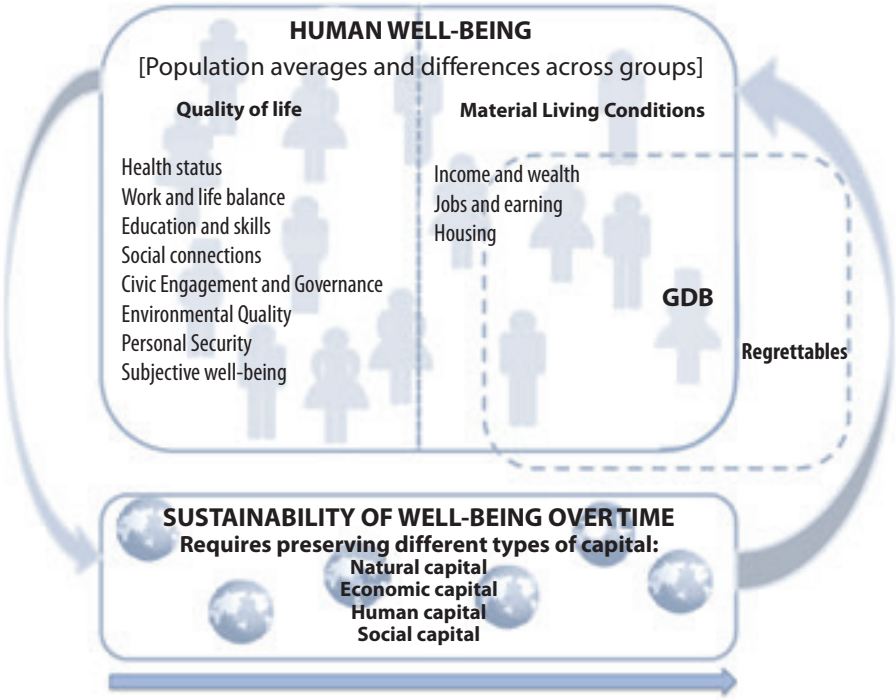
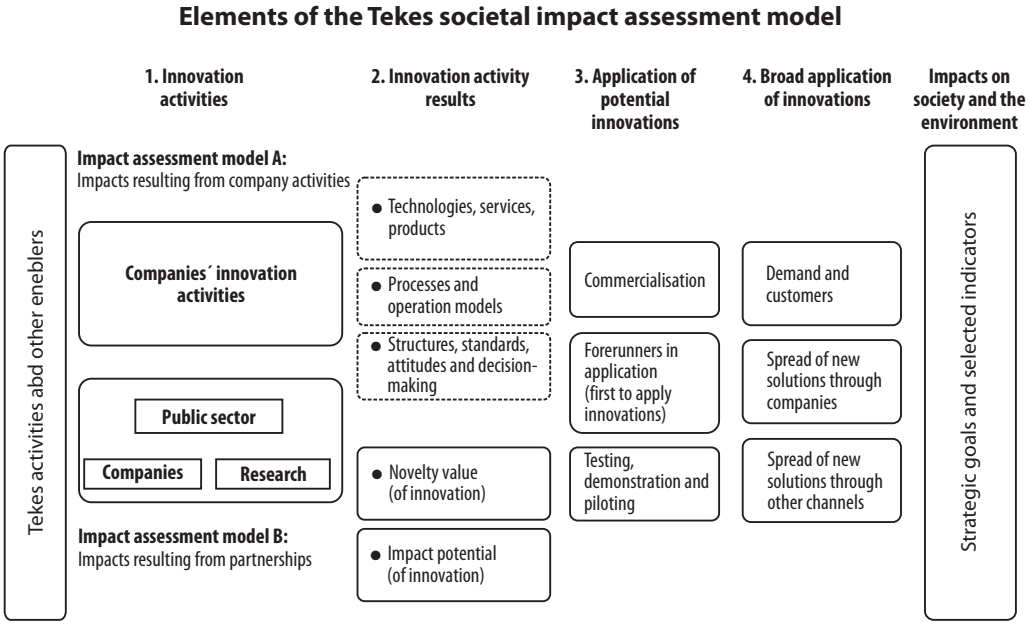


Figure 4. Tekes social impact assessment model. Gaia



3

Tekes Logical Framework: about mission, goals and activities

This section reviews the mission, goals and activities of Tekes as expressed in strategy and programming documents. In order to explicate the innovation patterns through which Tekes impacts on environment and wellbeing are generated we formulate a Logical Framework (LFA). With the LFA approach we are able to examine how Tekes has implemented the objectives and strategic choices for environmental and wellbeing related innovation activities, increase in innovations, competence, internationalisation and networking into Tekes financing criteria, financing instruments, operating methods and networking activities? This question relates thus to the **goals** of Tekes with regard to environment and wellbeing, and the **inputs** they provide to society.

3.1 Tekes' mission

Tekes has a long track record in developing programmes with some kind of societal goal. Over the years environment and wellbeing have become explicit objectives in the Tekes strategy. The strategic considerations were a mix between 'supporting companies in grasping commercial opportunities that societal issues offer' and 'tackling social challenges'. In the Tekes 2002 strategy the focus was on clusters, amongst others the welfare and the environmental clusters were targeted. In 2005 Tekes selected 'environment and energy' and 'health and wellbeing' as focus areas. In environment and energy "the focus area makes use of the market potential in mitigating global warming and responding to the challenges of obtaining energy in an acceptable and affordable way". The health area was also rather society driven "Health and wellbeing concentrate on productivity, quality and human approach of health care services, and also health and wellbeing products and services". In 2008 the strategic direction was given by themes, mainly guided by the great societal challenges and including a 'health and wellbeing theme' as well as a 'clean energy theme' (obviously not covering all environmental issues).

Tekes' (present) mission statement is the following:

> **"Tekes promotes the development of industry and services by means of technology, innovations and growth funding. This helps to renew industries, increase the value added and productivity, improve the quality of working life, as well as boost exports and generate employment and wellbeing."**

The main focus of Tekes is therefore economic ("development of industry and services"), but Tekes has a long track record in developing programmes with some kind of other societal goal. Over the years environment and wellbeing have become explicit objectives in the Tekes strategy. The strategic considerations were a mix between 'supporting companies in grasping commercial opportunities that societal issues offer' and 'tackling social challenges'. In the Tekes 2002 strategy the focus was on clusters, amongst others the welfare and the environmental clusters were targeted. In 2005 Tekes selected 'environment and energy' and 'health and wellbeing' as focus areas. In environment and energy "the focus area makes use of the market potential in mitigating global warming and responding to the challenges of obtaining energy in an acceptable and affordable way". The health area was also rather society driven "Health and wellbeing concentrate on productivity, quality and human approach of health care services,

and also health and wellbeing products and services". In 2008 the strategic direction was given by themes, mainly guided by the great societal challenges and including a 'health and wellbeing theme' as well as a 'clean energy theme' (obviously not covering all environmental issues).

The present strategy of Tekes is again primarily aiming to create growth by means of innovation in businesses. Tekes' slogan "growth and wellbeing from renewal" indicates strong attention to societal challenges as well. The present mission is schematically represented in Figure 5. In red (main headings of) are the objectives of Tekes[3] .

Development of industry and services is the overall goal in the mission of Tekes, and includes economic components (added value, productivity, exports, renewal of industry) as well as social components (quality of working life) generating employment and wellbeing.

Economic growth is not explicitly mentioned (but with a focus on development of industry and services, and mentioning of productivity and renewal definitely present in the Tekes reasoning). Since domestic growth has its limits export orientation is explicitly taken into account.

On its website Tekes states "our influence on society takes place primarily through financial impact. Yet, the research and innovation activities funded by us often also have other positive impacts on the wellbeing of people and the environment".

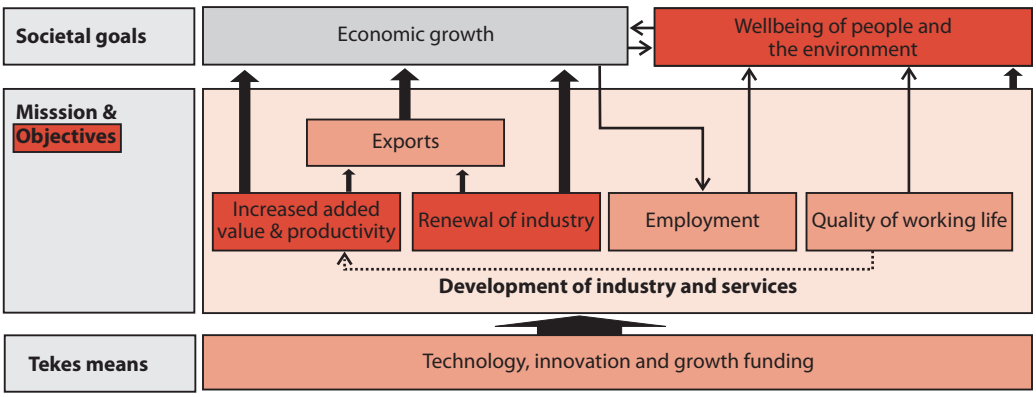
Interesting is in this context the explicit mentioning of employment in the mission, which is a result of economic growth, and an important factor determining wellbeing of people. A good quality of working life is also directly contributing to wellbeing of people, but obviously also has a positive effect on productivity and added value. Environment is not explicitly mentioned in the mission statement (but this seems to be part of a broad concept of wellbeing).

3.2 Tekes activities and intended results, programmes

In Figure 6 Tekes activities and the intended results are added to the analysis.

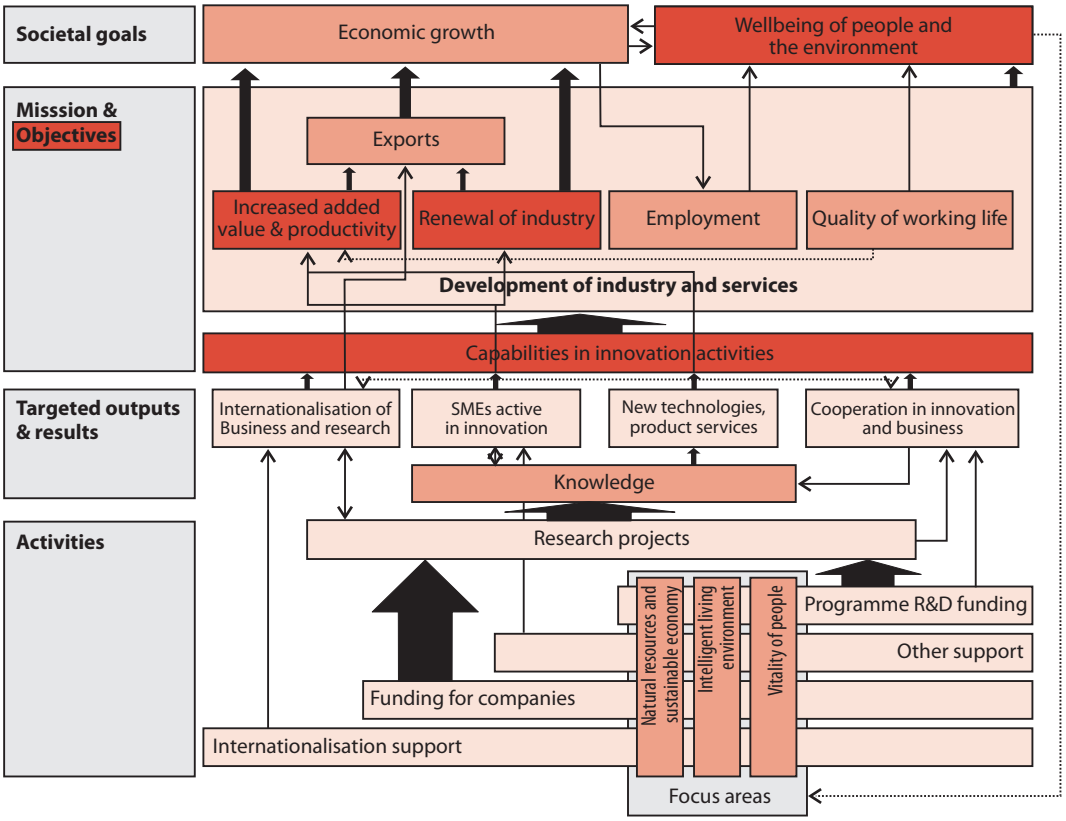
Tekes' activities are focused around 6 focus areas 'in which Finnish companies and research carried out in Finland have significant potential on the horizon', of which 3 are mentioned in Figure 6 because these 3 directly relate to environment and wellbeing: 'Natural resources and sustainable economy' (environment), 'Intelligent living environment' (environment and wellbeing) and 'Vitality of people' (wellbeing). The focus areas in their turn are 'guiding programme activities', i.e. they play a large role in the development of and choice for research programmes with participation of research groups from industry as well as from the research world.

Figure 5. Schematic representation of Tekes mission. Technopolis, after Tekes' mission



[3] Tekes English website, final view 22 January 2014. Not shown in this diagram are the Tekes objectives in the area of Renewal and forerunner status of Tekes itself (not directly related to impact on environment and wellbeing) and "capabilities in innovation activities" which is discussed below.

Figure 6. Tekes Logical Framework. Technopolis, based on Tekes' documentation[4]



In this study the focus was on 9 programmes in the area of environment and wellbeing from the period 2006-2015[5]:

- Focused on environment
  - BioRefine – New Biomass Products 2007–2012: To develop business from new value-adding products or new process or business concepts that utilise biomass.
  - Fuel Cell 2007–2013: Aims to speed the development and application of innovative fuel cell technologies for growing global markets.
  - Functional Materials 2007–2013: To develop new applications and competitive advantage through materials technology for Finnish industry.
  - Groove – Growth from Renewables 2010–2014: To enhance the business capabilities of Finnish small and medium-sized companies working with renewable energy
  - Sustainable Community 2007–2012: Focused on land use planning, energy efficient building and the integration of renewable energy production in built-in environments.
  - SymBio – Industrial Biotechnology 2006–2011: provide several sectors of industry with solutions based on biotechnology for effective and environmentally friendly production.
  - Water 2008–2012: Improving the Finnish water sector by utilising modern technology and innovation in business models, customer-focused services concepts and comprehensive solutions.

4 Mission, objectives, focus areas and programme documentation, as present on tekes website on 20 January 2014

5 In the ToR the Tourism and Leisure Services 2006–2012 programme was also included. It was decided to drop this programme because of the indirect relations between the programme and wellbeing and the large difference from the other programmes

- Focused on wellbeing
  - Innovations in Social and Healthcare Services 2008–2015: Aiming to renew health and social services and increase business opportunities by supporting effective, customer-oriented health and social services, more extensive preventive actions diversified partnership and cooperation.
  - Pharma – Building Competitive Edge 2008–2011: Eliminating bottlenecks for the Finnish pharmaceutical industry through the creation of new tools and operational models, as well as development processes for products, services, and methods.

Somewhat surprisingly maybe, all these programmes (the environment and wellbeing programmes), except one (the Innovations in Social and Health care services programme), have no explicit goals for environment or wellbeing. Other Tekes programmes (without specific focus in this area) might also have impacts on Finnish environment and/or wellbeing. The focus in this study was on the effects of this specific set of programmes, but comparison was made with other programmes where possible.

The programme goals of the environment and wellbeing programmes are all related to knowledge and networks for new products and services, new business concepts and new business. Most of these programmes have four activity components, related to knowledge development and translating this knowledge into commercial application, as is shown in Figure 6 as well:

- Programme R&D funding (for companies and R&D organisations, for generally somewhat longer term oriented research)
- Funding for companies (R&D funding as well as other funding, generally with a somewhat shorter time-horizon and a stronger business and capabilities orientation)
- Internationalisation support (for e.g. R&D cooperation, business cooperation and international business development)
- Other activities (e.g. support for networking, knowledge transfer and capability development)

Outside the programmes and the focus areas Tekes also supports companies with R&D, internationalisation and other supports (but generally no programmes are started outside the focus areas and no support is given to R&D organisations).

3.3 Balance between environment and wellbeing in this study

Environment has been an important topic for Tekes since the 1990s. Environmental projects were supported both inside focused programmes as well as in normal Tekes support outside the programmes.

By means of a number of different programmes, Tekes has supported health related innovation and the promotion of networking through funding of companies. Between 2000 and 2011, Tekes invested approximately €75 million in the development of mainly the pharmaceutical industry. These programmes are the Diagnostics programme (2000 to 2003), the Medicine 2000 programme (2001 to 2006) and the Pharma programme (2008 to 2011). From the evaluation of these programmes[6] is concluded that the programmes have shown their success in terms of increased scientific knowledge, technological development, promotion of networking and collaboration and a secured financial continuum. However concrete results and effects of the efforts to increase companies' competitive abilities, the creation of new business activities and internationalisation rate are rather limited or only achieved in certain projects. The evaluation furthermore shows that funding neither has a clear connection to business development, nor a long-term effect on companies' success rate. The wide-ranging character of the programmes' objectives and the lack of proper indicators to assess whether these goals are reached made extensive effect measurements rather complex and only limited to qualitative judgement.

From 2008 Tekes' focus in wellbeing broadened to outside the pharma sector. This reflects the transition in the health sector that is currently taking place: innovation is approached more from an open or collaborative model than the closed internal models of the past. This implies strong cooperation with

6 Final evaluation of Tekes' Pharma programme and post-evaluation of the Diagnostics and Medicine 2000 programmes.

actors involved in the health and wellbeing sector (i.e. health service providers, academia, large pharmaceutical companies, SMEs and actors on the local community level). This influences the way research and innovation is supported. This collaborative model approach is the core of the recently developed and soon to be launched *'Growth strategy for health sector's research and innovation activities'*.

The Finnish health and wellbeing sector is characterised by good and high-quality scientific and clinical research. Areas of Finland's particular interest in this sector are the field of health technology (including electronic healthcare services), and the pharmaceutical and biotechnology industries. Public funding is considered to be a major stimulus in order to achieve this competitive position of the sector. Although the level of industrial and technical know-how is sufficient and the right conditions for innovations are in place the future challenge will be to increase the business know-how of companies and the network capabilities between companies as well as between companies and (semi)-public stakeholders in the field.

The Tekes 'Innovations in Social and Healthcare Services programme' (2008–2013) is an early example of this change. The number of projects and companies in this programme is too small to report statistically relevant outcomes. This does not mean that Tekes support is not relevant, it means that Tekes support has been too small and too recent to be able to analyse at this moment.

4

Impacts of Tekes activities on Finnish environment and wellbeing, fulfilment of Tekes' objectives

In order to analyse the effects of Tekes on environment and wellbeing we used three research methods.

- In the first place we analysed the self-reporting data from post-completion questionnaires of Tekes projects. In these questionnaires the respondents also indicate whether the project supported has had societal impacts. The analysis is presented in chapter 4.1.
- Furthermore we made a comparison of innovation expenditures, innovation results and company growth between companies in the field of environment and wellbeing that were supported by Tekes, companies that were outside the field of environment and wellbeing that were supported by Tekes and companies not supported by Tekes. The results from this analysis are presented in chapter 4.3.
- By analysing the data from post-completion questionnaires of Tekes projects we can examine what is the share of firms that are capable of generating impacts on environment and wellbeing out of all companies receiving Tekes support. With the statistical analysis looked at the performance of companies. What these methods of analysis do not take into account is that some products may have large national or global reach, while others may influence only on a small scale locally. There is a need to assess what is the magnitude of impact per innovation in absolute terms: e.g. tons of CO2 reduced for environmental impacts, or e.g. size of population receiving cure to a particular health issue for wellbeing impacts. As there is no statistical data available to measure the latter dimension of impacts we have conducted case studies to examine the issue in a qualitative manner. These are presented in 4.3

4.1 Descriptive statistical analysis of Tekes post-completion questionnaires

Based on the perceptions of Tekes funded organizations, approximately 88% of Tekes funded projects have impacts on the environment and wellbeing between 2003 and 2008. Tekes funded research projects are partly evaluated based on an ex post questionnaire sent to the project manager by Tekes. This questionnaire partly focuses on what has been the perceived impact of the project to the environment and wellbeing in the society as a whole, while also including a number of other questions focusing on project successfulness, the impact of Tekes in the project and for example the impact the project results have had on the organization receiving funding. Seen in Figure 7, Figure 8 and Figure 9 the impacts on the environment and wellbeing, or societal impacts, are measured by the ten variables with a four level categorical (likert) scale, ranging from negative impact to significant impact.

By descriptive analysis of the ex post questionnaires we see that "no impact" is the dominant response by the respondents. Summarising the responses to the ten variables together, looking at RTOs, SMEs and large companies, roughly 60% of the answers reported "no impact" on the societal impacts of a project. This finding is contradictory to 88% of projects having impacts, but is explained by the focused nature of the impacts as seen in following.

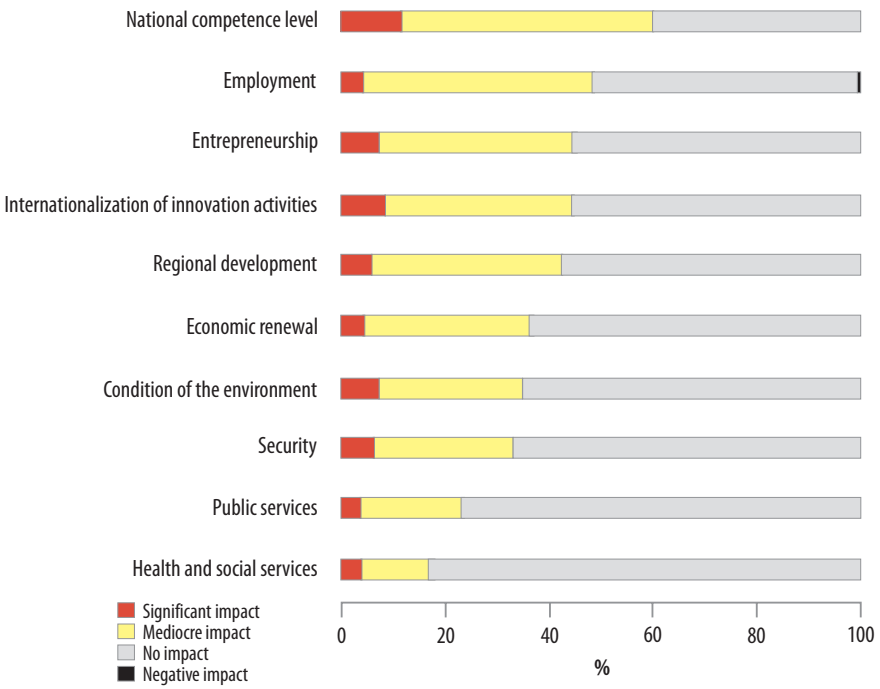
The above simplification gives narrow view to the societal impacts of Tekes projects. As seen from the variables measuring the societal impact, it is unlikely that one project would have significant impact on all of the measures, but rather we

would see that a project might have an impact on one or two of the variables. Looking at the descriptive data on the variables, we see that the societal impacts are not equally distributed across the variables and most projects have some societal impact, but these are focused on a few variables measuring societal impacts. Across the different organisation types impacts on national competence level are high, while impacts on for example health and social services or other public services are seldom reached by Tekes funded projects. However, only 12% of the projects reported across the board no societal impacts – responding to all 10 variables with "no impact". Clearly there are societal impacts, but these are focused on a few key variables measured by the questionnaire.

Analysing the societal impacts by the project organisation, research organisations (RTO), small and medium size companies (SME) and large companies, there are differences in the societal impacts produced by the projects. The data shows a significant relationship between the project organisation type and variables measuring societal impact (X2, $p<0.5$)[7]. Illustrated in the Figure 7, Figure 8 and Figure 9, this relationship is based on the intensity change between the project organisation type and not on organisation types ranking high in different variables. RTOs show highest societal impact in nearly all of the variables, except entrepreneurship and security where SMEs show highest impact. Large companies show lowest societal impacts in all of the variables, with exception of the national competence level indicator, where SMEs rank lowest.

Extracting the environment and wellbeing specific societal impacts from the data to Table 1, we clearly see that the majority of responses within these variables are in "no impact". However, this might be a result of the questions, specifically the lack of specificity in what is asked.

Figure 7. Impact on the environment and wellbeing by SME project between 2003 and 2008.
VTT analysis of Tekes post-completion questionnaire data



7 Chi-squared statistics were measured for ten societal variables across three organization types. Societal variables are categorical variables with four categories, negative impact, no impact, mediocre impact and significant impact. Due to the low number of observations in the category negative impact, categories no impact and negative impact were merged for the Chi-squared testing.

Table 1. Responses to environment and wellbeing specific societal impacts by organisations type.

2003–2008 data		Negative impact	No impact	Mediocre impact	Significant impact
SME	Condition of the environment	.0%	65.2%	27.5%	7.2%
	Public services	.0%	77.0%	19.3%	3.7%
	Health and social services	.1%	83.4%	12.4%	4.0%
	Security	.0%	67.1%	26.5%	6.3%
Large company	Condition of the environment	.2%	66.3%	25.7%	7.8%
	Public services	.2%	87.3%	11.0%	1.5%
	Health and social services	0.0%	93.3%	5.7%	1.0%
	Security	.1%	74.1%	21.3%	4.5%
RTO	Condition of the environment	0.0%	61.5%	31.4%	7.1%
	Public services	0.0%	70.3%	25.7%	4.0%
	Health and social services	.1%	82.3%	13.8%	3.8%
	Security	0.0%	67.5%	28.5%	4.0%

Establishing that the majority of projects have societal impacts and that the impacts are, on an aggregate level, different based on the type of project organisation; we look at factors resulting in societal impact. Adopting the approached used by Lemola et al. (2010) we looked at the ten societal impact variable and created an index variable as a sum of the numerical equivalents of the categorical responses to the questions, seen in Figure 7, Figure 8 and Figure 9. In this, a negative impact corresponded to the value of one, no impact to two, mediocre impact to three and significant impact to four. Thus the maximum value of the index variable is 30. Lemola et al. (2010)[8] used the created index variable as a measure of depth and breadth of societal impact a project has had. In this, a higher value of the index variable suggested a higher depth and breadth of societal impacts.

However, analysing the distribution of the index variable created based on the ten variables, the data resembles more a dichotomous response. Testing the created index variable for normality[9], we rejected the null hypothesis of normality. This was due to the volume of no impact responses within the questionnaire. Based on the fact that the majority of projects have some societal impact but a significant portion of the responses report "no impact", the projects show limited breadth of societal impact rather a focused impact on a few of the variables. Looking at the diversity of different types of societal impacts in the questionnaire, we question if a project should have a broad impact or would we rather assume a project impact only one or two of the variables. For example, projects in the Fuel Cell program might have high impact on the condition of environment where as the Pharma program projects impact Health and Social services, but assuming that a Fuel Cell program project would have a high impact on Health and Social Services is questionable. This resulted in changing the index variable to a dichotomous variable; if the project has had a perceived societal impact or not. Thus we look for any societal impact and factors that increase the probability of any societal impact, but do not make assumptions of broadness nor depth.

To uncover the variables that increase the probability that a project has societal impacts, we employed a logistic regression model. The logistic regression model was used to estimate the probability of an event, a project having societal impacts, occurring. In this, we used variables in the questionnaire describing 1) project success (meeting technical objective and meeting commercialisation objectives), 2) impact within the project organisation (project impact on differentiation, project impact on copy-ability and project impact on technology and innovation capabilities in company projects

8 The index variable created by the authors was based on a smaller number (six) societal impact variables.

9 Kolmogorov-Smirnov test of normality rejected the hypothesis that the created index variable was normally distributed.

Figure 8. Impact on the environment and wellbeing by RTO project between 2003 and 2008.
VTT analysis of Tekes post-completion questionnaire data

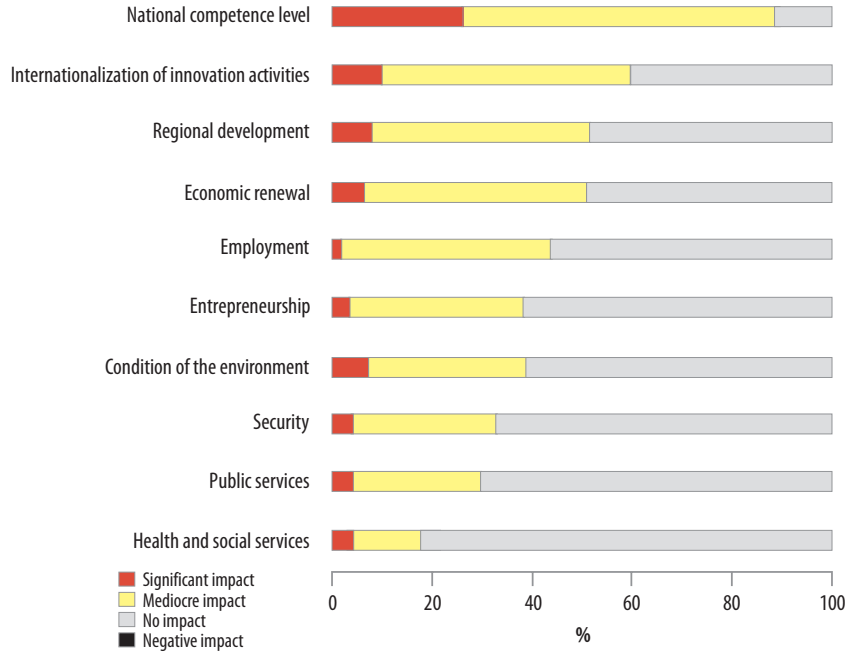
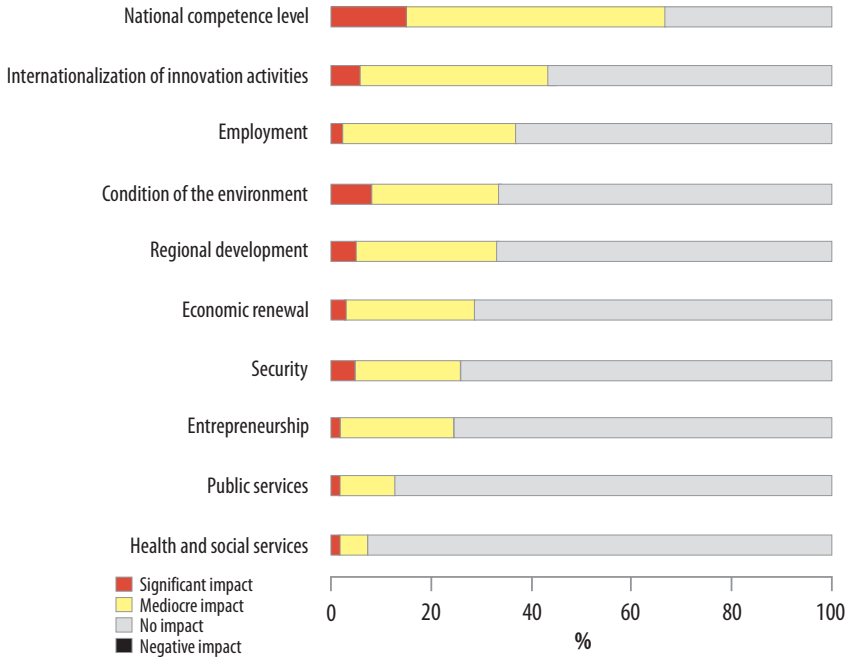


Figure 9. Impact on the environment and wellbeing by large company projects between 2003 and 2008. VTT analysis of Tekes post-completion questionnaire data



and project impact on research differentiation and project impact on research group competences in research projects), 3) the impact of Tekes (impact on project demand level, project scope, project timetable, project human resources, projects outside resources, number of partners in the project, overall impact of Tekes and if the project would have been started without the intervention of Tekes), and 4) background variables (company or research project, large or SME company project and if the project was a part of environmental and wellbeing projects run by Tekes). The model was run for all projects and then separately for research and industry projects. All of the independent variables were introduced to the model and the ones not statistically relevant removed prior to final analysis.

Summarising the results seen in Table 2, Appendix A for the logistic regression model, when looking at all of the projects and while controlling for other independent variables, the project being a research project increases the likelihood of societal impacts by 4.06 times. Other statistically significant variables increasing the probability of a project having societal impacts are listed as well. In this, the role of Tekes increases the probability of the project having societal impacts by the increase in challenge level, project use of outside resources, the number of project partners and the overall role of Tekes.

Focusing on research projects, the statistically relevant variables increasing the probability of societal impacts related to meeting project or commercialisation objectives and the increased differentiation of the research group. Within research projects the role of Tekes was not highlighted as a statistically relevant factor increasing societal impacts. Based on the results we can argue that research projects societal impacts are more driven by the overall successfulness of the project and its impact within the project organisation.

With industry projects, the statistically relevant independent variables increasing the probability of societal impacts are given in Table 1. In the model, for every increase in the independent variable, there was an increase in the likelihood of having societal impacts. With company size, a dichotomous variable, the increase described change from SME to large company. Although on an aggregate level SMEs seem to have a larger impact, when looking the logistic regression dichotomous variable, we see that large companies increase the probability of the project having some, while focused, societal impacts.

Summarising, the logistic regression highlighted the impact of **Tekes in projects** overall and industry projects were the intervention of **Tekes increased the probability that the project had perceived societal impacts**. The Tekes impact variables included were:

- All projects: Tekes impact on project challenge level, Tekes impact on project using outside resources, Tekes impact on the number of project partners and Tekes impact on project overall.
- Industry projects: Tekes impact on project using outside resources, Tekes impact on the number of project partners and Tekes impact on project overall.
- For research projects the impact of Tekes was found statistically irrelevant.

These results are limited by the well-known caveats of self-reported data.

Since the timeframe from 2003 to 2008, Tekes has adopted a new questionnaire to evaluate the perceived impacts of Tekes projects. This questionnaire been formulated to more precisely evaluate the specific impact areas, for example to the environment and wellbeing. The questionnaire has from 2009 onward remained the same. However from 2010 onward the likert scale variables focusing on societal impacts were changes to continuous variables, partly limiting possible analysis with the data. Due to the changes in variables and the limited time frame that the data has been collected, it is analysed here as descriptive data – giving an indication of how we might expect to see more specific societal impacts of Tekes in the future.

Seen in Figure 10 and Figure 11, the new variables measuring societal impact capture new aspects of projects impact to the society. Specifically the clearly visible impact on energy efficiency and materials efficiency is significant in comparison to the aspects that were strong already in the 2003-2008 data, such as the impact on national knowledge base. When making stronger analysis on the societal impacts in Figure 10 and Figure 11, it should be noted that these are highly impacted by the fairly narrow time frame of the data. As such, the results are highly impacted by programs, focus points and project types that have ended on a given year. However, the new data supports the assumption that Tekes projects have an impact on the environment; however impact on wellbeing remains limited in the data. This changes significantly from the period 2003–2008 and specifically the environment and wellbeing

Figure 10. Impact on the environment and wellbeing by SME projects in 2009 (likert scale variables).
VTT analysis of Tekes post-completion questionnaire data

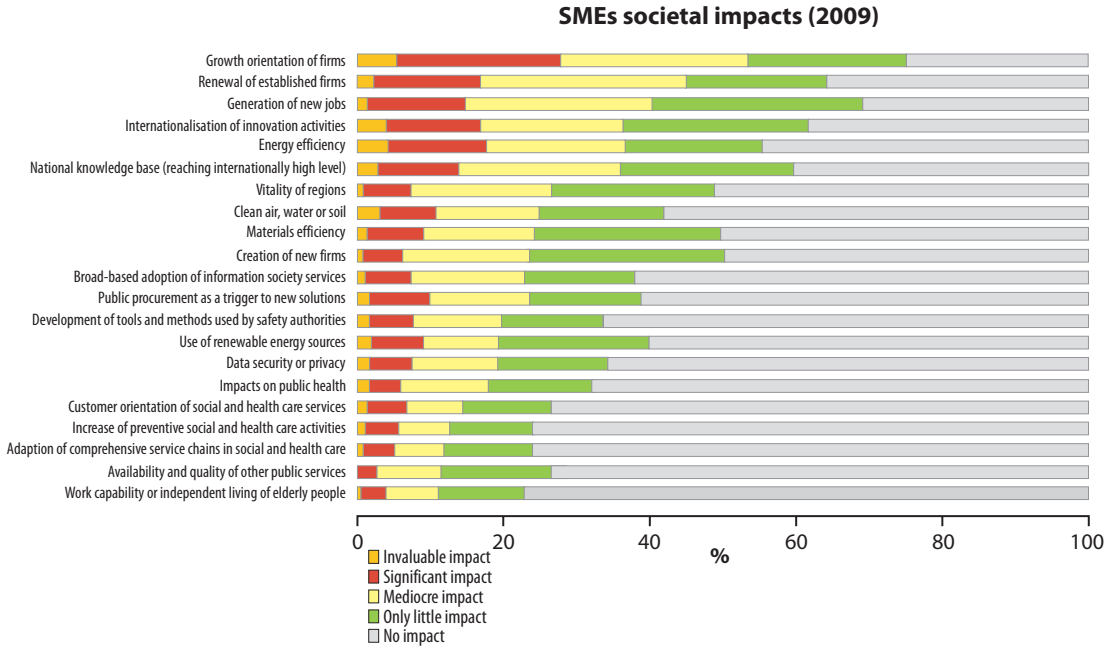


Figure 11. Impact on the environment and wellbeing by large company projects in 2009 (likert scale variables).
VTT analysis of Tekes post-completion questionnaire data

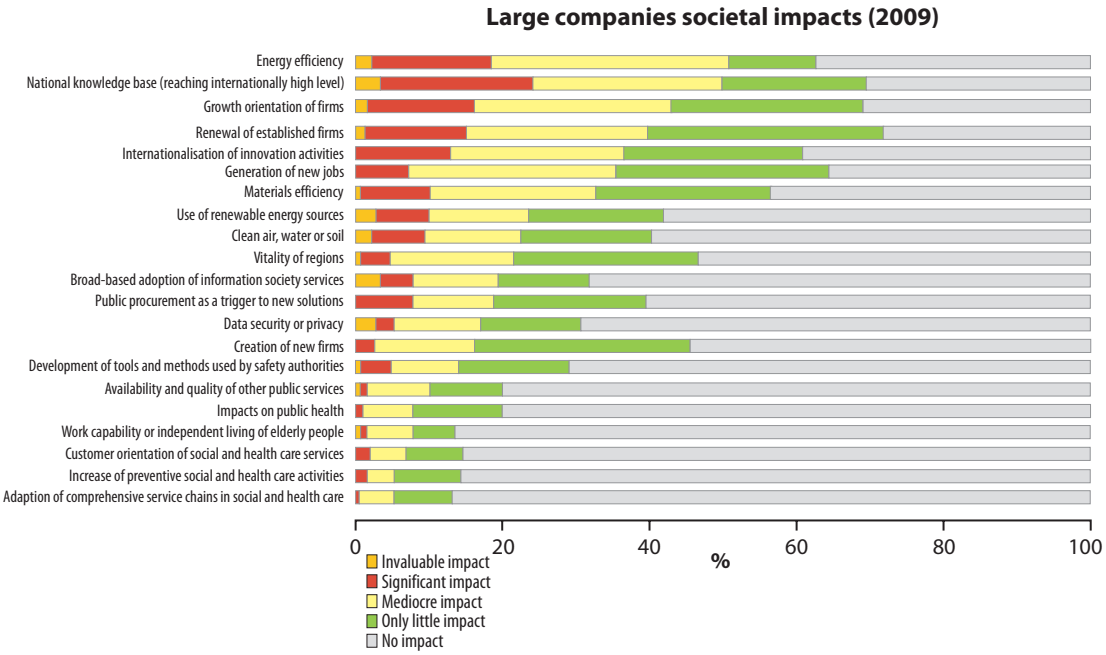
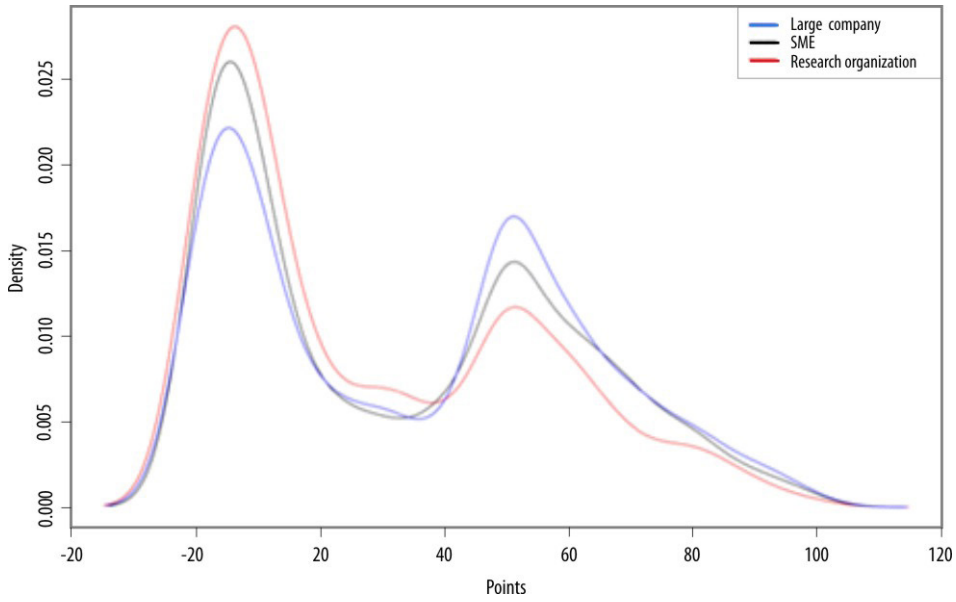


Figure 12. Density function giving a summary of societal impact variables for three organisation types for 2010 (continuous variable). VTT analysis of Tekes post-completion questionnaire data



related question seen in Table 1. It seems that the increased specificity in what has been asked has drawn out better responses or the focus points of Tekes funding have recently shifted. To analyse this change further, a longer time series of data, based on the questionnaire sent to respondents in 2010, is needed.

Using the 2010 continuous data, we are able to graphically compare the distribution of responses within different organisation types against the societal impact variables. The density plot in Figure 12 enables an organisation level comparison on the societal impact variable responses. In the plot, values near 0 are low societal impact and 100 are high societal impact responses.

Again visible in Figure 12 is the dichotomous nature of the data. The density plot suggest that Research projects are, in 2010, more inclined to assess no societal impacts, while large companies show a more balanced dichotomous response – more societal impacts. The plot suggests that, by measuring with a more focused set of questions, large companies report more perceived societal impacts. Based on Figure 10 and Figure 11, this has much to do with the breadth of impact across the measured variables.

By analysing the data from post-completion questionnaires of Tekes projects we can examine what is the share of firms that are capable of generating impacts on environment and wellbeing out of all companies receiving Tekes support. What this analysis does not take into account is that some products may have large national or global reach, while others may influence only on a small scale locally. There is a need to assess what is the magnitude of impact per innovation in absolute terms: e.g. tons of CO2 reduced for environmental impacts, or e.g. size of population receiving cure to a particular health issue for wellbeing impacts. As there is no statistical data available to measure the latter dimension of impacts we have conducted case studies to examine the issue in a qualitative manner.

4.2 Statistical comparison of company performance

4.2.1 Introduction

The activities of Tekes are not just funding, but also networking and activating different actors across the whole innovation system. As known, innovation is a multi-actor process that depends on the interaction of various actors and institutions. This systems character of innovation makes it difficult to measure the impacts of technology and innovation programmes. The results do not depend on the activities of the supported organisations alone but also on the activities of many other actors including the support providers. Furthermore, it is difficult to attribute innovations to a specific source or programme.

In this chapter, we, however, disentangle the relationship between innovation efforts and innovation outputs where ever these efforts are made. They can be conducted by the supporting organisations, industrial clusters or the companies introducing innovations. We cannot measure the additionality of specific programmes exactly, but we can compare the innovation efforts and results between companies that have been supported and companies that have not received or applied for a support. This comparison makes sense only if companies are otherwise as similar as possible, in which case the only difference between them is the support (grant, loan or capital loan) provided by Tekes.

By using these two groups of companies we can estimate how Tekes support affects first innovation inputs (input additionality) and then innovation outputs (output additionality) in these otherwise similar groups. This relationship should not be interpreted as a linear one or independent of activities taken by other actors or institutions. In innovation processes there are numerous interactions and feedbacks between different actors like users and producers. This estimated relationship just gives a dome under which these interactions and feedbacks take place. It does not tell a lot of the mechanisms which are in effect there. It, however, approximates the counterfactuals of what would have happened had also the non-supported be supported or simply the additionality in supported companies. It does not tell whether this had happened under different societal or economic conditions or what are the main reasons for the additionality.

4.2.2 The hypotheses and data

Hypotheses

Statistical analysis means inference based on statistical testing. The hypotheses used in testing can be drawn from a theory or they can be purely empirical. We pose the following hypotheses concerning the impact of Tekes support:

1. Tekes support improves or increases innovation expenditures and innovation in companies supported.
2. Tekes environmental and wellbeing programmes have added value over other Tekes programmes & individual support
3. Environment and wellbeing are markets with a larger growth potential than other markets

Data[10]

We utilise project level data on Tekes support by type and project coordinator over the time period 2000–2011, and sum the annual payments up to the level of projects and companies by type. The types of support are simplified to grants and loans. At company level support is related to company turnover by type (grants, loans, both).

Companies that have received Tekes support have been divided into four groups:

1. Companies that have received support from 10 Tekes environment programmes 1992–2013: Bioenergia, Puuenergia 1999–2003, ClimBus 2004–2009, BioRefine 2007–2012, Densy 2003–2007, Sustainable Community 2007–2012, Fuel Cell 2007–2013, Groove 2010–2014, FinnWell, Functional Materials 2007–2013
2. Companies that have received support from Tekes wellbeing programmes: Sote 2008–2015, Pharma 2008–2011
3. Companies that have received support from Tekes outside environment and wellbeing programmes (including individual support)
4. All companies supported by Tekes in 2004–2007 and 2008–2011

[10] Data and methods are described in more detail in Appendix A.2.

Finally there is company level data on companies not being Tekes clients in 1992–2012.

In the statistical analysis the unit of study is the company, not the programme or the project, because broader statistical data are only available for companies. The statistical data includes the following company level data:

- R&D Surveys: in-house R&D, R&D persistence; 2000–2011
- Patent data: Domestic patent applications; 1985–2011
- Patent data: Patents granted by the United States Patent and Trademark Office, USPTO; 1985–2009
- Business register: number of employees, turnover, sector, exporting; 2000–2011
- Innovation Survey CIS2010: new-to-market innovations; 2008–2010

4.2.3 Main results

The effects of the support can be displayed as the difference between the innovation input (resp. the innovation output or growth rate) of the supported companies and their counterfactual, estimated based on matched companies. In the graphical display below the mean input (resp. the innovation output or growth rate) of the supported companies and their mean counterfactual input are illustrated by the bars. The effect of public support is displayed as a shaded area.[11]

In Figure 13 we display the effect of public support on innovation input of the supported companies. In the period 2004–2007 we observe significant positive effects for delayed support L4: delay of 4-8 years. The effect of public support with delay L0: delay of 0-3 years is even more visible for companies not in environmental or welfare programmes (Figure 14). Figure 15 and Figure 16 describe the effect of different types of public support; the recipients of loans are distinguished from the recipients of grants. The diagrams display the effect of the respective instrument on the supported companies measured against the counterfactual situation. Figure 17 to Figure 20 describe the effect of public support on the growth rates of supported companies. We find a significant effect of the size of 5 to 8 percentage units on the average growth rates of supported companies compared to the counterfactuals. Finally in Figure 21 to Figure 23 the effect of public support on innovation output is illustrated. We use three measures for innovation outputs, the propensity to apply for and receive a patent, the average number of patents received and the propensity to introduce new-to-market innovations. The patents granted by the USPTO are in the focus here. On average, public funding has contributed to at least 1 more domestic patent application and almost ten times more patents granted by the USPTO.

Innovation input effect of Tekes support

Tekes support has a positive effect on the R&D intensity of supported companies, and so also on that of companies participating in environmental programmes. Especially, this effect comes into light with time delays. In the period 2004–2007 the effect of support is statistically significant with time lag of 4-8 years. In the period 2008–2011 the effects with different time lags are not significant. In Figure 13, we can observe that the supported companies have much higher R&D intensity then their similar non-supported twins (297 twins in the period 20082011). The dark and light shaded bars describe the difference between supported and non-supported companies.

Tekes support has a positive effect also on supported companies not in environmental or welfare programmes. As a group these companies (N=1676) have slightly different characteristics compared to companies participating in environmental programmes (see Figure 27 in Appendix A2). On the average, they are smaller. In the period 2004–2007 the mean number of employees in this sample was 66. About 11 percent of companies in this sample were large companies. Like companies participating in environmental programmes, their mean R&D intensity was high, 28%. On average, they had 1,4 domestic patents and 0,4 US patents. In this period of time, their average annual amount of Tekes payments was about 30 000 euros, 9 percent of turnover. Their average annual growth rate of turnover was almost the same than in the sample of companies in environmental programmes, 14 percent.

The fact that the sample of supported companies not in environmental or welfare programmes includes a higher share of SMEs may explain why the most recent years have a higher effect on R&D intensity in both periods. This effect being almost equal in both periods is highly significant. It is light shaded in Figure 14. The effect of the previous period (dark shaded area) is a bit higher than the innovation input effect of Tekes support for a different period in Ebersberger and Lehtoranta 2008.

[11] Note: ***(**, *) indicates significance at the 1%, (5%, 10%) level. 1% level of accepting null hypothesis (no impact) means highly significant impact, 5% significant impact and 10% slightly significant impact.

Figure 13. Innovation input effect of Tekes support with time delays.
L4: 4-8 years (dark blue), L0: 0-3 years (light blue), companies participating in environmental programmes, R&D intensity, average

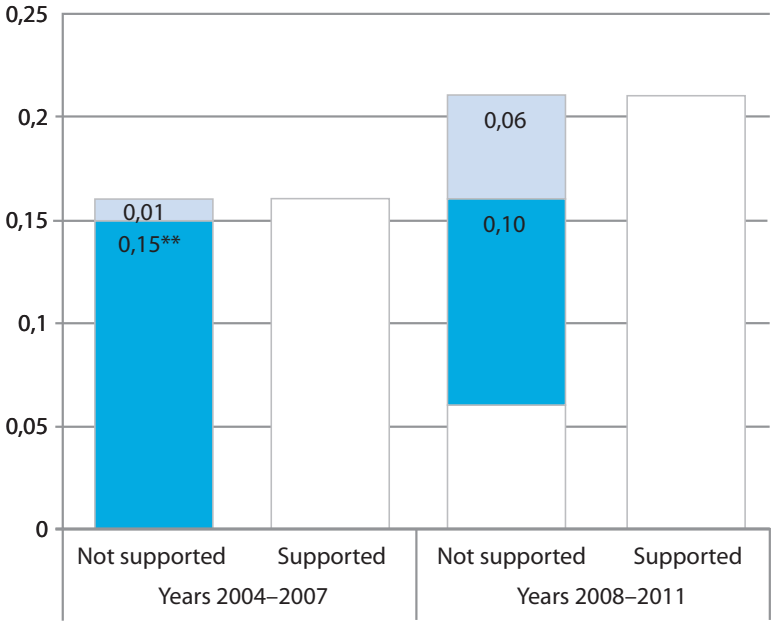
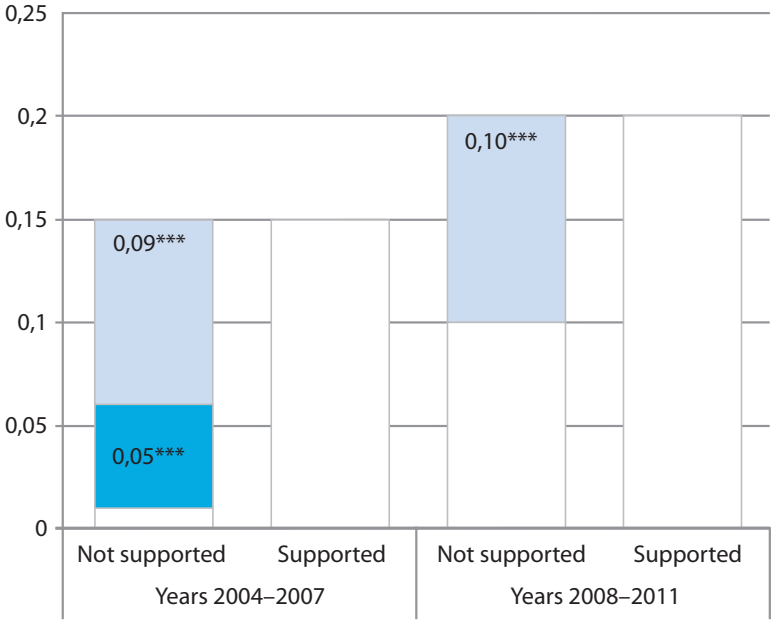


Figure 14. Innovation input effect of Tekes support with time delays.
L4: 4-8 years (dark blue), L0: 0-3 years (light blue), companies not in environmental or welfare programmes, R&D intensity, average



When considering the effects of different funding instruments, we can observe that for companies participating in environmental programmes, Tekes grants have a significant effect on R&D intensity in the period 2004–2007 but not anymore in the period 2008–2011. Instead, loans granted by Tekes maintained their significant effect in both periods. Loans with time delay of 0 to 3 years even increased their size of effect (Figure 15). This finding may arise from the changed economic conditions in 2008–2011.

For supported companies not in environmental or welfare programmes (Figure 16), loans constantly have higher effects on R&D intensity than grants. In this group, the average annual company level amount of grants (payments) was about €18 000 and that of loans about €13 000 in 2004–2007. In this sample, 85% of supported companies received grants and 46% loans, on average. The same shares for companies in environmental programmes were 91% for grants and 53% for loans in the same period.

In the period 2008–2011, the corresponding shares were 83% for grants and 74% for loans for companies in environmental programmes and 47% for grants and 25% for loans for companies outside environmental and welfare programmes. We can observe from this that the propensity of receiving loans has increased among companies participating in environmental programmes.

Figure 15. Innovation input effect of Tekes grants and loans with time delays.
L4: 4-8 years, L0: 0-3 years, companies participating in environment programmes
R&D intensity, average

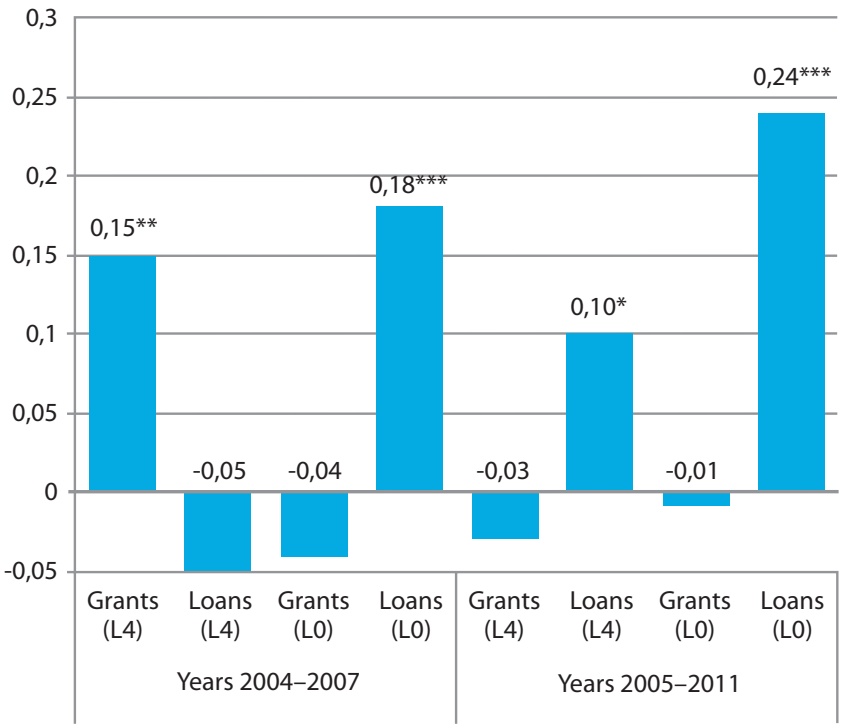
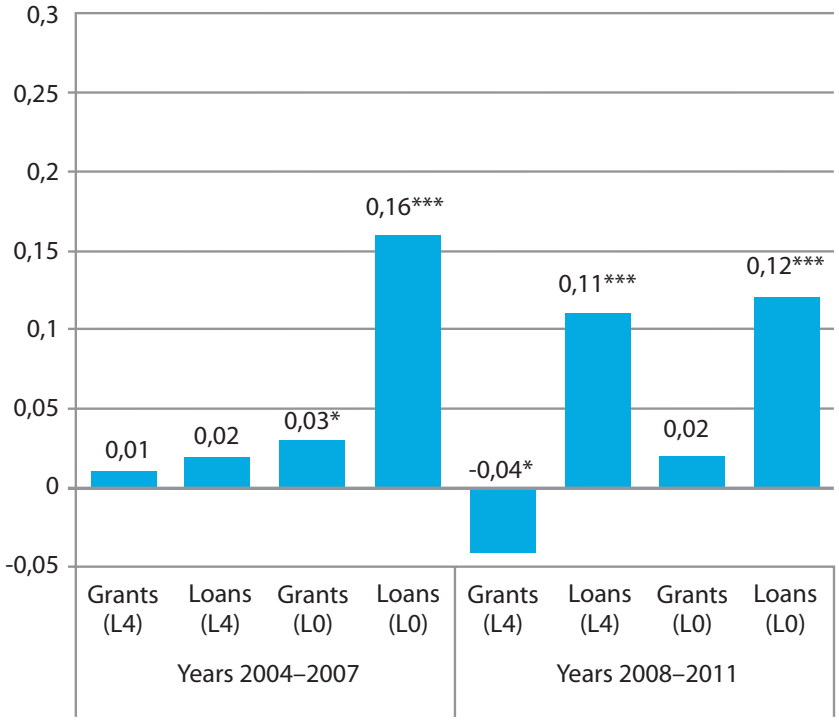


Figure 16. Innovation input effect of Tekes grants and loans with time delays.
L4: 4-8 years, L0: 0-3 years, companies not in environmental or welfare programmes
R&D intensity, average



Growth effect of Tekes support

Figure 17 displays the effect of Tekes support on the growth rate of supported companies measured against the counterfactual situation, had the companies not been supported. In the period 2004–2007, the supported companies in environmental programmes grew with an average annual growth rate of 12% whereas the similar non-supported companies grew with a growth rate of 4%. The difference in growth rates was 8 percentage units (0,15-0,7=0,8). In the period 2008–2011, the corresponding figures were 2% and -6%. Measured as percentage units, we can observe that the difference is again about 8 percentage units (0,10-0,1=0,9 for estimated impacts) between supported and similar non-supported companies participating in environmental programmes. This difference is statistically significant.

The effect of Tekes support on the growth rate of supported companies is a bit less in the sample of supported companies not participating in environmental or welfare programmes. In the period 2004–2007, these companies grew with a growth rate of 10%, on average, and similar non-supported companies with a growth rate of 4% (N=729). In the period 2008–2011 companies in the corresponding samples grew with a rate of 2% and -3% respectively (N=820). The difference between the growth rates is about 5-6 percentage units, and this effect is highly significant (Figure 18).

The effect of Tekes support on the growth rates of all supported companies is about the same size as in the sample considered above, 6 percentage units. In the period 2008–2011 all companies supported by Tekes grew 2% and similar non-supported companies -4%, on average. Here we compared 1001 supported and 1001 non-supported companies.

Figure 17. Growth effect of Tekes support with time delays. L4: 4-8 years (dark blue), L0: 0-3 years (light blue), companies participating in environmental programmes. Average annual growth rate, index (1,2 =20%)

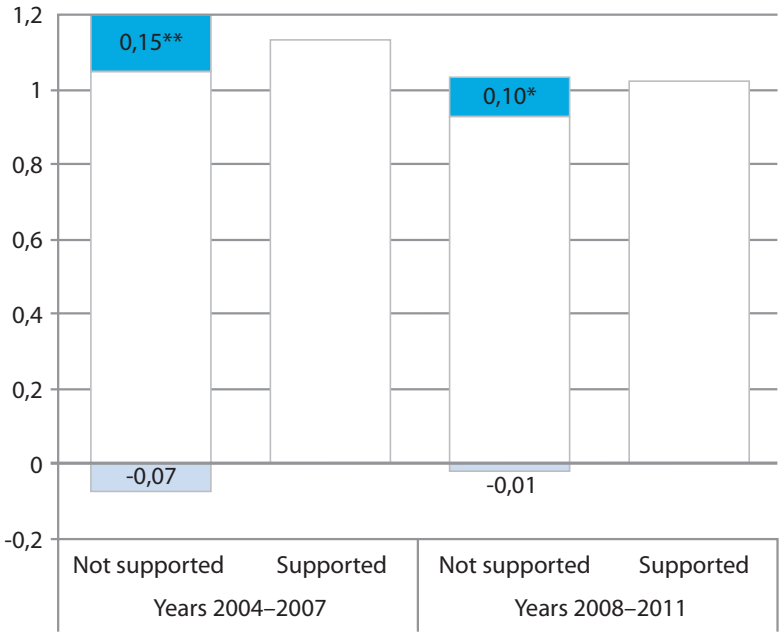
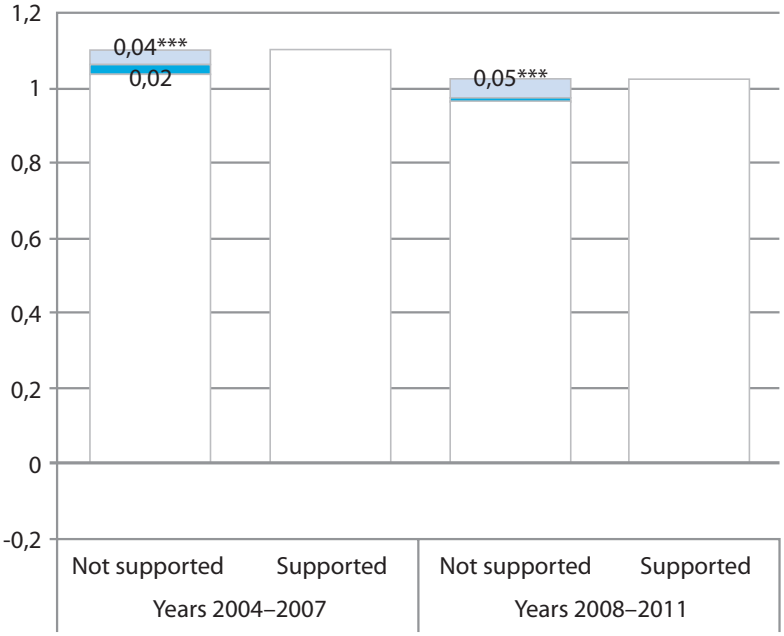


Figure 18. Growth effect of Tekes support with time delays. L4: 4-8 years (dark blue), L0: 0-3 years (light blue), companies not in environmental or welfare programmes, Average annual growth rate, index (1,2 =20%)



When considering the growth effect of different funding instruments in these two samples of companies, the following patterns (described in Figure 19 and Figure 20) can be observed. While grants in the period 2004–2007 had a significant (at 10% level) effect on the growth rates of supported companies participating in environmental programmes, this effect is smaller in the period 2008–2011 and is not significant. As will be shown later, while grants still have a significant effect on innovations, this effect does not manifest itself in growth rates. Loans with a time delay of 0 to 3 years had a highly significant effect on the growth rates in both periods.

For supported companies not in environmental or welfare programmes, being smaller, on average, than companies participating in environmental programmes, loans with a time delay of 0 to3 years have the highest and highly significant effects on the growth rates of supported companies (Figure 20).

Figure 19. Growth effect of Tekes grants and loans with time delays.
L4: 4-8 years, L0: 0-3 years, companies participating in environmental programmes

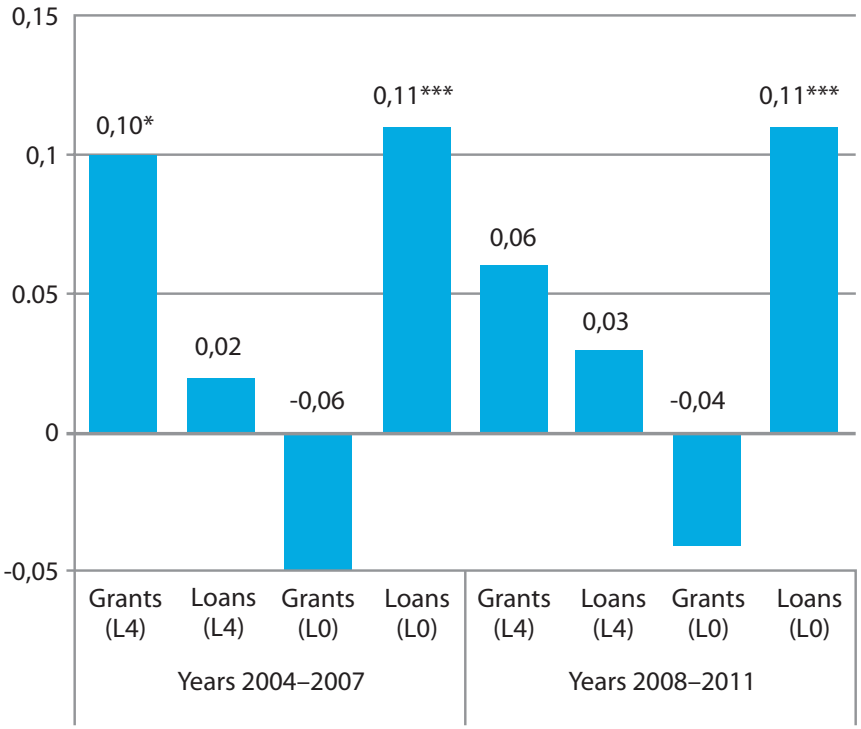
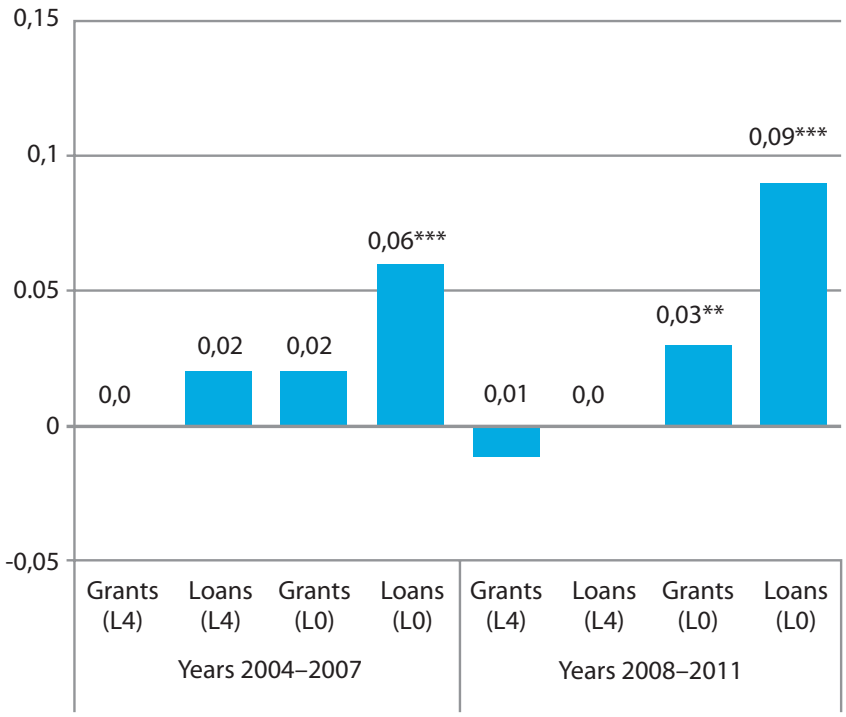


Figure 20. Growth effect of Tekes grants and loans with time delays.
L4: 4-8 years, L0: 0-3 years, companies not in environmental or welfare programmes

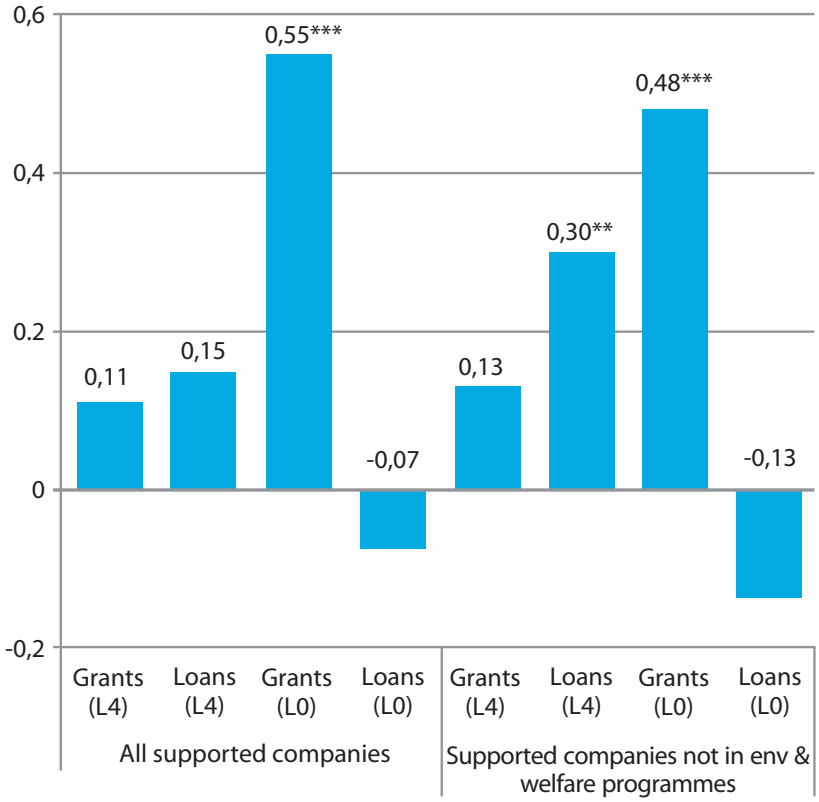


Innovation output effect of Tekes support

Next we turn to innovation output effects of Tekes support measured as the propensity to receive a patent from the USPTO, the propensity to introduce a new-to-market innovation and the number of patents granted by the USPTO in the period 2008–2011. Again we examine the effects of Tekes support in both periods: 2004–2007 and 2008–2011. Here we use the samples encompassing all companies supported by Tekes versus similar non-supported companies and all supported companies not in environment and welfare programmes in 2004–2007 versus similar non-supported companies. The reason for this is that when we now use the Community Innovation Survey for the years 2008–2010 (CIS2010) together with R&D Surveys, we lose observations and focusing on companies in environmental programmes is not possible anymore. However, for comparison purposes, the patent information has been taken from broader samples not linked with the CIS data (Figure 21 and Figure 22).

In 2008–2011, the propensity to apply for a patent and have it accepted by the USPTO was 0,02 for non-supported and 0,06 for supported. The number of companies in both of these samples was 1981. The average numbers of patents granted by the USPTO were respectively 0,02 and 0,17. The effect of support is highly significant. The numbers of domestic patent applications in this period were respectively 0,22 and 1,06. On average, public funding has thus contributed to at least 1 more domestic patent application and almost ten times more patents granted by the USPTO. Not surprisingly, grants awarded relatively more often to large firms than small firms, have clearly the highest effect on the propensity to apply for and receive a patent from the USPTO. This effect is

Figure 21. Innovation output effect of Tekes grants and loans with time delays.
L4: 4-8 years, L0: 0-3 years, all supported companies (2002 twins) & companies not in environmental or welfare programmes (1697). Propensity to be a recipient of patents granted by the USPTO 2008–2009



highly significant. In the sample of supported companies not participating in environmental or welfare programmes, the effect of loans with a time delay of 0 to 3 years is significant, as well. The fact that there are relatively more large companies in the sample of all supported than in the sample of supported and not in environmental and welfare programmes, may explain why loans are not significant among all supported companies (Figure 21).

The effect of grants on the number of patents granted by the USPTO is evident and highly significant as can be seen in the Figure 22. It is about the same size in the sample of all supported (N=2002) as in the subset of it, among companies not in environmental or welfare programmes (N=1697).

The mean propensity to introduce new-to-market innovations is given in the Figure 23. The same pattern as for patents can be seen here: grants have the highest and significant effect on innovations.

Figure 22. Innovation output effect of Tekes grants and loans with time delays.
L4: 4-8 years, L0: 0-3 years, all supported companies & companies not in environmental or welfare programmes. Patents granted by the USPTO 2008–2009, average

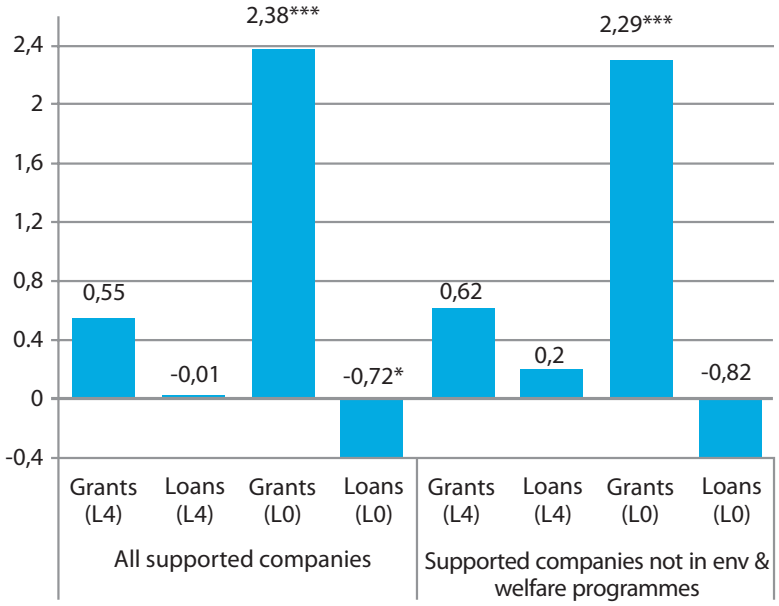
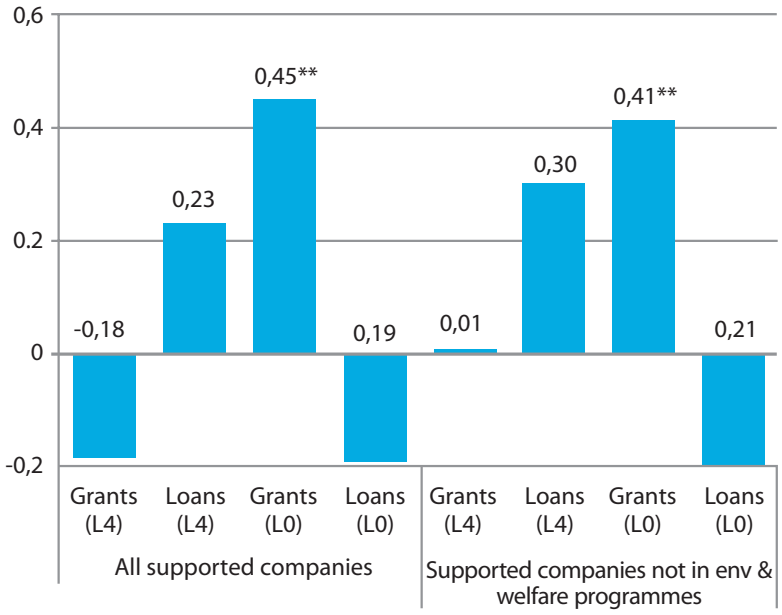


Figure 23. Innovation output effect of Tekes grants and loans with time delays.
L4: 4-8 years, L0: 0-3 years, all supported companies (248 twins) & companies not in environmental or welfare programmes (180 twins). Propensity to introduce new-to-market innovations 2008–2010, average



Conclusions concerning companies in environmental programmes

On the basis of results displayed in the last section, it is difficult to infer whether there are significant differences in innovation output effects between all supported companies and companies outside environmental and welfare programmes, had they otherwise been similar, and therefore between companies in environmental programmes and not in these programmes. Both of these samples have been compared with similar non-supported companies, not with each other. As a baseline for their comparison, already referred to, is that they are different in the shares of large companies, but not so much in other key variables. There are, however, also some other differences.

Reporting first the mean values for all supported companies, in the period 2008–2011, the mean number of employees in these two samples are 79 and 56, average growth rate is the same -2%, mean R&D intensity 0,10 and 0,23, mean number of domestic patent applications 1,06 and 0,70, mean number of patents granted by the USPTO 0,17 and 0,13, mean annual support payment €81000 and €61000, support intensity 0,9 and 0,8 and the mean propensity to be supported if supported in the previous period, 0,59 and 0,55. In the light of these mean values and the values of supported companies given in Figure 27, the supported companies participating in the environmental programmes are clearly above the average, in terms of average annual support payments, the share of support in turnover and the share of propensity to be supported, if supported in the previous period, which was 0,85.

4.2.4 Conclusions on the effect of Tekes support

As shown above, both the innovation input, innovation output and growth effects of Tekes support are evident and statistically highly significant or significant. The effects of grants and loans may, in some time periods, have opposite effects, which may hinder the finding of the effects of total support. In this study, besides the effect of total support measured with annual company level payments, the effect of grants and loans has been analysed. Instead of trying to investigate the separated effects of different funding instruments, which in the first place is impossible with the data in use, we conclude as Ebersberger and Lehtoranta (2008) that their effects depend on which companies, large or small, and in which innovation phases they are awarded to. A more detailed analysis should be made on the effects of their different combinations.

The main conclusion concerning the impact of grants and loans is that grants contribute to the creation of new technological inventions (proxy: patents and new-to-market innovations), and loans have a more direct impact on the economic success on the market (growth, profit). Because markets are hit by the economic crisis from 2008 onwards, loans rather than grants have a significant effect on the R&D intensity and growth rates of supported companies. This should not be interpreted so that grants have lost their economic impact. Grants and loans are complementary instruments over the innovation process. Large firms receive mostly grants through their participation in collaborative research projects. But a large majority of SME's use both instruments anyway: the combination of loans and grants probably varies depending on which innovation phase supported projects are at a specific point of time.

The main target of this study was to analyse whether companies participating in environmental and welfare programmes have innovation input and output additionality. Because of the small size of observations of companies in welfare programmes and at the same time in the R&D Surveys, these companies had to be dropped from the analysis. By using a matching procedure based on the propensity scores of the predicted probability mass function, we found evidence of the effect of Tekes support on supported companies' R&D intensities, growth rates, patents granted and innovations. Often these findings can be seen just after a few years. We used two period treatment effect models (probit models) where the mean performance in the latter period was explained with the earlier and the latter period treatments.

Because treatments are shown to have a measurable impact on companies R&D intensities, growth rates and innovations, they with a high probability also affect the environmental targets of these companies.

4.3 Case study results

The purpose of the case study analysis has been to create information which complements the statistical analysis with more qualitative view on the mechanisms through which Tekes can generate impacts on wellbeing and environment. The cases have been selected to cover (1) environmental and wellbeing related innovations, (2) tangible products and services, and (3) stand-alone innovations and more system level concepts. The Table 2 summarizes the cases and key findings.

The case study analysis provides the following observations:

- It is possible to identify innovations, developed and commercialised by companies receiving Tekes support, which have significant impacts on environment and/or wellbeing. In each case analysed, Tekes support was perceived to have played an important role. As the cases were intentionally selected to represent innovations with a strong link with Tekes it is not possible to generalize from them about the frequency of the impacts in statistical terms. However, cases provide valuable insight into identification of plausible mechanisms through which impacts may occur.
- The primary mechanisms through which Tekes activities contribute to wellbeing and environmental impacts are financial support to generation and diffusion of technological knowhow and innovation capabilities in firms. These capabilities transform to impacts through creation, development and commercialisation of innovative products and services with positive effects on environmental sustainability and individual wellbeing and adoption of these innovations by users.
- For large companies the financial support from Tekes does not appear to be equally important as to SMEs. Tekes support however gives credibility to a project, which in its turn increases the likelihood that such a project is funded and supported internally. It also has provided external credibility among potential users, stakeholders, and public authorities responsible for environmental regulation and public social and health care service provision.
- Tekes financial support is important for realising long-term research collaboration (financing of academic or institute research). Tekes support to long-term research programmes and collaboration with research organizations have played a key role in building necessary capabilities for innovation. This has contributed towards renewal of Finnish industry towards more ecologically sustainable products.
- For SMEs the Tekes funding is more important for complementing insufficient financial resources, thus generating input additionality.
- Financial support alone is generally not enough to realise fast growth and important societal impacts. This is related to the barriers mentioned before. If SMEs are able overcome risks of failure than it takes more time for them to grow. Tekes market pull support, especially in the semi-public markets of environment and wellbeing could be important, although it is not yet clear what the best role for Tekes would be. Supporting public procurement of innovation is becoming an established approach. The case of Kotitori supports the role of public procurement as a tool to create new market openings for innovative governance models and new commercial solutions. However, an assessment of the merits of public procurement as a policy tool to accelerate adoption and diffusion of environmental and wellbeing innovations still awaits more experiences and their rigorous evaluation. Sophisticated use of other forms of demand-side innovation policies (regulation, standards) are still in a nascent stage.
- The total magnitude of impacts is largely a function of the number of users adopting a particular innovation with positive impacts on environment or wellbeing. With their large production capacity, delivery channels and marketing capabilities large companies are in a better position to diffuse innovation successfully to a large user base than SMEs, thus generating larger total magnitude of impacts.
- Tekes impacts on wellbeing and environment are dependent on the success of new products, processes and organizing models not only being developed but also adopted in significant scale. Two cases analysed, biodiesel by Neste Oil and lactose-free milk by Valio, have been successfully commercialized and their production scaled up to the level where they have a significant and measurable impact on environment and wellbeing.
- In the area of environment and wellbeing the necessary capabilities needed might even be larger than outside these domains because there are in these domains significant institutional barriers (care sector), financial barriers (costs of clinical trials in pharmaceuticals) and regulatory barriers (or lack of regulatory drivers for environment).

Table 2. Summary of case study results.

Innovation	Characteristics	Impacts on wellbeing / environment	Tekes contribution
Lactose-free milk by Valio	Product innovation by a large firm Stand-alone technological innovation	Wellbeing impacts: health benefits within a population group with specific dietary limitations (lactose intolerance) Impacts with international scale covering Northern Europe	Financial support through SymBio programme Tekes contributed to improvement of collaboration with research organisations Support from top management to continue R&D work with help of Tekes funding
Net zero energy building by Järvenpään Mestariasunnot	System-level ("architectural") innovation by a small firm Enabled demonstration of supplier innovations upstream	Environmental impacts: improved energy efficiency at the local scale High potential to diffuse due to regulatory drivers (energy efficiency in buildings directive)	Financial support to concept development (input additionality) through Sustainable Community programme Tekes support enabled subcontracting of external expertise (output additionality) Co-contribution with other public funding agencies
Biodiesel by Neste Oil	Radical product and process innovation by a large corporation	Environmental impacts: significant reduction of CO_2 emissions on a global scale	Financial support to technology development through BioRefine programme Tekes contribution to technology development, search for raw material options, testing and verification
Kotitori home care service integrator by City of Tampere	Service innovation by a municipality Novel concept for integrating public and private services Public procurement of service innovation	Wellbeing impacts: improved accessibility and productivity of social services Local scale, little cross-sectoral or geographical diffusion so far	Financial support to concept development through FinnWell programme (input additionality) Expert support during the process (output additionality) Tekes the main external contributor
Water quality monitoring system by Liqum	Technology-based service innovation by a small firm	Environmental impacts: improved monitoring capability of environmental risks Small user base on a national scale within several industrial sectors, nascent export activities	Financial support through Water programme The contribution of Tekes is mainly input additionality
Traumakine™ by Faron Pharmaceuticals	Development of a new medicine by a small firm	No impacts yet, medicine is in phase of clinical trials	Financial support (loans) for clinical trails, and YIC grant. Support also enabled international networking necessary for further (EC) financing

- The scale and speed of innovation adoption is largely dependent on whether a market for an innovative product readily exists or not. Within the cases analysed, only one innovation had a rather direct route to existing markets with well-articulated user needs (Valio). In other cases the market for innovative product did not exist but it had to shape up before diffusion was possible, thus delaying generation of impacts. For one case the diffusion is still at a very early stage (Kotitori) and it remains to be seen how broadly it will eventually become scaled-up.
- For environmental innovations the key driver for new market creation has been introduction of new or tighter regulation. For wellbeing it was not possible to identify any single key driver for market emergence. The dynamics appear to be rather different for consumer demand (e.g. food with health claims), regulated demand (pharmaceuticals), or institutional demand (public and private health and social care services).

5
International benchmarking

In the above chapter we have looked at environment and wellbeing in Finland from a micro-perspective, inside out: we looked at the intentions and actions of Tekes, and what effects we could see from those actions. In this chapter we will take a more macro-perspective and compare the performance of Finland in the fields of innovation, environment and wellbeing with the performance of other countries. We do this in Chapter 5.1 by showing the position of Finland in a number of European or global rankings. In Chapter we provide some insight in the innovation policies with relation to environment and wellbeing in Switzerland and Sweden, two countries that are having high rankings in almost all of the ranking lists.

5.1 Performance of Finland in innovation, environment and wellbeing

5.1.1 General innovation ranking

An important ranking in the area of innovation is the EU's Innovation Union Scoreboard (IUS or Innovation scoreboard). The Innovation scoreboard consists of three themes, namely Enablers, Firm activities and Outputs. These are split up into two or three topics and each of these topics is represented by two or three measurements. In total there are 25 measurements included in the ranking.

Finland has the fifth spot on the Innovation scoreboard, out of a total of 34 countries. On the scoreboard groups are made differentiating innovation leaders, innovation followers, moderate innovators and modest innovators. Finland is the last country to be included in the highest group, innovation leaders. The differences between the five innovation leaders are relatively large as the seven highest ranked countries in the innovation followers group are pretty close to each other.

Figure 24. Innovation Union Scoreboard, main ranking elements.

Enablers	Firm activities	Outputs
Human resources (3 indicators)	Firm investments (2)	Innovators (3)
Open, excellent and attractive research systems (3)	Linkages & entrepreneurship (3)	Economic effects (5)
Finance and support (2)	Intellectual assets (4)	

Finland scores very well in human resources and finance and support. From firm investments it is clear that innovation investments are mostly R&D related. With far less non-R&D expenditures the Finish market is characterised as knowledge intensive and shows less power to valorise these knowledge investments. Finland also scores well on the amount of collaborating innovative entrepreneurs in the linkage and entrepreneurship topic, they however score less on the amount of SMEs with in-house innovation.

Finland has a very similar pattern in terms of strengths and weaknesses compared to Switzerland who is ranked first in the scoreboard. Switzerland scores generally a little higher on every indicator. They have a little stronger intellectual assets indicator score but are a little weaker on the linkage and entrepreneurship indicator. The Innovation scoreboard report refers to a relative weakness in the number of non-EU doctorate students, however also other innovation leaders seem to show the same pattern.

5.1.2 Environmental rankings

General environmental ranking: Yale Environmental Performance Index (EPI)

The Environmental Performance Index is based on two themes, namely environmental health and ecosystem vitality.

These are split up in respectively three and six topics. The score of a country on each of these topics is constructed one to four measurements. The themes, topics and their measurements look like this:

Theme 1, Environmental heath:

1. Health impacts – Child mortality
5. Air quality – Household air, Air pollution (<MP2.5), Air pollution (>MP2.5)
6. Water and sanitation – Access to drinking water, Access to sanitation
7. Theme 2, Ecosystem vitality:
8. Water resources – Wastewater treatment
9. Agriculture – Pesticide regulation, Agricultural subsidies
10. Forests – Change in forest cover
11. Fishery – Fish stocks, Coastal shelf fishing pressure
12. Biodiversity and habitat – Critical habitat protection, Marine protected areas, Global biome protection, National biome protection
13. Climate and energy – Trend in CO_2 emissions, Trend in carbon intensity, Change of trend in carbon intensity

Finland has the eighteenth spot on the EPI ranking, out of a total of 178 countries. Switzerland, on rank one, is clearly ahead of the rest of the world. Their lead on Luxembourg, on rank two, is half the size of the difference between other countries in the top twenty. So besides Switzerland these other countries, including Finland, are pretty close together.

Finland scores very well on the environmental health theme. Most other European countries also have a good score on the environmental health theme, but the Scandinavian countries clearly score better on the air quality measurements.

Within the ecosystem vitality theme Finland scores overall weaker. Wastewater treatment is still a strong suit but forests and fishery could really need some improvements, considering that Finland's score in fishery has declined over the past years this could need some extra attention.

Eco innovation ranking: Eco-innovation observatory

The Eco-innovation observatory has five themes on which the ranking is based. These themes consist of Inputs, Activities, Outputs, Environmental outcomes and Socio-economic outcomes. Each of these is themes has three to four measurements:

Eco-innovation inputs

1. Governments environmental and energy R&D appropriations and outlays
2. Total R&D personnel and researchers
3. Total value of green early stage investments

Eco-innovation activities

4. Firms having implemented material input reduction innovation activities
5. Firms having implemented energy input reduction innovation activities
6. Registered organisations with environmental management (ISO 14001)

Eco-innovation outputs

7. Eco-innovation related patents
8. Eco-innovation related academic publications
9. Eco-innovation related media coverage

Environmental outcomes

10. Material productivity
11. Water productivity
12. Energy productivity
13. GHG emissions intensity

Socio-economic outcomes

14. Exports of products from eco-industries
15. Employment in eco-industries
16. Turnover in eco-industries

Finland has the first rank in the Eco-innovation observatory out of 26 countries. However Finland got in first place by being the leader in the themes: Input and Output, while being only on the 16th place when it comes to environmental outcomes. A similar drop in rank is seen eco-innovation activities, where Finland drops to the seventh spot. This indicates that although Finland is putting a lot of effort in creating knowledge (Input), and they also succeed (Output), firms don't seem to reach the same level of excellence when it comes to implementation. This would also partially explain the clear lack in outcomes compared to the high input and output. This conclusion is not strange considering that the Finnish economy is based strongly on added value obtained from natural resources.

The country report for Finland states that the greatest challenges for eco-innovations in Finland concern high material consumption, the aging of society as well as low material productivity, energy-efficiency and high GHG emissions, which result from energy intensive industrial sectors, freight transportation and traffic as well as extensive earthworks and hydraulic engineering.

5.1.3 Wellbeing rankings

General wellbeing rankings: OECD - Better Life Index

The Better Life Index is based on 11 topics that contribute to a better life. Each of these topics is a translation from available measurements that are often a combination of objective and subjective figures. The 11 topics and their sub-measurements consist of:

1. Housing – No basic facilities, housing expenditure, rooms per person
2. Income – Household disposable income, household financial wealth
3. Jobs – Employment rate, job security, long-term unemployment, personal earning
4. Community – Quality of support network
5. Education – Educational attainment, Student skills, years of education
6. Environment – Air pollution, water quality
7. Civic Engagement – Consultation on rule-making, voter turnout
8. Health – Life expectancy, self-reported health
9. Life satisfaction – Life satisfaction
10. Safety – Assault rate, homicide rate
11. Work-Life balance – Long working hours, time for leisure and personal care

Finland comes in on ranking number twelve of the total 36 countries, although this is not necessarily a bad spot as the first 15 countries are very close together. However, this does not mean that these countries are all on the top level within each topic. Each country has its own qualities and weaknesses.

Finland scores exceptionally well on education, were they have the first rank. For environment and life satisfaction Finland scores high as well with rank seven. Areas for Finland that would benefit most from improvement are health, income, jobs and community.

Construct health indicator from OECD numbers

There are some country rankings available but they are often made from the perspective from one specific country. Although this may be an indicator of where Finland stands in terms of health, it doesn't not provide an understanding of why nor does it give good leads on where improvement can be made. However the data behind the ratings is often based on the OECD or World Bank health indicators, therefore our own ranking can be created from this data as well. Two rankings will be constructed, the first will be based on the medical related health status and the second will be based on non-medical related health.

Medical related health

To do this four indicator levels where identified and matched against available data. The first indicator is life expectancy, which simply relates to general health in the population. The second indicator is based on the number of incidences of tuberculosis; a basic but decent healthcare system should be able to decrease the number significantly. The third is based on dental care, this indicates a bit more advanced healthcare, as dental issues are mostly not lethal but still very important. The last indicator is based on the number of incidences of cancer, this a disease that is still a problem all over the world, therefore also present in western European countries like Finland.

Finland has a very dominant position on these topics, coming in at rank three out of 34 countries. Surprisingly the life expectancy is not very high in Finland, although still close to average. Finland excels at the indicators for dental care and tuberculosis, also compared to other western European countries. On the indicator for cancer Finland scores just below average.

Non-medical related health

Three indicators where used here, namely amount of alcohol consumed, people smoking and people who are overweight (including obesity). These are common unhealthy habits that should represent the non-medical related health state of countries. The amount of countries for which all three of these indicators were available was rather limited, however there are still 25 countries that could be compared.

Finland is in 7th place in this ranking, scoring well on the amount of people smoking and very close to average on the alcohol and obesity indicator, opportunities for Finland can thus be found in these two indicators. Clear winner Turkey scores extremely low on the amount of alcohol consumed.

5.1.4 Table overview of rankings

Figure 25. Overview of rankings. Technopolis analysis, from internet sources

	General innovation	*General environment*	*Eco-innovations*	*General wellbeing*	*General health*	*General health*
No.	**Innovation scoreboard**	**Environment performance index**	**Eco-innovation observatory**	**OECD Better Life Index**	**Health medical indicators**	**Health non-medical indicators**
1	Switzerland	Switzerland	**Finland**	Austria	Switzerland	Turkey
2	Sweden	Luxembourg	Denmark	Sweden	Sweden	Sweden
3	Germany	Australia	Sweden	Canada	**Finland**	Norway
4	Denmark	Singapore	Germany	Norway	Canada	Korea
5	**Finland**	Czech Republic	Spain	Switzerland	Luxembourg	Canada
6	Netherlands	Germany	Belgium	Unites States	Japan	Italy
7	Luxembourg	Spain	Slovenia	Denmark	Italy	**Finland**
8	Belgium	Austria	Ireland	Netherlands	Germany	Denmark
9	United Kingdom	Sweden	Austria	Iceland	Austria	Switzerland
10	Iceland	Norway	Netherlands	United Kingdom	Netherlands	Australia
11	Austria	Netherlands	Luxembourg	New Zealand	Greece	Netherlands
12	Ireland	United Kingdom	United Kingdom	**Finland**	Spain	Slovak Republic
13	France	Denmark	France	Austria	United Kingdom	France
14	Slovenia	Iceland	Italy	Luxembourg	Iceland	United States
15	Cyprus	Slovenia	Czech Republic	Ireland	Australia	Slovenia
16	Estonia	New Zealand	Portugal	Belgium	Israel	Chile
17	Norway	Portugal	Bulgaria	Germany	Norway	Germany
18	Italy	**Finland**	Romania	France	Estonia	Austria
19	Spain	Ireland	Estonia	Slovenia	United States	Poland
20	Portugal	Estonia	Cyprus	Spain	Denmark	Estonia

5.2 Innovation policies in Switzerland and Sweden

In the above rankings Switzerland and Sweden are consistently in high positions. Although these kind of composite index scores are always open for debate (how does the importance of one sub criterion relate to that of others, or to issues that are not monitored?) and the relation between (a part of) policies in a country and the ranking is generally rather indirect and therefore positions cannot often be attributed to specific policy instruments, we have looked at innovation policies in Switzerland and Sweden. Specific studies on effects of innovation policy measures on environment and wellbeing in Sweden and Switzerland were not found, so the comparison is at a low level of detail, however this might provide food for thought and learning.

5.2.1 Switzerland

Country properties of interest

- Financial global hub
- Strong sustainability culture, with the highest recycle rate in the world
- Policy priority, recent 10 strategy for cleantech

- Advanced green building rating systems, named Swiss Minenergie
- High cleantech workforce (4.5% of all employment)
- Hydroelectric power (58% of Switzerland's electricity production)

General overview RD&I policy

Switzerland has two organisations that are responsible for RD&I support instruments. The Swiss National Science Foundation (SNSF) is responsible for stimulating basic research and the Commission for technology and innovation (CTI) is responsible for applied research and development with a focus on SME's.

Swiss research funding is a bottom-up system. This means that there are few clearly prescribed thematic guidelines; the topics of the research are largely determined by the project proposals of the researchers themselves or by the companies involved in the R&D project.

Environmental policy is mostly clustered under "clean tech policy". A federal governmental strategy combines the effort of multiple departments. In order to sustainably enhance Switzerland's innovative strength in the cleantech sector, the Federal Council adopted five areas of focus. These areas are: research/knowledge and technology transfer, regulation and market-based grant programmes, international markets, competencies and cleantech innovation environment.

There is no dedicated policy cluster for wellbeing in Switzerland like there is for cleantech. The Commission for technology and innovation (CTI) does have a specific focus area for life sciences. The range of disciplines covered is wide and the potential for market-orientated application is high. Life Sciences comprise the areas biology, biochemistry, biotechnology, pharmacology, nutrition, food technology, agriculture and medical technology.

Funding

The SNSF had a total budget of €619,3 million in 2012 and the CTI had a total budget of €90,9 million in 2011.

Federal funding allocated specifically to cleantech research is drawn from the policy sector research budgets of the Swiss Federal Office for Energy (SFOE) and the Federal Office for the Environment (FOEN). The Federal Office for the Environment (FOEN) has a total budget of €3,6 million available each year for FOEN research into environmental technology. The Swiss Federal Office of Energy (SFOE) has a total budget of around €16,4 million for energy-related research and around €4,1 million for industry pilots and functional prototypes.

Within the SNSF there are no clear thematic groups of research funding for either environment or wellbeing. For cleantech they have identified and listed the sub programs that are relevant to cleantech. This however still makes it hard to make an estimate on how much funding goes specifically and only to cleantech related projects.

In 2009, CTI provided a total of CHF 17.2 million in grants to 46 cleantech-related R&D projects. This amounts to 16% of the CTI's total budget for R&D project funding. Funding in wellbeing will come primarily from the CTI. The budget dedicated towards SME's in life sciences was €22.2 million in 2011. This funding comes directly from the Federal Department of Economic Affairs, Education and Research (EAER).

Agencies

Commission for technology and innovation (CTI):

The CTI stimulates cooperation between firms and research institutes. CTI's objective is to generate more innovative products and services by encouraging higher education institutions and companies to work together on joint R&D projects. Private sector R&D activities of companies are therefore not funded directly but rather via joint R&D projects where companies and higher education institutions work together.

CTI's activities are generally focused on SME's by granting access to know-how, staying power, financial resources and a professional team.

Swiss National Science Foundation (SNSF):

The Swiss Confederation has mandated the SNSF to fund basic research and promote young scientists in Switzerland. The SNSF's strategy and objectives are geared to fulfilling this task and strengthening Swiss research as a whole.

The SNSF's strategic goals are:

- Support high-quality research as well as researchers in their quest for excellence.
- Bring research funding closer into line with the researchers' needs.
- Support the spread of knowledge in society, the economy and politics and demonstrate the value of research.

Non funding organisations:

Swisscleantech sees itself as an information and political voice of sustainable Swiss economy. Their core activities are networking, promotion and information services.

The Cleantech Strategy Switzerland sets the following five objectives for Switzerland:

1. Increase the security of energy supplies, as well as resource and energy efficiency
2. Create attractive jobs
3. Guarantee a high Swiss standard of living
4. Generate short- and long-term profits from fast-growing global Cleantech markets
5. Contribute to sustainable development on a global level

Cleantech Switzerland is the export platform dedicated to the Swiss cleantech sector. It provides small and medium-sized Swiss cleantech businesses with information, services, and contacts and helps them access cleantech markets around the world.

5.2.2 Sweden

Country properties of interest

- Strong separation of public and private R&D
- Private R&D mostly done by handful of multinational corporations
- Good framework conditions for innovation, including solid macroeconomic fundamentals and institutions, a robust financial system and a supportive business environment
- Successful socioeconomic development combining economic success with a high degree of equality and outstanding quality of life
- Wide public acceptance of innovation and recognition of the importance of science, technology and innovation (STI) for sustainable future growth.
- Good links with international academic and industrial networks

General overview RD&I policy

Most of Sweden's Innovation funding in the areas environment and wellbeing are in the hands of Swedish Governmental Agency for Innovation Systems (VINNOVA). VINNOVA is Sweden's innovation agency, which is responsible for strengthening Sweden's innovativeness, aiding sustainable growth and benefiting society.

Next to VINNOVA there are two councils that are responsible for the funding of there ministries. The first council is the Formas, the Swedish Research Council, and the second is FORTE, the Swedish Council for Working Life and Social Research.

Besides these councils there is not dedicated agency that is purely responsible for wellbeing or environment. However there is a strong focus on environment from the central government. So besides the supply side incentive mechanisms from the VINNOVA and the councils there are a set of demand side policy measures to support eco-innovative activities, products and services. Several regulations, performance standards tax incentives, tax reductions and demand subsidies are in place to help consumers to purchase more environmentally efficient products.

Although the Swedish Government takes all decisions collectively with the Ministry of the Environment preparing decisions on environmental policy matters, all ministries have responsibilities for environmental consequences in their respective fields.

5.2.3 Funding

The Ministry of the Environment supports Formas, which has a total budget of around €100 million. FORTE, supported by the Ministry of Health and Social Affairs has a total budget of around €50 million. VINNOVA has a budget of €250 million to support innovation but co-financing from actors must total at least the same amount. VINNOVA is part of the funding of the Ministry of Entrerprise, Energy and Communication, this ministry also supports R&D in energy for around €170 million and R&D in space for around €115 million.

5.2.4 Agencies

Formas:

The mission of Formas is to promote and support basic research and need-driven research in the areas Environment, Agricultural Sciences and Spatial Planning. The research that is funded should be of the highest scientific quality and relevance to the areas of responsibility of the Council. Formas may also fund development projects to a limited extent.

FORTE:

The mission of FORTE is to promote the accumulation of knowledge in matters relating to working life and the understanding of social conditions and processes through promotion and support of basic and applied research. The Council's support for research takes various forms. The main one is grants for projects, but the council also creates research positions at Swedish universities and provides grants for visiting researchers as well as scholarships for post-doc studies abroad. The research funded by FORTE covers mainly the areas work and health, work organisation, labour market, public health, welfare, and social services and social relations. Of particular interest is multidisciplinary research and research that addresses topics relating to equality between the sexes.

VINNOVA:

VINNOVA has the role of an expert authority, a funding agency and tries to stimulate international cooperation and provide catalytic meeting places.

As expert authority VINNOVA has an important role to play in the development of research and innovation policy. VINNOVA provides the Ministry of Enterprise, Energy and Communications and other parts of the Government offices with data and thematic studies in order to support the policy making process. Their role is to provide knowledge that will influence strategic prioritisation and policies, for the innovation system.

VINNOVA funds research that can be classified via three ways. First they have four thematic competences that define their focus areas. Three out of four of these thematic competences, are relevant to environment and wellbeing, namely: health and healthcare, manufacturing and working life and transportation and environment.

Secondly they target four specific groups, which are mostly differentiating research that strengthen the general innovation landscape, SMEs / entrepreneurs or the education/ public sector. Thirdly their funding should contribute to broad initiatives, which are very much linked to well known societal challenges. Within this VINNOVA strives to perform well on three forms of sustainability, namely: economic, social and ecological sustainability.

5.2.5 Comparison of Switzerland and Sweden

It is striking to see that the systems for innovation support in these two well-performing countries are so different. Where Switzerland has small agencies, with fairly small budgets that do not follow strong thematic policies, Sweden has strong agencies with fairly large budgets and thematic agendas. In both countries the attention of government policy for the interaction between companies and knowledge infrastructure is limited. If there is a theme that is supported in both countries this is environment/sustainability. Wellbeing has received significant attention in Sweden.

6 Reflection and recommendations

The purpose of this study has been to investigate what impacts Tekes generates for the environment and wellbeing, and how the impacts come about. Based on quantitative analysis of post completion project questionnaires, statistical analysis of firm level data and qualitative case studies the following key findings emerge.

A significant positive effect of Tekes support on companies has been found within samples studies. Tekes support improves or increases supported companies' R&D intensity (the share of R&D expenditures in turnover), innovation outcomes (new-to-market innovations) and growth rates. These results are in line with earlier impact studies.

The logistic regression of post-completion project questionnaires highlights that societal impacts were perceived higher from projects in which Tekes had a significant role. Particularly for industry projects the intervention of **Tekes increased the probability that the project had perceived societal impacts**. The Tekes impact variables included were:

- All projects: Tekes impact on project challenge level, Tekes impact on project using outside resources, Tekes impact on the number of project partners and Tekes impact on project overall.
- Industry projects: Tekes impact on project using outside resources, Tekes impact on the number of project partners and Tekes impact on project overall.
- For research projects the impact of Tekes was found statistically irrelevant.

We may conclude that the role of Tekes in producing societal impacts strongly relates to Tekes ability to create networks, add relevant partners to project consortiums and to enable the usage of relevant outside resources. This suggests that Tekes has impacted firm behaviour (Behavioural additionality) through its intervention and created positive changes in how networks are created. This behavioural additionality appears to be positively linked with generation of societal impacts.

The findings from the statistical analysis of firm data provides evidence that while environmental and wellbeing markets are attractive for innovative products, companies with innovations in these domains supported by Tekes, do however not show a different economic performance than companies supported by Tekes outside this area.

According to various international indices Finland is among the top performing countries in the world in the area of wellbeing. Wellbeing has only recently become an area of specific attention for Tekes and in the past ten years only a limited number of projects with (positive) wellbeing effects has been found. In most of these projects SMEs have been supported, and more recently also the public health and social services have become eligible for support. A statistically relevant effect on the performance of these companies could not (yet?) be found.

Case studies show that involvement of Tekes in the wellbeing domain can be very relevant. For all innovative companies access to expertise, networks and innovation partnerships is highly important. For smaller companies the funding is important as well, especially since the wellbeing market is to a large part determined by public service organisations and detailed regulation of access to market (especially in pharmaceuticals). Consequently implementation and diffusion of innovations takes a long time. Developing markets is of great importance to have commercial success in this area. Tekes attention for this is welcomed but the optimal role of Tekes is not yet clear. Effects on a macro-level can, because of present small size of the Tekes activity and lack of data not be attributed to Tekes.

In the field of environment high material consumption, fairly low energy-efficiency and high GHG emissions, which result from energy intensive industrial sectors, freight transportation and traffic as well as extensive earthworks and hydraulic engineering, put large pressure on ecosystems in Finland. Finland has however been placing a lot of emphasis

on solving this issue. There have been a large number of Tekes-programmes in this area. Tekes projects supported highlighted the positive impact of Tekes in projects overall and industry projects where the intervention of Tekes increased the probability that the project had perceived societal impacts. In recent years, at project level, impact on energy efficiency and materials efficiency becomes apparent. This efforts is apparent in the European eco-innovation index where Finland ranks no 1, especially because of strong eco-innovation inputs. From innovation to environmental impact is however a long process and a relation between Tekes projects and the state of the environment in Finland cannot (statistically) be made.

Case studies on Tekes supported innovations again show significant economic and environmental impacts. While generalisation from few cases is not possible, they demonstrate some of the key mechanisms through which Tekes can have a positive contribution to environmental sustainability. Investments in knowledge creation, support to knowledge transfer through research subcontracting, and support to demonstration projects are among the key mechanisms observed. Part of the environmental impacts are realised outside Finland (with generally economic benefits for Finland).

Appendix A. The overall approach and methodological tools

For determining impacts at the different levels various methods were used:

- **(Statistical) analysis** of Tekes database
- **Econometric analysis** of performance of companies receiving Tekes support in environment and wellbeing area
- **Case studies** of 6 projects from the 9 relevant programmes to gather in-depth insight in chains of interaction leading to effects on environment and wellbeing.

A.1. Statistical analysis of Tekes database

Methodology is described in the text of chapter 4.1. The outcome of the logistic regression model is presented in Table 3.

Table 3. Logistic regression variables in equation.

	Independent variables	B	S.E.	Wald	df	Sig.	Exp(B)
All projects	Industry/Research project	1.399957	0.144228	94.21779	1	2.83E-22	4.055028
	Project meeting technical objectives	0.568741	0.058925	93.16048	1	4.82E-22	1.766042
	Project meeting commercialisation objectives	0.21086	0.032645	41.71992	1	1.05E-10	1.23474
	Tekes impact on project challenge level	0.285944	0.10838	6.960927	1	0.008331	1.331018
	Tekes impact on project using outside resources	0.381152	0.124339	9.396872	1	0.002174	1.463971
	Tekes impact on the number of project partners	0.439168	0.116491	14.21282	1	0.000163	1.551417
	Tekes impact on project overall	0.349264	0.06243	31.29803	1	2.21E-08	1.418023
	Constant	-4.43126	0.342684	167.2121	1	3.01E-38	0.011899
Research projects	**Independent variables**	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
	Project meeting technical objectives	0.720021	0.14471	24.75661	1	6.5E-07	2.054477
	Project meeting commercialisation objectives	0.161905	0.07019	5.320769	1	0.021073	1.175748
	Project impact on research group differentiation	0.968205	0.221279	19.14488	1	1.21E-05	2.633213
	Constant	-0.85635	0.548131	2.440796	1	0.118216	0.42471
Industry projects	**Independent variables**	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
	Project meeting technical objectives	0.433276	0.067349	41.38736	1	1.25E-10	1.542302
	Project meeting commercialisation objectives	0.212621	0.03832	30.78734	1	2.88E-08	1.236916
	Tekes impact on project using outside resources	0.300746	0.141115	4.54209	1	0.033071	1.350866
	Tekes impact on the number of project partners	0.559328	0.132694	17.76778	1	2.5E-05	1.749496
	Tekes impact on project overall	0.370443	0.071229	27.04747	1	1.99E-07	1.448375
	Project impact on differentiation	0.323952	0.123568	6.873027	1	0.008751	1.38258
	Project impact on technology and innovation competences	0.450504	0.123161	13.37988	1	0.000254	1.569102
	Company size (SME is reference group)	0.333899	0.133741	6.233068	1	0.012539	1.396401
	Constant	-4.40851	0.403591	119.317	1	8.93E-28	0.012173

A.2. Statistical analysis on the impact of Tekes activities on environment and wellbeing companies

Methodology

We use treatment effect analysis and propensity score matching in picking up the control group for companies that have received Tekes support. For getting the two groups of companies, namely companies that have received Tekes support (Tekes clients) and companies that have not received or even applied for Tekes support (non-Tekes clients) pairwise as similar as possible, we merge Tekes clients as well as non-Tekes clients with R&D Surveys, Patent and Business Register data.

For each company that has received Tekes support we identify a company that has never received Tekes support, but that is similar to the supported company. We use the following criteria to capture similarity: size, sector, earlier R&D persistency, patenting and export orientation. We integrate both the supported and the similar non-supported company into our data set for analysis. These 'twins' generate a data set that has for instance 204 supported companies and 204 not-supported companies, which are similar to the supported ones with the only difference that the former are supported and the latter are not. When we find differences between these groups in the data set we can attribute these to the support as both groups are otherwise similar if not identical.

The population of R&D Surveys includes Tekes clients, with the limitation that only companies which have 10 or more employees are included. Unlike Patent and Business Register R&D Surveys are samples. However, in principle R&D Surveys are panels for companies which have performed R&D and are at least once included in a Survey.

Merging Tekes clients with R&D Surveys does not reduce the number of observations a lot. But when we pick up companies performing R&D in the periods under consideration, the numbers will drop. The numbers of R&D active companies in the groups of interest are:

1. Companies that have received support from 10 Tekes environment programmes, N= 481
2. Companies that have received support from Tekes wellbeing programmes, N=19
3. Companies that have received support from Tekes outside environment and wellbeing programmes, N=4054

In addition, there are 1661 non-Tekes clients that have performed R&D at least in one of the R&D Surveys over the period 2000–2011. Further, when we go to consider smaller periods of time including four years, even these numbers will drop. It follows from this that impacts from environment support and wellbeing support cannot be considered separately.

Some of the environmental and welfare programmes are ongoing or just recently ended and some go back to the 1990's. This means that the time span and delays until results have to be taken into account in the estimation. We will do this by using two period models, where dependent variables in period 2 like company level R&D intensities, new-to-market innovations or company level average growth rates in turnover will be explained with firm characteristics and Tekes support by type in periods 1 and 2.

In this analysis, the following time periods are used: 2000–2003, 2004–2007 and 2008–2011. These periods are selected on the basis of data availability. They capture well the changes in the economic conditions taken place in the markets. First we consider Tekes support by type over the periods 2000–2003 and 2004–2007 and impact variables like R&D intensity, new-to-market innovations or company level growth rates over the latter period. Then we proceed to consider Tekes support by type over the periods 2004–2007 and 2008–2011 and its impacts in the latter period.

The dependent variables are counted as company level mean values for the period 2004–2007 or 2008–2011. Respectively, the explanatory variables are counted as company level mean values for the periods before and including the period under consideration. This way, an average time lag of 4 years is used here, but as a whole time lag varies from 0 up to 8 years.

For testing the hypothesis 1, we estimate both the input and output additionality of Tekes support. Because we are interested in the impact of Tekes activities on companies participating in environmental and welfare programmes, only companies included in these programmes and simultaneously in R&D Surveys are used here.

For testing the hypothesis 2, we estimate the input and output additionality of Tekes support by using the matched samples of Tekes clients outside environmental and welfare programmes and similar non-Tekes clients.

By comparing the impact of Tekes support on R&D intensities, patenting activities, new-to-market innovations or company level growth rates across different samples we can at least assess, if not directly test, the hypothesis 3.

Companies included in environmental programmes

After cleaning the data we have 297 R&D active companies participating in environmental programmes of Tekes in the period 2004–2007. This group will define the sample of environmental companies used in the matching and the performance of which is examined in the period 2008–2011. But next we take a glance at the characteristics of these firms in the previous period, i.e. in the period 2004–2007.

In this sample the mean number of employees is 169 and the share of large companies 16 percent. The average share of R&D intensity, i.e. the share of R&D expenditures in turnover is quite high among these companies, 31 percent. Besides the high share of R&D intensity, at least 65% of these companies performed R&D persistently from year to year. This share can be underestimated because annual information on individual companies can be missing in the R&D Surveys. On the average, they had 3,4 domestic patents and 1,2 patents granted by the USPTO. A third of them filed domestic patent applications and 16 percent received patents from the USPTO in the period 2004–2007. Almost all of them were export oriented. In this period, their average annual growth rate of turnover was 15 percent, and the average annual amount of Tekes' support payment a bit more than 60 000 euros, which was about 9 percent of turnover.

In the period 2008-2011, this same sample of companies had, on average, 185 employees and their R&D intensity was 27 percent. In this period, a bit more than a third of them filed domestic patent applications and 11 percent received patents from the USPTO. Their average annual growth rate over this period was 2 percent, and the average annual amount of Tekes payment 180 000 euros representing 12 percent of turnover.

The characteristics of the sample of R&D active companies participating in environmental programmes in 2004–2007 are given in Figure 27. These figures describe their characteristics in this particular period. Included are also companies which according to the R&D Surveys were R&D active over the same period but which had not been Tekes clients over the period 1992–2013. After cleaning the data there were 625 R&D performing companies not supported by Tekes.

As displayed in Figure 27, companies receiving public support tend to be larger, have a higher R&D intensity, R&D persistence and technological experience proxied by the patent stock. They also have a slightly higher export orientation.

Matching the data

We cannot compare the samples of supported and non-supported companies given in Figure 26 as such: there is as strong selection bias as shown in Figure 27. Figure 27 displays the probit regressions used to illustrate how the matching procedure will soothe the selection bias problem in the initial sample. The first two columns of Figure 27 show how different company characteristics determine the public support. The company characteristics jointly determine the public support. This means that there is a strong selection bias in the initial data set with respect to Tekes support for innovation.

The second section in Figure 27 displays the explanatory power of the same regression after the matching. As we can observe, after matching receiving public support does not anymore depend on company characteristics. After matching, the probit regression does not reveal any explanatory power: the estimated parameters are not individually or jointly significant. It follows from this that the effects of public support can be estimated on the basis of the matched samples.

In the results displayed in Chapter 4.2. the supported companies are matched to similar non-supported companies and the similarity is measured by the likelihood to receive funding. This likelihood is estimated on the basis of probit regressions reported in the left part of Figure 27.

Figure 26. Determinants of public funding.

Public support	Before matching		After matching	
	Coef.	Std. Err.	Coef.	Std. Err.
Size (log employees)	-0,144***	0,027	-0,028	0,030
R&D persistence	0,813***	0,101	-0,098	0,118
Domestic patent applications	0,796***	0,118	0,099	0,127
US patents	0.772***	0,163	0,073	0,146
Export orientation	0,186	0,160	0,081	0,190
Constant	-0,460***	0,179	0,094	0,208
N of obs	922		594	
LR chi2(10)	248,39***		2,66	
R2	0,214		0,003	
LL	-455,25		-410,40	

Note: ***(**,*) indicates significance at the 1%, (5%, 10%) level. 6 sector dummies included in the regressions are not reported here.

Figure 27. Descriptive statistics of key variables. VTT/Statistics Finland analysis

Variable	Non-supported 0 Supported 1	Obs	Mean	Std. Dev.	Min	Max
N of employees	0	625	104	189	0	2053
	1	297	169	387	0	2301
log (N of employees)	0	625	3,43	1,89	-2,30	7,63
	1	297	3,15	2,13	-2,30	7,74
Share of large firms	0	625	0,11	0,31	0	1
	1	297	0,16	0,37	0	1
Turnover	0	625	3,30E+07	1,50E+08	0	2,90E+09
	1	297	7,80E+07	3,20E+08	0	3,60E+09
Average annual growth rate of turnover	0	449	1,09	0,22	0,04	3,17
	1	241	1,15	0,29	0,17	2,76
R&D expenditures	0	625	4,10E+05	1,10E+06	2000	1,50E+07
	1	297	1,90E+06	5,70E+06	7000	7,00E+07
R&D intensity	0	611	0,12	0,24	0	1
	1	293	0,31	0,36	0	1
R&D persistence	0	625	0,31	0,46	0	1
	1	297	0,65	0,48	0	1
Domestic patent stock	0	625	0,33	1,12	0	14,10
	1	297	3,43	9,58	0	99,61
US patent stock	0	625	0,06	0,41	0	7,01
	1	297	1,21	4,56	0	47,69
N of dom. patent applications	0	625	0,22	1,03	0	17
	1	297	2,39	7,06	0	60
N of US patents	0	625	0,04	0,37	0	5
	1	297	0,95	4,43	0	59
Has dom. patent applications (share)	0	625	0,09	0,28	0	1
	1	297	0,34	0,48	0	1
Has US patents (share)	0	625	0,02	0,15	0	1
	1	297	0,16	0,36	0	1
Export orientation	0	625	0,89	0,32	0	1
	1	297	0,92	0,27	0	1
Tekes support	0	625	0,00	0,00	0	0
	1	297	63200	1,20E+05	592	9,10E+05
Support intensity (share in turnover)	0	625	0,00	0,00	0	0
	1	297	0,09	0,22	0	1
Tekes grants	0	625	0,00	0,00	0	0
	1	297	47213	1,10E+05	0	9,10E+05
Tekes grants intensity (share in turnover)	0	625	0,00	0,00	0	0
	1	297	0,04	0,14	0	1
Grants receivers (share in sup. receivers)	0	625	0,00	0,00	0	0
	1	297	0,91	0,28	0	1
Tekes loans	0	625	0,00	0,00	0	0
	1	297	17531	41630	-2715	3,30E+05
Tekes loans intensity (share in turnover)	0	625	0,00	0,00	0	0
	1	297	0,06	0,18	0	1
Loans receivers (share in sup. receivers)	0	625	0,00	0,00	0	0
	1	297	0,53	0,50	0	1
High technology manufacturing	0	625	0,03	0,16	0	1
	1	297	0,02	0,14	0	1
Medium high tech manufacturing	0	625	0,08	0,27	0	1
	1	297	0,02	0,15	0	1
Medium low tech manufacturing	0	625	0,22	0,42	0	1
	1	297	0,27	0,45	0	1
Low tech manufacturing	0	625	0,16	0,37	0	1
	1	297	0,09	0,29	0	1
Knowledge intensive services	0	625	0,24	0,43	0	1
	1	297	0,21	0,41	0	1
Other services	0	625	0,28	0,45	0	1
	1	297	0,39	0,49	0	1

A.3. Case study methodology

The case study analysis has been guided by the following research question: how has Tekes activities (funding, activation, networking etc.) contributed to creation, commercialization and diffusion of innovation with impacts on environment and wellbeing?

Case studies conducted in programme evaluations conventionally tend to focus on a single company or a product. In this evaluation a more comprehensive case study approach was applied with a focus on innovation as the unit of analysis. The approach has a longitudinal focus based on the unique Sfinno database comprising 5000 Finnish innovations.

The case study approach analyses identified innovations in the context of a variety of factors: knowledge base accumulation, technological trajectories, changes in the socio-economic landscape, policy, and contribution of Tekes and other public funding agencies. This broader perspective allows connecting a specific innovation with several contributing factors, such as continua of funding programmes and related R&D projects.

The case selection will balance the following perspectives:

1. Coverage of both environment and well-being related innovations
2. 'Stand-alone' vs. systemic innovations
3. Tangible product vs. service innovation

VTT Sfinno batabase was exploited in the selection of cases. Firms which have received funding from Tekes programmes in the field of environment and well-being was matched with the Sfinno innovations.

The relatively small number of cases (six) allows more in-depth analysis of various impacts Tekes has had along the long continuum of knowledge creation, use and diffusion.

The unit of the case study is an innovation with impact on wellbeing or environment. Innovation is defined here broadly and it refers to new products (tangible and non-tangible/services), process, business model, or a governance model at the interorganisational (system) level.

The selection of case studies started with examination of Tekes environmental and wellbeing programme results and VTT Sfinno database of Finnish innovations. An email inquiry was sent to Tekes programme managers to select the most significant results from the programme. On the basis of collected information a long list of candidate case innovations was created.

Three main questions were set for the case studies: (1) What is the innovation? (2) How did it evolve from idea to commercialization and diffusion? (3) What has been contribution of Tekes to the development of the innovation?

Appendix B. Case studies

B.1. Case 1: NExBTL renewable diesel by Neste Oil

Background, characteristics and state-of-the-art

Neste Oil's NExBTL technology (a **NEx**t generation **B**iomass **T**o **L**iquid diesel technology) enables premium quality renewable diesel to be produced from a wide range of vegetable oil and animal fat. The background of NExBTL technology is in existing and foreseeable regulations of climate change and required solutions to mitigate greenhouse gas emissions. An EU directive on biofuels and renewable energy, approved in 2008, require the use of renewable energy in traffic and transport across the Community to reach 10% by 2020. Conventional biodiesel and higher-quality renewable diesel production capacity in Europe totalled some 16 million t/a in 2008 but consumption is expected to outstrip this rapidly. Consequently Neste Oil has increased its renewable diesel capacity significantly and has become the world leader in renewable diesel.

NExBTL technology is in many ways a radical innovation related both to process and product technologies. The fuel offers essentially better technical properties than conventional first-generation biodiesels. NExBTL is fully compatible with existing diesel vehicles and fuel distribution systems, and without modifications to refuelling system or vehicles or causing operational problems. It is the only diesel produced from renewables that can be used as such or as a high-content blending component. The higher the NExBTL content, the better is technical performance and the smaller the emissions. NExBTL diesel's performance meets tough specifications of automotive manufacturers'. It is a pure hydrocarbon without sulphur, oxygen, nitrogen, or aromatics. NExBTL has high cetane number (CN[12]) i.e. it burns efficiently and helps keep engines clean with high performance. It offers good storability and does not dissolve easily in water. With excellent low-temperature properties NExBTL can be used year-round also in cold climates. NExBTL is a flexible technology in terms of raw materials it uses. Palm oil has proved to be the best vegetable oil for the process due to its availability and positive environmental footprint. Today the company produces biodiesel from wide range of raw materials (more than 12 different sources, in 2013 waste and residue streams stood for 55% of the total raw-material base) such as waste animal fats, waste oils, residues and side streams.

Neste Oil has four renewable diesel plants in operation with a combined capacity of 2 million t/a. The two NExBTL plants in Finland, both of 200,000 t/a, are located at Neste Oil's Porvoo refinery and two 800,000 t/a NExBTL plants, largest globally, are located in Singapore and Rotterdam. In Singapore plant palm oil makes up for about 45% of the biomass and the rest uses by-products from the plant oil production process and waste animal fat from Australia and New Zealand. The Rotterdam facility is capable of using Neste Oil's wide feedstock base consisting of a variety of vegetable oils, by-products of vegetable oil refining (e.g. stearin), and waste oils and fats which all meet the sustainability criteria included in the EU Renewable Energy Directive. The Rotterdam refinery is capable of utilizing future feedstocks like algae oil. Neste Oil´s revenue from renewable fuels business has grown rapidly, from 116 Million Euros to over 2 Billion Euros in 2012. The full year 2013 comparable profit is expected to be clearly above 200 Million Euros. NExBTL diesel is primarily sold to oil companies in Europe and North America. According to field tests NExBTL biodiesel performs well in buses and public transport, passanger cars, heavy traffic and transportation, and aviation and marine.

From R&D via testing to markets

Since the early 2000s NExTBL product development proceeded through various stages during which company did investigate national and international competitive environments of biofuel area, searched for alternative raw materials for biodiesel, and carried out product and process technology development. Among potential raw-material sources examined in the early phase of product development were tall oil,

[12] Cetane number (CN) is a measurement of the combustion quality of diesel fuel during compression ignition.

soybean and turnip rape and methyl ester. Gradually the company preferred vegetable oil, and in this stage abandoned tall oil alternative by pyrolysis technology[13]. After various phases the decision was made in favour of NExTBL because in this technology the company already had high competence level and it could continue R&D without acquisition of new know-how. What proved to be new, however, was the processing of palm oil as raw material of biodiesel. The process development of NExTBL was carried out mainly in Neste Oil. The company did not build any pilot plant for NExBTL production but directly in unprejudiced way a full-scale plant. Neste Oil did not face remarkable challenges in product development itself. However, because catalysts play important role in different stages of NExBTL production process, catalyst suppliers proved to have difficulties in organising production effectively to deliver catalysts to Neste Oil. It is important to have catalysis expertise and related suppliers close to the company. Among important collaboration partners in catalysis area are the Department of Biotechnology and Chemical Technology in Aalto University, the Laboratory of Chemical Reaction Engineering at Åbo Akademi University, and Neste Jacobs.

During the early renewable diesel development phase Neste Oil examined various raw material options and concluded to concentrate on palm oil. According to later investigations palm oil is the most effective biodiesel raw material due to its availability and to positive environmental footprint (yield per hectare). Other raw material sources were examined in company specific projects of Tekes BioRefine programme. In Trident I project Neste Oil searched for alternatives for bio oils (microbes, yeasts and moulds) together with Aalto University, VTT and Tampere University of Technology targeting to develop new patentable technologies. The Trident III project concentrated to produce microbes and, at that stage, algae as option was abandoned. Today the range of raw material sources used and explored is extensive including waste animal and waste fish processing fat, technical corn oil, tall oil pitch, camelina oil, jatropha oil, soy oil and rapeseed oil. The search and exploration activities were followed by intensive networking of Neste Oil among biofuel experts some of which were recruited to Neste Oil.

The introduction of NExTBL to markets proved to be a challenging task as in case of many innovations. Convincing customers and markets, policy-makers, politicians and all stakeholders of the benefits of NExTBL biodiesel required a lot of efforts. The marketing to car industries was of particular importance. The broad testing and verification process in OPTIBIO project in Tekes BioRefine programme gave an important reference to NExBTL in national and global markets, among national and global authorities, and stakeholders. The Helsinki Region Transport, Neste Oil and Proventia Emission Control carried out in 2007-2010 the world's largest field test of paraffinic renewable diesel fuel. Some 300 buses at four operators in Metropolitan Helsinki and the bus manufacturer Scania took part in this exercise with technical support from VTT, Aalto University and TEC TransEnergy Consulting Ltd. The project confirmed that hydrotreated vegetable oil (HVO) actually works as a drop-in fuel and can replace diesel fuel 100% without any modifications to the refuelling system or vehicles, or causing operational problems. The emission testing, both the screening and the follow-up measurements, demonstrated significant emission benefits. Based on the findings of OPTIBIO project, Scania approved the use of 100% HVO (NExBTL) in its city and intercity buses (with DC9 model engines). After the demonstration phase, the markets will determine the future of high concentration HVO fuels in Finland. Low-level blending is already used commercially to fulfil the general biofuels obligation. The international introduction of NExTBL faced various protectionism related barriers before becoming successful product in global markets.

Environmental and health impacts and sustainability dialogue

The benefit studies of NExBTL renewable diesel show that NExBTL offers reduced emissions of greenhouse gases and tailpipe emissions. Greenhouse gas emissions compared to fossil diesel, as measured over the product's entire life cycle, are 40-90% lower depending on the raw material inputs used. Particulate emissions and NOx emissions are lower than those of conventional diesel. A lower level of tailpipe aldehyde and particulate emissions underlines that NExBTL is a

[13] Neste Oil, in collaboration with Stora Enso and VTT (re)started later in the 2000s wood based biofuel product development supported also Tekes BioRefine programme. The collaboration lead in 2009 to the decision of demonstration plant in Varkaus based on biomass gasification by using forest residue as raw-material. In 2012 companies decided not to progress with these plans as the application of EU NER 300 funding for building biodiesel plant was not accepted by the EU.

clean-burning fuel. Low emissions have positive health and welfare impacts. According to Press release of Neste Corporation (19.12.2011) the emission benefits of Rotterdam refinery's output will be equivalent of removing more than a quarter of a million cars from the roads. This means reducing greenhouse gases by a total of over 1.5 million tons annually.

Neste Oil has been active in global and local stakeholder dialog related for example to critical NGO discussion of palm oil use from rainforest as raw material of biofuel. The company is an active member of the Roundtable on Sustainable Palm Oil (RSPO), a non-profit organisation that brings together palm oil producers, users, governments, and environmental and nongovernmental organisations. The certification system for palm oil developed by the RSPO has been introduced on the plantations from which Neste Oil sources its palm oil. Although palm oil is stated to be best vegetable oil for the process due to its availability and positive environmental footprint, today renewable diesel is produced from wide range of raw materials (waste animal fats, waste oils, residues, side streams).

The company is working with over 20 universities and research groups internationally on new raw materials, such as algae, microbes, and logging waste. The criterion in using raw materials is that they are produced responsibly and sustainably, and the company expects its suppliers to commit themselves to continuously improving their operations. For example, the company can trace the origin of its palm oil from the plantation to its refineries. When selecting raw materials, determining greenhouse gas reduction potential across the entire life cycle is crucial. The final choice depends on a combination of security of supply, availability, and price – once sustainability criteria have been met.

Contribution of Tekes

The NExBTL technology R&D work was carried out by Neste Oil. The technology development and search for raw material options contributed by company specific projects Trident I – III, supported by Tekes BioRefine programme. The broad testing and verification process in OPTIBIO project created credibility of NExBTL biodiesel among customers, policy-makers, politicians and stakeholders. Biocomponents used in OPTIBIO project were granted also tax exemption. With the help of tax exemption Neste Oil committed to deliver the test fuels (diesel + HVO blend and neat HVO) at the same price (€/l) as regular diesel fuel. In addition OPTIBIO project, BIOVAIKU project of BioRefine programme provided perspectives on varying challenges and problems that are encountered when assessing the sustainability of biofuels in general. BIOVAIKU project provided perspectives on varying challenges and problems encountered when assessing the sustainability of biofuels in general, and gave the company ideas to broaden the raw-material base of biodiesel from palm oil to other raw-material alternatives such as animal fats.

Interviewed experts

Ari Juva, former Vice President, Product Development, Neste Oil Corporation (interview 10.12.2013)

Research Professor Nils-Olof Nylund, VTT, Coordinator of OPTIBIO (interview 28.11.2013)

Review of case description

Simo Honkanen, SVP Sustainability, HSEQ, Neste Oil Corporation

Other sources

Renewable fuel from waste and residues, presentation slides by Simo Honkanen, SVP sustainability, HSEQNeste Oil in the visit of Association for Environmental Management in Neste Oil (18.1.2014).

Nylund, N.-O., K. Erkkilä, M. Ahtiainen, T. Murtonen, P. Saikkonen, A. Amberla and H. Aatola (2011) Optimized usage of NExBTL renewable diesel fuel, VTT RESEARCH NOTES 2604.

Articles of NExBTL by Heikki Kilander in: HighTech Finland websites 2009 & 2010

NExTBL related material from: http://nesteoil.com/

Appendix

Projects related to Neste Oil's NExBTL and biodiesel in Tekes BioRefine program

Research projects

- **Optimized Usage of NExBTL renewable diesel fuel – OPTIBIO (VTT, Helsinki Region Transport, Neste Oil, Proventia Emission Control)** The OPTIBIO project needed to explore how to optimise fuels that can be used in both existing and new vehicles, using high quality paraffinic renewable diesel (HVO) as fossil fuel replacement of up to 100%. The value, in addition to fuel replacement, would be the reduction of harmful emissions which are most crucial

for urban air quality, namely nitrogen oxides and particulates. The project results confirm that HVO works perfectly as a drop-in fuel, and can thus replace diesel fuel 100% without any modifications to the refueling system or to the vehicles. The tests show that HVO does not cause any operational problems whatsoever, even during exceptionally cold winters as sometimes experienced in the Helsinki region (e.g. below –25°C).

- **Environmental and economic implications of second generation biofuels for transportation (BIOVAIKU), VTT, SYKE, MTT, Metla, VATT.** The project provided perspectives on varying **challenges and problems that are encountered when assessing the sustainability of biofuels in general**. The most critical factors of different environmental implications that are caused by increased production and use of biofuels were analysed. The main uncertainties and sensitivities associated with the assessment task were discussed and suggestions for further research needs were provided. The technological focus was on evolving technologies of highest interest from the Finnish point of view, that are the **production of FT diesel from forest residues, production of NExBTL diesel from palm oil and tallow, and bioethanol production based on domestic lignocellulosic raw materials**. Critical sustainability aspects of imported Brazilian bioethanol made from sugar cane were also addressed.

Company specific projects

- **Optimal use of NExBTL diesel from renewable feedstock, phase 2, Neste Oil Oyj.** *Helsinki City Transport* with Helsinki Metropolitan Area Council, Neste Oil and Proventia Emission Control have joined forces to demonstrate **the potential for emission reductions using NExBTL renewable diesel fuel**. The new biofuel developed by Neste Oil will be used in high concentrations in buses and refuse trucks in greater Helsinki. The new hydrotreated renewable diesel fuel will be tested as a 30% blend and as such and especially for the latter case significant emission reductions are expected. Some of the buses taking part in the field test will be equipped with retrofitted P-DPF type particulate catalysts to enhance emission performance. If the demonstration is successful, the share of advanced biofuels in greater Helsinki bus services could be as high as 50% in 2010. In this case metropolitan Helsinki could act as a forerunner in developing sustainable public transport. However, the widespread use of high concentration biofuels is only possible if these fuels are covered by fuel standards, and that these fuels are approved by the vehicle manufacturers. The field tests will be conducted in close cooperation with the vehicle manufacturers. If possible, the activities in greater Helsinki will be linked to international activities demonstrating advanced biofuels.
- **Renewable diesel from forest residue, phase 1, Wood based BTL diesel development, stage 2, Neste Oil Oyj.** Neste Oil, a refining and marketing company focusing on advanced, cleaner traffic fuels, and **Stora Enso**, an integrated paper, packaging, and forest products company, have **joined forces to develop technology for producing new-generation liquid biofuels from wood residues**. The selected technology route is based on gasification of biomass and generation of clean synthesis gas to make liquid fuels by synthesis process such as Fischer-Tropsch. The first step will be to design and build a gas generation – **gas cleaning demonstration plant at Stora Enso's Varkaus Mill in Finland**. The plant, owned on a **50/50 basis by the two companies**, is expected to start up in 2009. The project will also focus on using Fischer-Tropsch process to produce **biowax from synthesis gas**. Expertise from **Neste Oil, Stora Enso, and VTT Technical Research Centre of Finland**, as well as from technology partners will be utilized to implement the development phase and commercialize wood-based renewable diesel production.
- **Wood based BTL diesel development, stage 3, Neste Oil Oyj.** Neste Oil, a refining and marketing company focusing on advanced, cleaner traffic fuels, and Stora Enso, an integrated paper, packaging, and forest products company, have joined forces **to develop technology for producing new-generation liquid biofuels *from wood residues***. The selected technology route is based on gasification of biomass and generation of clean synthesis gas to make liquid fuels by synthesis process such as Fischer-Tropsch. Expertise from **Neste Oil, Stora Enso, and VTT Technical Research Centre of Finland**, as well as from technology partners will be utilized to implement the development phase and commercialize the technology. The core development **facilities are Varkaus BTL-test** plant and **VTT's pressurised process development unit in Otaniemi**.

- **Trident I-III, Neste Oil Oyj.** The project objective is to **expand the base of raw materials of renewable fuels (primarily NExBTL) from current plant oils towards sustainable and economical fats and oils**. The project will be executed in several other projects and monitored annually together with the budgeting process. The main aim is to **find, develop, analyse and introduce new suitable, sustainable feedstock either by own work and investments, or in collaboration with reliable and best available partners.**
- **Pilot investments for the expansion of NExBTL raw material base, Neste Oil Oyj.** Pilot scale equipment is developed and built in this project. This equipment is used for the investigation of new bio-based feeds for Neste Oil's renewable diesel. This project is an essential part of Neste Oil's strategy as a producer of renewable and cleaner products for traffic.

B.2. Case 2: Tampere Kotitori home care service integrator

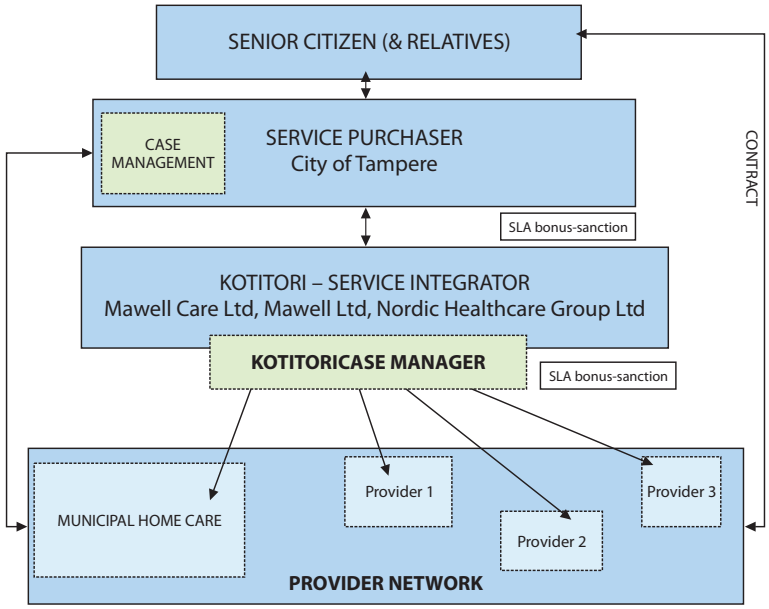
Tampere Kotitori is a service integrator concept bringing together public and private home care services for elderly people. The integrator is run by a private consortium under a multi-year contract for the city of Tampere. As all municipalities in Finland, the City of Tampere holds responsibility for providing elderly care and other social care to its residents. Some of the services the city produces itself, others it contracts out to private service provider firms and non-profit organisations. In addition, there are privately provided services on the market with no public subvention.

In the Kotitori model, the city has made a contract with a private consortium to operate as an intermediary between elderly care clients, private service providers, and the city. The purpose of the integrator is to provide a one-stop-shop of home care services – both public and private. This is intended to improve responsiveness to client needs, easy access for senior people and their families, optimise use of resources, and stimulate development of private services on the marketplace.

The service integrator does not produce the home services itself but procures them from a network of private providers. The Kotitori integrator provides the following services:

- Provides client counselling and guidance in collaboration with the service units of the City: telephone call service, physical service point and online services.
- Accounts for home care for 400 clients (one district) regular home care services: assessment of service need, home care, home health care, catering, other support services.

Figure 28. Tampere Kotitori home care service integrator.



- Provides support services for the entire city (2 300 clients): safety services, temporary home care, cleaning, shopping
- Intermediates privately funded home care services from partners.
- Process and information system development in collaboration with the city and other service providers.

Kotitori is operated by a private service provider, Mawell Care, under a four year contract with the city of Tampere. An extension option of two years was included in the contract. Mawell Care is the leader for a consortium consisting of Nordic Health Care Group (NHG) and Mawell Ltd. The partners operate under a division of work in which NHG accounts for setting quality standards and quality assurance and Mawell Ltd provides technological solutions.

Innovation process

The idea about developing a new model to provide elderly home care emerged in discussions within Tampere city social care around 2003. Home care for elderly people appeared to be a problematic area. There were challenges in coordinating home care services at the interface of two separate service domains, health care and social care. From the point of view of the client services were fragmented. The city would assess the client's service need primarily from the perspective of eligibility to public service provision rather than client's comprehensive needs. Thus senior citizens with only slightly compromised capability to cope at home, but not yet suffering from severe enough capacity loss, were rejected from public service without re-directing them to use commercially available services. Opportunities for supporting clients' capacity to live at home were consequently missed. Clients were not given a freedom to choose between alternatives according to their liking and financial capability.

The public elderly care services were dominated by institutional care. Many clients who wished to stay at home were directed to institutional care facilities. This resulted in high costs and ineffective care for some segments of clients.

The development process started in 2005 when a task force was established. It was led by a senior physician in the elderly care services of Tampere. Other partners in the task force were the hospital district, a consulting company (Eera), a research organisation (VTT), and two ICT companies (TeliaSonera, WM-data). The discussions about these challenges developed into an idea that the service model should be designed to take the client need more comprehensively into account. The idea of service integrator came up.

At the same time, discussions were initiated at the national level by the Ministry of Finance about ways to improve performance and effectiveness of public services. At the city of Tampere it coincided with introduction of the so called purchaser-provider model within the city of Tampere. The model separates the service production and service purchasing to distinct administrative functions.

The idea about setting up a service integrator was pushed forward within the City administration. Gaining the support at the political level required several rounds of negotiations. The initiative was first not supported by all the political groups. After the decision was done at the City Council, the project plan was submitted to Tekes to apply for external funding.

Tekes made a positive decision to grant development funding within the FinnWell programme. The objective of the FinnWell programme was to improve the quality and productivity of health care and promote business and internationalisation. The Kotitori development project was executed 2006–2009 in two phases. The development phase took place from February 2006 to March 2007. During this first year the general concept and its components were defined. The concept was developed into a specification for a public procurement. Three organizing model options were evaluated: city operating as an integrator, joint organisation between city and private partners, and a private consortium as a contractor to the city. The third one, a private supplier model was selected due to its capacity to generate largest transformation potential compared to the old model.

The concept was designed around three key ideas. The first was a principle that the integrator must be an organisation independent from service producers providing the home care. This would guarantee genuine consideration to client needs without pressure to 'sell' any of the specific services. The independence principle proved to be a key insight guiding the design of the model. The second key idea was that in addition to the integrator role, the contract would also include one service district in Tampere where the public services were outsourced. This district comprised 400 clients. The third principal idea was that the contractor provides the city administration with development services to improve public service delivery. The integrator would then also operate as an external consultant in advising the city social care division.

The main tools used in the preparation phase were a market study about the prospective service concept, business

planning, service level agreement, bonus/saction model, feasibility studies, and strategic procurement planning.

The development phase resulted in an initial service specification according to which the City of Tampere will purchase these three components: an integrator service, outsourced elderly care for one service district, and the development function to improve the public services provided by the city. External legal experts were consulted when designing the procurement procedure.

The implementation phase of the Tekes project was carried out between April 2007 and October 2009. In this second period, the City of Tampere executed the public procurement process for the integrator service.

The negotiated procedure was selected as the procurement method. Unlike more conventional public procurement procedures it allowed negotiations with the candidates. It is a suitable procedure when requirements cannot be specified in detail without interaction with suppliers. In Kotitori procurement a new concept for integrating public and private services was developed. It was not known in advance what features should be included in the contract in order to find a competent supplier to provide them.

While the city aspired to set the contracting requirements for service results (quality of care), not activities (home visits), it proved not to be fully feasible yet. The information base was not sufficient to execute a performance-based contracting. Without reliable data proposals could not be evaluated and compared in a fair manner.

In all, the procurement took place over a period of 12 months. The maximum value of the four-year contract was 18,6 million Euros.

Impacts

The operation of Kotitori service started in September 2009. It has been successful in generating multiple impacts. In the district under Kotitori outsourced service responsibility the following increase in productivity and quality of care have been measured:

- 29% less placement of clients to elderly service homes
- 30% less costs in specialised health care
- 15% less placement of clients at hospital wards
- 14% less use of emergency duty services

Within the city social care services productivity has increased with 10% during the Kotitori contract period.

New markets for private service provision have been created. There are currently more than 50 firms and non-profit organisations registered as service providers at the Kotitori platform (as of January 2014). New innovative services have also been created for catering, cleaning, transport, safety and shopping services.

While widely assessed as a successful pilot the service integrator model has not diffused to other service functions inside the city, nor has it been adopted by other cities yet. Development efforts are currently under way, but they are still at early stage. Therefore it can be concluded that the Kotitori has significant local impacts, but not yet regional, national nor international effectiveness.

Tekes contribution

The Tekes financial support enabled the project to go forward under challenging conditions. It provided not only extra financial resources, but along with the project planning came a more structured and goal-driven approach to development and external credibility to this line of thinking as having national significance. Collaboration between the city and the Tekes official was intensive in the early phase of the development project and provided external guidance to it execution. The FinnWell programme activities were providing some networks and visibility to the project, but were not considered essential to the success of the project.

Persons interviewed

Eeva Päivärinta, Sitra (ex. City of Tampere)

Sari Luostarinen, ForumVirium Helsinki (ex. City of Tampere)

Jarkko Hämäläinen, City of Tampere

Literature and document sources

Kari Hakari & Liina-Kaisa Tynkkynen 2013. Governing the Innovation Process: Tools of Meta-Governance–The Kotitori Model in Tampere Finland. International Journal of Public and Private Healthcare Management and Economics, 3(1), 1-16.

Tanja Koivumäki 2010: Kotitori-konsepti. Presentation, Kuntatalo 2.2.2010.

Tanja Koivumäki 2009: Kotitorin neuvottelumenettely. Presentation, tilaajalautakuntien hankintakoulutus 30.10.2009.

Leijo, Jenni 2012: Kotitorin asiakkaan kuuleminen. Tampereen ammattikorkeakoulu.

Liina-Kaisa Tynkkynen, Sari Miettinen, Juhani Lehto 2012: The Kotitori Integrator of Home Care Services in Finland. OECD

B.3. Case 3: Lactose-free milk products by Valio

Background and state of art

Lactose intolerance stands for inability to digest lactose (milk sugar) because of a genetically inadequate amount of the enzyme lactase. Lactose intolerance is common in Asia, where up to 100% of the population are lactose intolerant, while in Northern Europe the same figure is circa 15%. Lactose-free milk was introduced in 2001 by Valio Ltd, a Finnish dairy company. The lactose-free milk with less than 0.01% of lactose had similar organoleptic properties as normal milk and could be drunk by lactose intolerants without any symptoms associated with lactose intolerance. At the time of market launch, the product was unique in the world and its household demand exceeded all expectations in Finland.

The successful introduction of lactose-free milk was dependent on two developments. First, increasing general awareness of lactose intolerance created household demand for low-lactose and lactose-free milk products. Medical research on lactose intolerance had been conducted and published since the 1960s, and gradually this research reached the attention of general public and media. By the 1990s, general awareness of lactose intolerance was high in Finland and a multitude of low-lactose products were available on milk shelves. Second, the acumen of Valio's R&D staff made it possible to see new production possibilities with a dairy process equipment whose original production purpose had ceased to exist. The R&D staff was also persistent in its efforts of inducing company management to trust in the successful launch of a new-to-market product. Introduction of lactose-free milk was seen as a risky business and several market reviews were required before an approval to proceed was given by Valio's management.

Milk consumption (per capita) in Finland is highest in the world together with Sweden and the Netherlands. Still, it is estimated that circa 17% of Finns are lactose intolerant, which means that drinking regular milk would cause them unpleasant symptoms, such as abdominal bloating and cramps (Peuhkuri et al. 2000). Low-lactose milk products that contain less than 1% of lactose have been available in Finnish grocery stores since the beginning of the 1980s. The low amount of lactose in end products was achieved by applying industrial enzymes for hydrolysis in milk processing. By 1985, Valio Ltd, the largest dairy company of Finland, offered low-lactose alternatives in every milk product category. It was known, however, that low-lactose milk was sweeter than regular milk, which did not appeal to many milk consumers. It was also known that the most sensitive lactose intolerants could not consume low-lactose milk because of the symptoms it would bring about. In comparison to low-lactose milk, the unique feature of Valio's lactose-free milk was hardly measurable amount of lactose (less than 0.01%) without observable changes in taste when compared to regular milk.

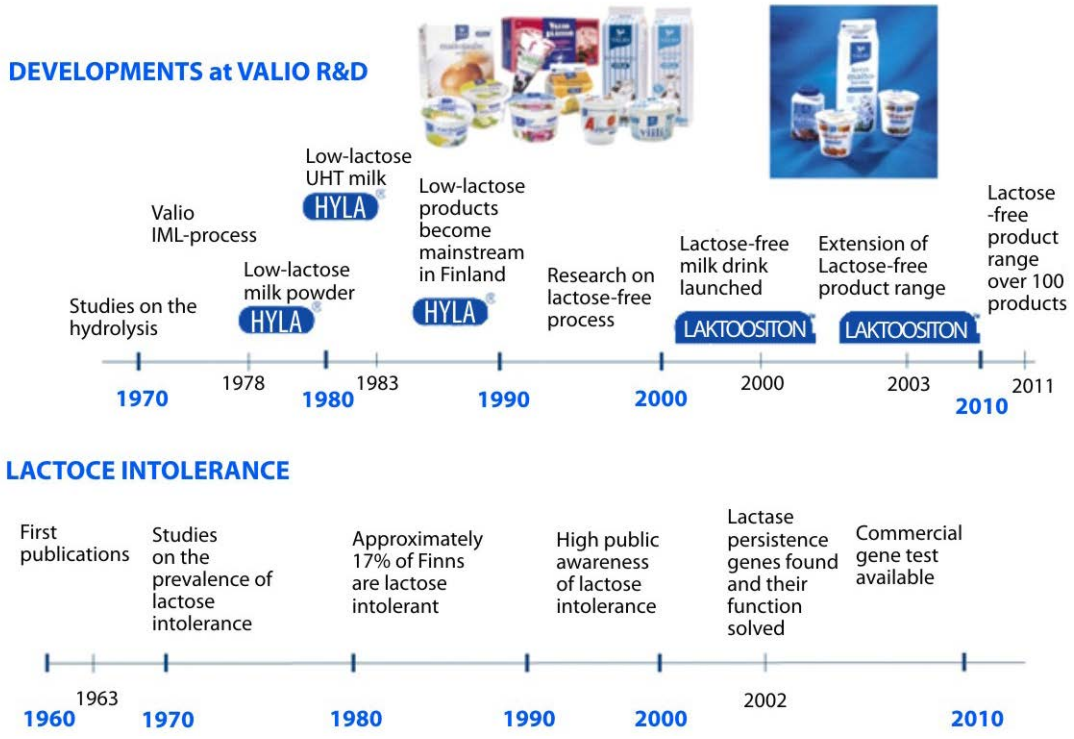
After the market launch of 2001, one million litres of lactose-free milk was sold in Finnish grocery stores in two months, and the growth has been continuous ever since: from 12 million litres sold in 2002 to 70 million litres in 2010. In five years' time the share of lactose-free products amounted up to 13% of Valio's total sales of milk products. At the same time, the sales of low-lactose milk products did not decrease, which means that a new market for lactose-free products was found among, e.g., consumers who did not use milk products at all previously.

Today, there are over 90 lactose-free products in Valio's sales catalogue and the company exports lactose-free products to Sweden, Russia, Belgium, France and the Baltic States. Valio also licenses out production methods to other dairies located in Switzerland, Spain, Norway, the Netherlands and South Korea. Valio has filed several patents of lactose-free technologies. Recently, competing lactose-free products utilizing different production technologies have been introduced by Arla Foods and McNeil in the European and US food markets.

The long way of R&D work from low-lactose to lactose-free milk

Valio Ltd has been active in R&D on lactose hydrolysis since the 1970s (See Figure below). Lactose hydrolysis means breaking down lactose (milk sugar) into other sugar forms, glucose and galactose, by means of the lactase enzyme. As a result of development work mainly related to enzyme technologies, a range of low-lactose (80% less lactose) food dairy products were introduced by 1985, such as low-lactose milk powder and low-lactose low-fat milk. Low-lactose food products were sold under the brand name HYLA and their market evolved steadily during the next three decades.

Figure 29. Combined timelines of Valio's R&D work on low-lactose and lactose-free dairy food products and public research on lactose intolerance from 1960s to 2010s. Source: Valio's R&D department.



The origins of development work of lactose-free milk did not stem from the R&D work on low-lactose milk products and enzyme technologies. Instead, the starting point was an industrial and business dilemma faced by Valio's R&D staff at the end of the 1980s. Valio had established a factory in the city of Joensuu to produce lactose by means of chromatographic separation. The equipment used in the chromatographic separation was a large chromatographic column that contained lactose-retaining porous structure. The chromatographic separation method was jointly developed and modified to milk processing with another Finnish food company, Suomen Sokeri Ltd in the mid-1980s. It soon turned out that producing lactose was not profitable enough and Valio decided to run down lactose production at the Joensuu plant. The expensive chromatographic column equipment was taken out of service and years of development work seemed to be wasted.

At this point, Valio's R&D staff started to search for other possible uses for the chromatographic column. Instead of producing lactose, the same separation technique could be applied to producing lactose-free milk. In the beginning of 1990, a two-year Tekes project was launched at Valio for developing production methods and end products based on lactose-free technology, including chromatographic separation technique. At the time, Valio was facing downturn and Tekes funding proved to be important in absolute terms. The first new product produced with the lactose-free technology was a diet ice cream. Thanks to the lactose separation, the ice cream contained less sugar and energy than regular ice creams. Development of other products utilizing chromatographic separation was halted, however. The marketing division of Valio did not see the benefits of lactose-free products in comparison to the low-lactose product line of Valio. Lactose-free products would

have been more expensive than low-lactose products and consumers who enjoyed low-lactose products were not ready to pay the premium for lactose-free milk in consumer tests conducted by the marketing division. The management of Valio was critical towards lactose-free products because it was afraid that lactose-free products would "cannibalise" markets of Valio's low-lactose products resulting in a zero-sum game. Multiple consumer tests were conducted about the issue.

Despite critical attitudes, R&D work continued at Valio and the production technology of lactose-free milk was conceived and tried out: half of the lactose was taken out by means of mechanical separation and the other half by enzymatic hydrolysis that broke down the remaining lactose into glucose and galactose. The end product was lactose-free milk that tasted similar to regular milk. Because of the efficient market network and logistics of Valio, test marketing of lactose-free milk required little extra resources. The success following the market launch was a surprise to Valio. It turned out that consumers buying lactose-free milk were different to consumers enjoying low-lactose milk products, which means that a new market was found among people who did not consume milk or preferred lactose-free milk to regular or low-lactose milk for other reasons. Valio's R&D work has continued during the 2000s and 2010s and new lactose-free products are introduced under brand name Eila constantly. New production methods of lactose-free milk based on membrane filtration technologies have been introduced and licensed out, as well.

To sum up, the following factors were crucial for the innovation process of lactose-free milk:

- R&D competence of food processing technologies developed during the decades and in collaboration with food industry
- Support from top management to continue R&D work with help of Tekes funding
- Efficient market network and logistics that made possible to test new products in milk shelves with little extra resources
- Educated consumers who were aware of lactose intolerance and were ready to pay premium for lactose-free foods

Environmental and wellbeing impacts of lactose-free milk

The health impacts of lactose-free products have not been studied at the population level. It is probable, however, that because lactose-free milk increases consumption of milk, it will also contribute to health impacts associated with milk consumption. Based on scientific review, the European Food Safety Authority (EFSA) has validated several nutrition and health claims related to the ingredients of milk products, such as calcium, protein, vitamin D and phosphorus.[14] It is also likely that lactose-free milk has benefitted the quality of life of lactose intolerants because their diet can be more versatile than before because of the availability of lactose-free products.

Environmental impacts of lactose-free milk are difficult to assess. Valio and its factories have held the ISO 14001 environmental certificate covering its domestic operations since 2000 and company's environmental system performance undergoes continuous evaluation via internal and external audits. The same company policy applies to production of lactose-free products. In comparison to regular milk, production of lactose-free milk requires a higher degree of processing and more resources and energy are consumed. The higher degree of processing also entails more side products and waste during the production process.

Contribution of Tekes

Valio collaborates with Tekes on a regular basis. Recently, Valio participated in the SymBio programme 2006–2011 via three public research projects and seven enterprise projects. One of the projects focussed on milk protein hydrolysis and the results have been commercialized in Sweden when lactose-free, protein-hydrolysed milk was introduced recently. Tekes is the most important public funding source for Valio and the company has avoided applying for EU funding because the effort required does not seem to match the benefits. In most cases, Tekes' funding is used to cover the expenses of a public research organisation participating in the project, namely VTT or university. In-house projects funded by Tekes are rare in case of Valio.

[14] See http://ec.europa.eu/nuhclaims/

During the recent years, communication with Tekes' experts has increased, and for instance a general meeting providing an overview on Valio's R&D activities is arranged in the beginning of every year with Tekes. Tekes has urged Valio to find SME partners for R&D projects but with little success because Valio has met difficulties to find adequate capabilities in the Finnish food industry. Most importantly, Tekes has contributed to improvement of Valio's R&D skills and collaboration with public research organisations. At present Valio considers this more important than funding in absolute terms.

Interviews

Smit Gerrit, Senior Vice President, Renewal, R&D, Valio Ltd (13.12.2013)

Matti Harju, Vice President, Technology, Valio Ltd (23.1.2014)

Olli Tossavainen, Research Manager, Valio Ltd (23.1.2014)

Sources

Peuhkuri, K., Vapaatalo, H., Korpela, R. & Teuri, U. (2000). Lactose intolerance—a confusing clinical diagnosis. Am J Clin Nutr, 71, 2, 600-602.

Press and marketing material of Valio Ltd.

B.4. Case 4: Net zero energy building by Järvenpään Mestariasunnot

The first net zero energy apartment buildings in Finland were completed in 2011. A municipally owned social housing corporation Järvenpään Mestariasunnot Oy undertook a pioneering project to design and construct a net zero energy nursing home for elderly people in the city of Järvenpää. The house accommodates 110 seniors with reduced functional or memory capacity. While the first zero energy houses were built In Finland already in the early 1990's they were single detached houses, not multi-store apartment buildings.

A net zero energy building has very high energy performance. The low amount of energy consumed should be covered from renewable sources produced on-site or nearby. A net zero energy thus produces as much energy as it consumes over the annual cycle. To achieve the net energy balance in the harsh Nordic climate, the energy purchased during the winter season is offset with excess energy produced during the summer.

In the Järvenpää project a number of technical solutions were adopted to achieve net energy balance. Ground heat

Figure 30. The net zero energy nursing home for eldery people in Järvenpää.

and solar heat provide complementary sources of renewable energy to municipal district heating. Electricity is produced with solar panels installed on the roof. Waste energy is also harnessed by capturing heat energy from outbound air ventilation and breaking of elevators. During the summertime apartments are cooled with a ventilation system, which exploits lower temperatures of the ground heat well. Extra heat energy can be sold to the neighbouring buildings. Energy balance data is made publicly available through a monitoring dashboard on an internet website.

By adopting innovative construction solutions a high air tightness value has been achieved. Whereas a standard building has a thermal resistance value 4.0, net zero energy aims at the tightness level of 0.4. According to measurements performed the values of 0.15-0.35 have been achieved. A new type of element construction developed by suppliers was adopted to achieve high air tightness. It includes a sting truss, which allows seamless attachment of insulation panels and lower heat conductivity.

Energy performance is continuously monitored with data collected from sensors, which are embedded inside the building structures. Temperature and moisture levels are measured by an extensive sensor network covering several layers: external and internal surfaces of the insulation and inside the insulation panel.

The building project and the company have received several awards for sustainable and innovative construction solutions. There has also been high interest from foreign countries (e.g. China) to benchmark energy efficient building solutions.

Development

The net zero energy building project of Järvenpään Mestariasunnot was triggered by rising energy costs and tightening energy efficiency regulation. High energy consumption impacts the operation and maintenance costs over the life cycle of the building. Because Järvenpään Mestariasunnot holds the ownership of the buildings through their entire life cycle the company has an economic incentive to develop and adopt solutions to cut down total energy costs of ownership.

The development process started from the initiative of ARA, The Housing Finance and Development Centre of Finland. ARA was looking for suitable pilots to demonstrate the performance of energy efficient house concepts. Järvenpään Mestariasunnot expressed their interest to study the possibility of developing a net zero energy concept. The project started with a feasibility study phase. A research organisation (VTT) carried out simulations on optimal performance levels for the energy system with regard to estimated energy consumption patterns. Potential technical solutions were extensively scanned in order to identify appropriate designs, constructions and components. The feasibility study concluded that a net zero energy building was possible to achieve by adding energy production to already existing passive house concepts and further improving them. While technical solutions at the component level were available there were no readily applicable integrative design concepts for the energy system.

A development project was started with financial support from three funding and development agencies: Tekes, ARA and Sitra. Their financial support covered the costs of the development project. A parallel project was carried out in Kuopio by a student housing corporation (Kuopion Opiskelija-asunnot Oy). The shared development goal was to develop a technically, economically and functionally optimal concept for zero energy housing. In addition to financial support to the concept development the building project received financial subsidy for the actual investment from ARA. The specific interest of ARA was to promote energy saving in social housing.

A number of challenges needed to be solved during the development process. High energy performance goals impact the whole supply chain of designers and contractors. High quality of construction is emphasised to achieve the target performance. Getting the contractors committed to high quality standard of construction could be only achieved through extensive communication. Technical challenges were related to creating the necessary integration within the energy system and building automation. Specific issues with protecting the circulation of glycol in the heat pipelines had to be solved. The information base had to be developed as there were little earlier references about establishing the baseline values and estimation of target values. Regulatory bottlenecks also emerged as the urban master plan did not approve installation of roof top solar energy collectors. How to exploit excess energy production was solved by using the heat energy in the neighbouring houses. However, the market for extra electricity produced by buildings still does not exist in absence of mechanisms and economic incentives (such as tariffs) to feed it in the grid.

The elderly home construction was finished 2011. A project monitoring group was set up to follow up operation of the building and provide advice on adjustments needed. The group composed of designers and researchers. During the first two years various adjustments were needed in the energy system and building operation to meet the target levels.

The construction costs of net zero energy buildings are 2-7% higher than in conventional construction due to the investment to energy production systems. In Järvenpää project it has been estimated that the investment in the energy system will be paid back in fifteen years.

Diffusion and impacts

The demonstration project had a transformative impact on the building developer company, Järvenpään Mestariasunnot. The business and operational model has changed permanently through a learning process. High energy efficiency and renewable energy production are now standard components in all buildings developed by the corporation.

The pilot project has provided a demonstration site for technical innovations of suppliers. A new structure for connecting outer and inner layers of concrete panels was first implemented in Järvenpää by Lipa-Betoni Oy. The novel sting truss structure attaches insulation panels seamlessly together removing the need to cover seams with polyurethane foam insulation. This improves the heat insulation capacity of the element. The new structure also shortens the construction element production process as one pre-fabrication phase is avoided. Heat loss is also smaller than in traditionally used diagonal trusses due to smaller cross-sectional area of the truss. The sting truss structure was developed in collaboration between three concrete element manufacturers (Lipa-Betoni Oy, Joutsenon Elementti Oy, Mikkelin Betoni Oy), an insulation producer (SPU Eristeet Oy) and a steel work (Taiter Oy). The new structure has been protected with patent.

The building designers and engineers have also obtained a valuable reference for successfully executing a net zero energy project. A collective learning process has taken place in solving joint challenges and learning a new building design practice.

The net zero energy building concepts are still in the early phase of diffusion. The most significant successor to Järvenpää and Kuopio buildings is a service house for elderly people in Lahti. With the capacity of serving 230 elderly people the Onnelanpolku building has a scale considerably larger than the building in Järvenpää. In Lahti efforts were made to keep investment costs at the same level as in conventional construction projects for service homes. One of the outputs of the development project in Lahti was design-guidelines for zero energy construction (ARA 2013). These guidelines can be expected to be instrumental in the further diffusion of zero energy building concepts.

At the level of the building and local area the environmental impacts of the Järvenpää zero energy house are considerable. Replicated to other buildings developed by the company it will have a measurable impact over the years in the city of Järvenpää.

The net zero energy performance is likely to become mainstream practice in construction due to European regulation. The pilot project has accelerated creation of necessary knowledge to transform towards energy efficient building stock. Because 40% of energy is consumed by buildings, achieving net zero energy level in all new constructions will bring about a considerable saving in energy consumption and CO2 emissions. When scaling up zero energy buildings to a large scale many issues still need to be solved related to balancing energy production and consumption within distributed energy systems.

Tekes contribution

The direct contribution of Tekes is that without financial support from public development agencies the net zero energy building project would not have been undertaken. Tekes together with other public funders shared the costs and risks with creating a new concept within the building and construction industry which is slow to adopt new solutions.

The indirect contribution of Tekes comes through the support it has provided over the last decades to energy efficient buildings research, development and demonstrations in Finland. The first low energy building pilots were already done in the 1980's. Much of the technology has been available already since then. Barriers to widespread diffusion are more of institutional and cultural nature. Incentives for adopting zero energy concepts are missing from building developers whose end clients do not give high preference to low energy consumption. Debate in public and professional media is dominated by the risks of increased moisture levels in tightly insulated building structures.

The large scale diffusion of net zero energy buildings will be driven by the European regulation. The Energy Performance of Buildings Directive requires that 2020 all buildings must be net zero or net plus energy buildings. Putting the European regulation into practice will have large scale impacts in the energy production matrix. As in the cold climate the consumption of energy in buildings and production of renewable energy are asynchronous there are major issues unsolved how to balance the system.

The case also highlights the importance for Tekes to work in strategic partnership with other funding agencies and stakeholders. As low energy buildings technology development supported by Tekes has mainly focused on building materials, components and automation, their main beneficiary has been the construction supplier industry. However, without demand created by the building developers, the market for these products remains modest. ARA was a natural counterpart for the building developers to push forward the net zero energy pilots.

Experts interviewed

Veikko Simunaniemi, CEO, Järvenpään Mestariasunnot Oy
Jarkko Piiparinen, Development Manager, Mestaritoiminta Oy
Jyri Nieminen, Chief Sustainable Officer, FinnMap Consulting Oy
Riikka Holopainen, Senior Scientist, VTT Technical Research Centre

Figure 31. LEW-100 and Liqum Interner Hub.

B.5. Case 5: Water quality monitoring systems by Liqum®

Liqum® Water Technology is a small Finnish company that provides real-time clean water and liquid quality monitoring solutions globally for industrial processes and the natural environment.

Liqum Oy was established in 1999 by a group of electrochemistry engineers, chemists and scientists. The team developed a real-time liquid quality monitoring system. The system consists of four key parts:

- The wireless Liqum Early Warning (LEW-100) **electrochemical measurement device**, capable of monitoring liquids in industrial processes and in the natural environment. It detects changes in water/liquid quality caused by contamination, disturbances or incorrect chemical dosing, and reports these changes in real-time. The LEW-100 sensor communicates wirelessly with the Liqum Internet hub (LIH), which forwards the monitoring data to the Liqum Server Centre (LSC).
- The **Liqum Server Centre**, where the water quality data is processed, converted into a clear visual format and sent via a secure Internet connection to the user interface. The transmission of the data from the sensor, via the server centre, to the user interface happens in an instant.
- **The user interface** was developed in accordance with typical customer requirements and is customizable. As well as being displayed on the user screen, the monitoring data can be imported into other systems. An app is also available for smartphones (App Store).
- **The Liqum Alert Service**, whereby the system is configured to trigger SMS or e-mail contamination alerts, which are sent automatically to key personnel.

The founder of Liqum, Sakari Laitinen, has a background as an automation engineer in the pulp and paper industry and has also worked on military gas detection, as well as on electrochemical corrosion prevention systems and corrosion monitoring. His original vision was of developing a real-time worldwide monitoring network to safeguard the quality of the world's precious water resources, but he began developing the technology whilst working at a paper mill, where a solution was required in order to tackle liquid quality related issues in the pulp and paper production lines.

Development

The electrochemical measurement device was further developed in cooperation with Helsinki University of Technology. For her MSc thesis, Suvi Papula (guided by Professor Hannu Hänninen) carried out research into electrochemical polarisation curves during the papermaking process and proposed additional new materials for the sensor's electrodes.

The first measurement device was rather large (the size of a domestic fridge) and weighed 50kg); it was suitable only for monitoring the wet-end chemistry of a paper machine. Liqum then developed a platform, which monitored liquid quality at other stages of the papermaking process too, and all the data was collated to provide a useful overview of the effectiveness of the process, indicating clearly where liquid quality issues were affecting production. With this platform Liqum was the first company in the world to provide a remote monitoring service to its customers via the Internet. The first commercial systems were sold in 2001 to the Finnish papermaking industry, and subsequently a number of systems were sold to the USA to.

Investments in the pulp and paper industry declined steeply from 2003 onwards, and consequently the market developed more slowly than expected. However, Liqum developed its system for use in the mining industry, in collaboration with two mining companies and Outokumpu. The hydrometallurgical knowledge of the mining companies contributed to the development of the technology and Chena® (Chemistry Navigator) was born: a technology for improving the efficiency of industrial production processes. The system produces synergies from the professional expertise of the plant operators, process measurements and new information received from the process chemistry, and uses advanced data processing to refine the information into an easily understandable visual format.

In 2007 the technology was sold by Liqum to Outotec (the former technology subsidiary of Outokumpu). Outotec acquired two related patent families covering electrochemical measuring and process monitoring, and exclusive rights to the technology in mining, minerals and metals industry applications, and they took on three employees from Liqum. As stated in Outotec's press release at the time: "The acquisition further improves Outotec's competitiveness by complementing our offering in minerals processing and hydrometallurgical process solutions."

From 2008/9 onwards, Liqum focused on technology for global water quality monitoring. At present the Liqum technology contains features protected by a number of patent families:

- Electrochemical monitoring technology, easy to handle, maintenance free, requiring only little power while providing significant useful outputs.
- Neural calculations for data handling.
- Data transfer technology for transferring data around the world at a very low price.

The technology's unique selling point is that it is a very cost-effective way of monitoring liquid quality changes in real time, delivering more useful data than any other system, and making the data available in real time anywhere in the world.

When a LEW-100 sensor is installed, water samples are taken at the installation site and analysed in the laboratory. A standard analysis covers 80 parameters, including 69 elements, nutrients, and so forth. This analysis is used to calibrate the system and then monitoring can commence. In the standard set-up, good water quality is given an index value of 100, and the alarm is given when the index drops below 80, at which point Liqum advises sampling and analysisin order to discover the cause of the quality deterioration.

These days, large corporations are reducing their in-house R&D operations and there is increased reliance on universities, so that real practical knowhow is becoming scarce. In developing its technology, Liqum drew on the knowledge of both academics and industry experts, some with 45 years of experience in the field.

In order to gain access to the best technical knowledge, networking played an essential role. Liqum has made invaluable contacts within a number of industries (e.g. pulp & paper, mining), within various kinds of institutes (VTT, universities,

nanotech institutes around the world), within the ICT sector, and within media companies.

Diffusion and impact

Liqum has become exclusively a service provider: they do not sell the equipment, but charge a subscription fee for their monitoring services. In this way Liqum is able to relieve their clients of their entire monitoring burden. With no initial investment required of the customer, a working system is delivered which begins to provide useful monitoring data as soon as it is installed.

Liqum's monitoring and reporting service is very easy to use and data is presented online in the clearest possible format. Moreover, installation of the service is quick, clean and non-disruptive. It can be deployed even in the most isolated of locations and the user screen can be accessed on a smartphone.

Liqum generally concludes service agreements with their customers for periods of three or five years. For some pilot cases the contract period is 12 months. The service fee is between €300 - €500/month per sensor, depending on the scope of service required.

Liqum's monitoring technology has been used in hundreds of different solutions around the world and the company's focus is now 100-1000 unit solutions. The main customers are water utilities, mining companies (quarries, circulation waters, waste waters), beverage companies, the pulp & paper industry, the metals sector, and bioenergy. They also offer services to river authorities and for public projects. Liqum intends to grow the volume of commissioned units to the tens of thousands within a couple of years, creating a significant turnover.

Liqum does not produce anything themselves: they are in the business of selling and delivering the service. They have outsourced production to a Finnish company. They do this deliberately, in order to keep their knowledge in Finland and to create jobs for young people in Finland. They also know the companies who supply the components of the system. It is easier to work within Finland and easier to co-develop with organisations that have the requisite knowledge. In this way they assure the quality of their equipment, and have a better quality guarantee.

In the present growth and diffusion phase, networks are very important, not only amongst companies and institutes, but also among domestic and foreign government departments, industry- and environment ministries, lawmakers and diplomats.

The key positive environmental effect of the Liqum Early Warning system is on the early detection of pollution. Prompt detection means prompt action can be taken. It is, however, difficult to quantify the effect, as it is very case specific.

There are examples of where Liqum's monitoring system has prevented health problems. At a drinking water extraction site, as a direct result of using a LEW-100 sensor the customer found that in the springtime some wells contained much lead. It was discovered that in springtime, the oxidation level of the soil dropped and lead moved from sand into the well. As a consequence these wells were closed and lead poisoning may have been prevented.

Tekes contribution

Liqum has a long history of interaction with Tekes. The founder, Sakari Laitinen, had his first contact with Tekes in 1998; he founded Liqum in 1999.

Over the years Liqum has had support from Tekes for 5 projects:

- The first project was just after the start-up of Liqum, namely the project to develop a system for the paper industry. Tekes provided funding to help develop the measuring technology.
- The second project was to develop the data handling technology for monitoring the entire paper manufacturing process. The Industrial Internet was ready at the beginning of 2000, when Liqum remotely monitored almost 100 paper machines around the world.
- The third project was the development of the system for the mining industry. This was a larger project in which they developed the monitoring platform, further focusing on mining slurries and mining waters.
- From 2008/9, they worked on technology for global water quality monitoring and they reduced the physical size of the technology.
- The final project was customizing and piloting the platform globally.

The main role of Tekes was providing finance for R&D. The funding from Tekes was essential all of the time. Also in the local area Tekes' support has been important to Liqum.

Laitinen has participated in user committees in the Water programme, but considers that the supported research projects tend to be too remote from real-world practice: the projects produce reports but not solutions. According to Laitinen, the Dutch Wetsus model for water research is a good example of closer interaction: here representatives from all participating companies spent one Friday every two weeks at Wetsus, working with each other and with the Wetsus researchers.

The case highlights the importance of Tekes as a source of finance for SMEs. The contribution of Tekes increases the available financial sources for R&D. The financial support of Tekes has been of crucial importance to Liqum's development. Without Tekes, it would not have been possible to build such an advanced industrial Internet platform. The contribution of Tekes has mainly input additionality: it increased the available financial sources for R&D.

Experts interviewed

Sakari Laitinen, CTO and founder, Liqum Oy

Information sources

Website Liqum, www.liqum.fi

Website Outotec, www.outotec.com

Various newspaper articles via Internet

B.6. Case 6: TraumakineTM by Faron Pharmaceuticals

Faron Pharmaceuticals is a virtual Finnish drug discovery and development company based in Turku. The parent Faron Ventures company was founded early 2003 and appointed prof. Markku Jalkanen, one of Finland's early biotech pioneers, as President and Chief Executive Officer. He is also co-founder and CEO of another biotech company in Finland, Biotie Therapies Corp.

Faron Pharmaceuticals was spun out from Faron Ventures in 2007 and has currently three major drug development projects focusing on acute trauma, inflammatory diseases and cancer/metastasis growth. Contrary to the business model of biotech and pharmaceutical companies in the 1990s, Faron chose a different approach, requiring less money. During the last decade of the last century, it was relatively easy for these companies to raise money for research and development activities through seed money facilities and the availability of venture capital. This changed completely in the new millennium, due to September 11 and the financial and economic crisis. Early 2000 biotech and pharmaceutical companies were facing difficulties in attracting new funds. Therefore Faron decided to adopt a new business model to source its innovations from academia and incubate projects longer in a university setting. The inventors of the projects, the scientists, are closely involved in further developments work. Because of his knowledge of the Finnish centres of excellence in biotechnology research, Mr. Jalkanen is able to select the right research groups and people. This way, the proof-of-concept stage can be contracted to the university laboratories, which allows Faron to maintain a lean operating structure keeping its fixed costs at a minimum level (i.e. significantly less staff and lower costs than a typical drug development company). The figure below shows the difference between the costs associated with the subsequent phases of drug discovery and development of Faron compared to other biotech and pharmaceutical companies.

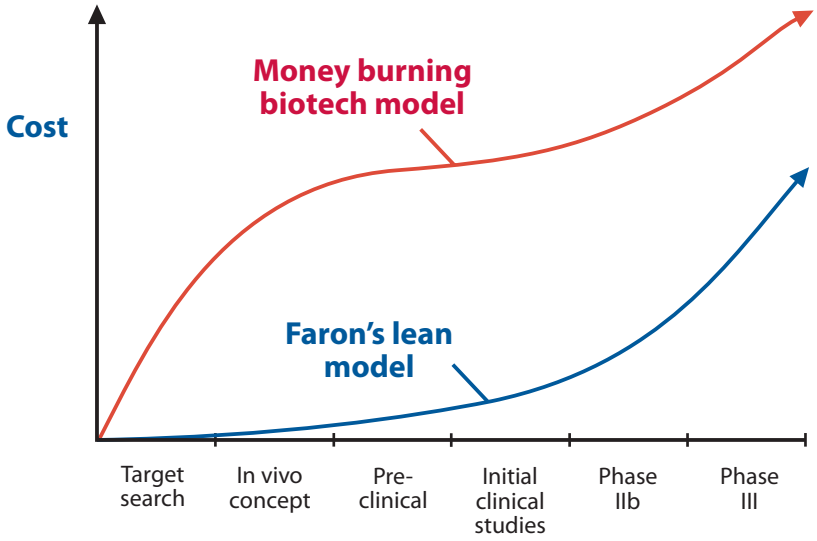
Over the past years, more and more drug development companies have adopted this model as the traditional model is not very viable anymore. The majority of the companies that have issued IPO (initial public offering) last year employ 10-20 employees. In the past companies launching on the stock market typically had more than 100 employees. This is an indication that companies nowadays are more cautious in building large development organisations in-house.

The success behind the success of Faron's drug discovery and development approach can be found in the following criteria:

- A strong scientific background;
- A promising intellectual property position that can be improved even further;
- An unmet need and significant market potential;
- Joint commitment with the academic inventors for further development; and
- Industrial business models with 2-3 alternatives and an early implementation.

The three drug target molecules of Faron (two enzymes and one adhesion receptor) are synergistic in the sense that they all share the same development technologies, disease models

Figure 32. Faron's business model compared to more traditional drug development companies. Source: Website of Faron Pharmaceuticals (2014)



and disease indications (vasculopathies[15], traumas, inflammation and metastasis[16]) and are expressed either to endothelial cell surfaces of blood or lymphatic vessels. This results in strong links between the projects and lowering the individual project development costs. The three current drug candidates are presented in the table below, including their targeted indication and current development phase.

Figure 33. Drug candidates and development stages. Source: Website of Faron Pharmaceuticals (2014). NB. Green = Completed, Orange = in progress.

Product name	Description	Indication	Research	Pre-clinical	Phase I/II	Phase III
Traumakine (FP-1201)	Acute use of interferon-beta, to prevent vascular leakage in acute respiratory distress syndrome (ARDS) and other traumatic conditions	ARDS				
		Brain/Spinal Core Injury				
		Organ Injury				
Farbetic (FP-1101/1115)	Inhibitor to prevent incipient vasculopathies, e.g. in metabolic syndrome patients	Metabolic Syndrome/ Diabetes				
Clevegen (FP-1304)	A fully humanized antibody to prevent inflammation and cancer spread.	Metastasis/ Inflammations				

15 The destruction of blood vessels.

16 The spread of a cancer from one organ or part to another non-adjacent organ or part.

Acute Respiratory Distress Syndrome (ARDS)

Acute Respiratory Distress Syndrome (ARDS) is a serious clinical disorder and is characterised by pulmonary inflammation leading to increased vascular permeability and loss of aerating lung tissues. ARDS is common in many critically ill patients, affecting nearly 175,000 patients per year in Europe alone, which means that ARDS is considered to be an orphan disease[17]. This implies a substantial financial burden for the health care system but also a burden of mortality as approximately 35 to 40% of the patients suffering from ARDS fail to survive. Meanwhile, those patients that do actually survive face a substantial and sustained morbidity, with evidence of impaired functional capacity and increased healthcare costs extending up to 5 years or more after hospital discharge. At present no pharmacological treatment is available for ARDS that shows impact to a positive outcome of ARDS patients. Current treatments are mostly supportive (fluid management treatments), which is rather remarkable for a central organ like the lung. When people get infected, caused by flu, inflammation, trauma and sepsis, it will lead to serious health problems. This implies a strong medical need for an effective and safe treatment.

The development of Traumakine

In the early 2000s a Finnish academic group at the University of Turku has developed a mechanism and target molecule for acute long injuries (interferon-ß). This was translated into a company structure to set up Faron Pharmaceuticals. During the period 2003-2006 the development of this drug candidate was still in a phase of pre commercial incubation, in which more knowledge was gathered about the molecule and the use of animal models. At that time it was known that the molecule could be used for other lung diseases as well. In order to get a real commercial case the innovation should be protected. Because of the orphan status, an Orphan Drug Designation for treating ARDS was perceived a better alternative than standard IP protection. In December 2007, following the European Medicines Agency (EMA) recommendation based on a positive decision by its Committee for Orphan Medicinal Products (COMP), the European Commission has granted the Orphan Drug Designation to Traumakine. Companies that obtain an orphan drug designation benefit from a number of incentives, including protocol assistance, a type of scientific advice specific for designated orphan medicines and market exclusivity of ten years once the medicine is on the market[18].

Soon after the Orphan Drug Designation was granted, Faron contacted Tekes to ask support for an international development of Traumakine outside Finland. One important part was the identification of key opinion leaders in this area and stimulated Faron to get in touch discussing further development of Traumakine. Faron identified experts outside of Finland: this was initially not acceptable for Tekes, so Faron did not receive additional support. However, after consultation, Tekes agreed that the area of biotechnology innovations is a global market and international opinion leaders are essential in proceeding the development.

Supporting the further stages of development (i.e. clinical trials phases I/II and III) Faron has received funding from both Tekes and the European Commission. Early 2008 Tekes has granted €1.223 million for clinical phases I/II study, in particular for acute lung injury (of which ARDS is the most severe form) but also to develop additional indications of interferon-ß. The funding consists of a loan covering 50% of the costs, which means that Faron should match the other half by other means. The clinical trials have been initiated in eight hospitals in the United Kingdom, the University College London Hospital being the lead site. Mid-2010 the second phase of the clinical trial has been initiated, recruiting more patients to assess safety and tolerability of the treatment.

During the term of the clinical trials, Faron applied for Tekes' Young Innovative Company Grant (YIC or NIY in Finnish) to already start the commercialisation phase of the Traumakine development. The focus of the YIC programme is to accelerate the growth and internationalisation of the most promising small Finnish companies. Companies capable for fast international growth can get financing up to 75% of the project's total costs if the company: is young (less than 6 year old), small in size, has a new business idea with credible potential in the world market and uses at least 15 percent of its turnover for research and development. At the end of 2009 Tekes positively decided on Faron and awarded the YIC grant with a total value of €1 million.

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[17] Orphan diseases are life-threatening or very serious conditions that are rare and affect not more than 5 in 10.000 persons in the European Union.

[18] http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/general/general_content_000029.jsp&

In 2010, Faron received a third grant from Tekes for the further development of Traumakine (contributing to show proof-of-concept in humans). The amount of this loan was €467.000.

After positive results from the clinical trial phase I/II studies in May 2011, because of good tolerance and a significant reduction in the mortality of patients treated, the European Commission provided a grant of €6 million to support the next clinical trial phase. The grant was received by a consortium led by Faron Pharmaceuticals, and including three universities: the University College London Hospital (UCLH in the UK), the University of Torino (Italy) and the University of Turku (Finland). The grant was part of the 7th Framework Programme for Research and Technological Development (FP7) within the Call for Proposals: HEALTH.2012.2.4.4-1 'Preclinical and/or clinical development of substances with a clear potential as orphan drugs'. The key activity for this grant is the support of the clinical trial phase III study aiming at European marketing authorization of treatment of ARDS by Traumakine. The phase III trial will be a pan-European study conducted by tens of hospitals with significant intensive care units (ICU) around Europe.

Diffusion and impacts of Traumakine

Although the development of Traumakine is not finalised to date, the prospects are promising. Especially compared to traditional pharmaceutical companies, the research and development process of Traumakine has progressed fast and well. The expectations are almost fulfilled. The market approval for Traumakine is expected to be in 2016 based on current estimations and procedures of the European Medicine Agency (EMA).

Furthermore, Faron signed an agreement with Rentschler Biotechnologie GmbH in Germany in 2011 for the manufacturing and supply of Traumakine. Retnschler will be the sole global manufacturer for this product. Faron has also agreed to sign an exclusive license agreement with Maruishi Pharmaceutical Co. in Japan for the development and commercialisation of the Traumakine programme in Japan. Other negotiations with licensing candidates are currently ongoing. Up till now Faron raised about €10 million through equity funds and investments by private individuals.

In terms of impacts, based on the results from the clinical trials, Traumakine will have a major influence, both on individual patient level and on the level of the entire health system. The clinical trials show a difference of 80% in mortality between treated and non-treated patients. As ARDS can affect anyone, independent of age, reduction in mortality rate is considered to be significant impact. As the days people with ARDS have to spend within the intensive care unit (ICU) of hospitals decreases with almost 50%, health care costs per patient will be reduced while the capacity of the ICUs will increase. Traumakine is expected to have a tremendous impact on society. For Faron the estimated revenues are calculated at €200-800 million per year.

Contribution of Tekes

For Faron the activities of Tekes were very supportive both in terms of financial support through the different grants and loans, but also in terms of support for networking and outreach activities. Because of Tekes' support in the first phases of the Traumakine development, Faron was able to look beyond the Finnish borders for key opinion leaders. The flexibility of Tekes to allow Faron to connect to people outside Finland was an essential step in the overall development of the Traumakine product. To realise this, Tekes provided the resources to create market pull instead of market push, understanding that drug markets are outside of Finland and the development work must be carried out there.

Interviews

Prof. Markku Julkanen, Chief Executive Officer of Faron Pharmaceuticals (interview 4 March 2014).

Helena Laine, Senior Business Adviser Start-up companies at Tekes (written consultation 3 February 2014).

Other sources of information used

Website of Faron Pharmaceuticals [http://www.faronpharmaceuticals.com].

Website of the FP7 Traumakine programme [http://www.traumakine.eu].

Faron Pharmaceuticals press releases (available through the website of Faron Pharmaceuticals).

Information (presentations and other material) on Tekes Young Innovative Company Grant.

Bellingan et al. (2014). *The effect of intravenous interferon-beta-1a (FP-1201) on lung CD73 expression and on acute respiratory distress syndrome mortality: an open-label study.* The Lancet Respiratory Medicine, Volume 2, February 2014.

Tekes' Reviews in English

308/2014 The impact of Tekes Activities on Wellbeing and Environment. A study by Technopolis B.V., VTT and Statistics Finland. Ville Valovirta, Janne Lehenkari, Olavi Lehtoranta, Torsti Loikkanen, and Arho Suominen (VTT); Hanneke Bodewes, Bastian Mostert, Stijn Zegel and Geert van der Veen (Technopolis). 83 p.

307/2014 Verso – Vertical Software Solutions 2006–2010 – Katsaus ohjelman toimintaan. Marit Tuominen, Sari Vähämäki, Kari Ryynänen ja Risto Setälä. 74 s.

306/2014 Innovation policy options for sustainability transitions in Finnish transport. Armi Temmes, Venla Virkamäki, Paula Kivimaa, Paul Upham, Mikael Hildén and Raimo Lovio. 55 p.

301/2013 Fuel cells and hydrogen in Finland – Finnish Fuel Cell Programme 2007–2013. 20 p.

296/2012 Innovation Activity, Global Production Sharing and Productivity. Jari Hyvärinen. 26 p.

295/2012 New opportunities for China-Finland r&d&i cooperation. Jani Kaarlejärvi and Matti Hämäläinen.

291/2012 Capabilities for innovation activities – Impact study. Johan Wallin (ed.), Philip Cooke, Arne Eriksson, Tomi Laamanen and Patrik Laxell. 134 p.

290/2011 Business Opportunities at the United Nations for the Finnish Safety and Security Industry. Annamari Paimela-Wheler and Laura Hämynen. 41 p.

289/2011 Funder, activator, networker, investor... Exploring Roles of Tekes in Fuelling Finnish Innovation. Kirsi Hyytinen, Sirkku Kivisaari, Olavi Lehtoranta, Maria Lima Toivanen, Torsti Loikkanen, Tatu Lyytinen, Juha Oksanen, Nina Rilla and Robert van der Have. 136 p.

288/2011 Better results, more value – A framework for analysing the societal impact of Research and Innovation. Päivi Luoma, Tuomas Raivio, Paula Tommila, Johan Lunabba, Kimmo Halme, Kimmo Viljamaa and Henri Lahtinen. 120 p.

284/2011 BioRefine Yearbook 2011. Tuula Mäkinen, Eija Alakangas and Marjo Kauppi (eds.) 207 p.

282/2011 Towards green growth? The position of Finland in environmental technologies. Raimo Lovio, Tuomo Nikulainen, Christopher Palmberg, Jenny Rinkinen, Armi Temmes and Kimmo Viljamaa. 59 p.

280/2011 Network governance and the Finnish Strategic Centres for Science, Technology and Innovation. Kaisa Lähteenmäki-Smith, Petri Uusikylä, Katri Haila, Antti Eronen and Pekka Kettunen. 57 p.

279/2010 New Economic Perspectives of Innovation Market. Jari Hyvärinen. 78 p.

278/2010 Safety and Security Business Opportunities in World Bank projects. Annamari Paimela-Wheler and Maija Arellano. 40 p.

276/2010 BioRefine Yearbook 2010. Tuula Mäkinen, Eija Alakangas and Marjo Kauppi (eds.) 188 p.

275/2010 ROADMAP for Communication Technologies, Services and Business Models 2010, 2015 and Beyond. Pekka Ruuska, Jukka Mäkelä, Marko Jurvansuu, Jyrki Huusko and Petteri Mannersalo. 47 p.

274/2010 Business Dynamics and Scenarios of Change. Petri Ahokangas, Miikka Blomster, Lauri Haapanen, Matti Leppäniemi, Vesa Puhakka, Veikko Seppänen, Juhani Warsta. 65 p.

272/2010 The Future of Service Business Innovation. 75 p.

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