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Enhancing the efficiency of the cooperation between business and science – Moving away from silos through a mission-orientated STI policy

Final Report

Project funded under the call for tenders No SRSS/C2019/065

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Acronyms

AI	Artificial intelligence
AKTS	Annual Knowledge Transfer Survey
AWIT	Advisory Council for Science, Technology and Innovation
CDI	Challenge-Driven Innovation
CEST	Centres for Science, Engineering and Technology
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
DBEI	Department of Business, Enterprise and Innovation
DES	Department of Education and Skills
DESI	Digital Economy and Society Index
DIGG	Agency for digital government
DIHs	Digital Innovation Hubs
DTIF	Disruptive Technologies Innovation Fund
DVI	Dutch Venture Initiative
EDP	Entrepreneurial Discovery Process
EI	Enterprise Ireland
EIS	European Innovation Scoreboard
ELI	Extreme Light Infrastructure
EMBL	European Molecular Biology Laboratory
ERDF	European Regional Development Fund
ESA	European Space Agency
ESF	European Social Fund
ESIF	European Structural and Investment Fund
EZ	Ministry of Economic Affairs
FDI	Foreign Direct Investment
FIMTP	Science and Technology Park of Institute of Physics
Formas	Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
Forte	Working Life and Welfare
FRÖN	For increased innovation in publicly funded activities
FTMC	Centre for Physical Sciences and Technology
GDP	Gross Domestic Product
GERD	Gross domestic expenditure on R&D
GII	Global Innovation Index
GLP	Good laboratory practice
GMP	Good manufacturing practices
HEIs	Higher Education Institutions
HRB	Health Research Board

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ICT	Information and Communication Technology
IDA	Industrial Development Authority
Infobalt	Lithuanian ICT association
IoT	Internet of Things
IoTs	Institutes of Technology
IRC	Irish Research Council
IRDG	Industry Research and Development Group
KETs	Key Enabling Technologies
KK	Knowledge Foundation
KNAW	Royal Netherlands Academy of Arts and Sciences
KTI	Knowledge Transfer Ireland
KTU	Kaunas University of Technology
LiDAR	Light Detection and Ranging
LMT	Lithuanian Research Council
LSMU	Lithuanian University of Health Sciences
LVPA	Lithuanian Business Development Agency
M&A	Mergers and Acquisitions
MIT	SME Top Sectors Innovation Support Scheme
MITA	Agency for Science, Innovation and Technology
MNC	Multi-National Companies
MoEI	Lithuanian Ministry of Economy and Innovation
MoESS	Ministry of Education, Science and Sport
NCAD	National College of Art and Design
NCI	National College of Ireland
NIS	National Innovation System
NSO5	Enterprise, Innovation and Skills
NSTP	National Science and Technology Programmes
I	Netherlands Organisation for Scientific Research
OCW	Ministry of Education, Culture and Science
OECD	Organisation for Economic Co-operation and Development
OGP	Office of Government Procurement
OP	Operational Programme
PCP	Pre-commercial procurement
PCT	Patent Cooperation Treaty
PECS	Plan for European Cooperating States
PIANOo	Dutch Public Procurement Expertise Centre
PiiA	Process Industrial IT and Automation
PP	Public Procurement

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PPI	Public Procurement of Innovation
PPP	Public Private Partnership
PTI	Procurement Transformation Institute
R&D	Research and Development
R&D&I/RDI	Research and Development and Innovation
RCSI	Royal College of Surgeons in Ireland
RD&I	Irish Research, Development and Innovation
RIO	Research and Innovation Observatory
RIS3	Research and Innovation Strategies for Smart Specialisation
RISE	Research Institutes of Sweden
RPE	Research Prioritisation Exercise
RPOs	Research Performing Organisations
RTOs	Research Technology Organisations
RVO	Netherlands Enterprise Agency
S3	Smart Specialisation Strategy
SBIR	Small Business Innovation Research
SFI	Science Foundation Ireland
SIAs	Strategic Innovation Agendas
SIO	Strategic Innovation Programme
SIPs	Strategic Innovation Programmes
SS	Smart Specialisation
STEM	Science, Technology, Engineering, and Mathematics
STI	Science, Technology and Innovation
STW	Technology Foundation
TRL	Technology Readiness Levels
UCD CCI	University College Dublin Cybersecurity and Cybercrime Investigation
VDI	Vision-Driven innovation
VMU	Vytautas Magnus University
VSNU	Association of Universities in the Netherlands
VU	Vilnius University
WUR	Wageningen University & Research

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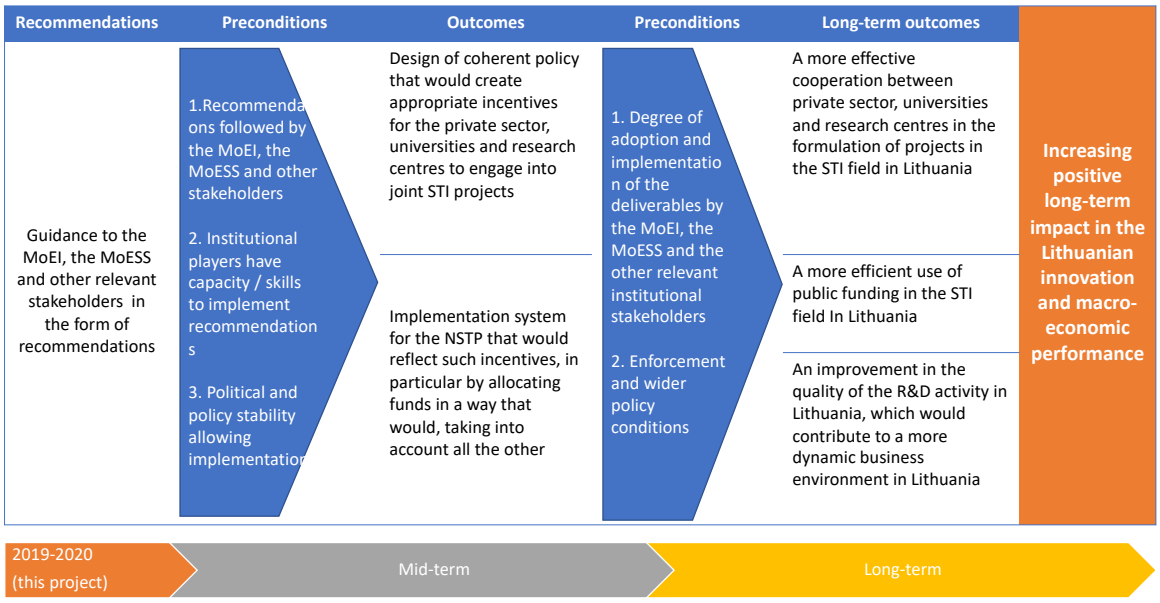
1 Introduction

In October 2019 the European Commission's Directorate General for Structural Reform Support (DG REFORM) signed a contract with the European Future Innovation System (EFIS) Centre and Visionary Analytics to deliver a service contract to contribute to the institutional, administrative and growth-sustaining structural reforms in Lithuania and support national stakeholders with insights useful for the design of national STI activities and reforms. More specifically this project was set to provide guidance to the Ministry of Economy and Innovation (MoEI, as the main beneficiary) as well as the Ministry of Education, Science and Sport (MoESS) and other relevant national stakeholders for the design and implementation of R&D programmes aimed to improve and stimulate business-science cooperation culture in the country. A particular focus was given to the R&D activities in the engineering (including laser technologies), food, life sciences, and Information and Communication Technology (ICT) sectors. Although not directly linked to the topic of business-science cooperation, the beneficiaries were also keen to learn how to support pre-commercial and innovation public procurement, as well as innovation development in the public sector.

With a view to the next Multiannual Financial Framework 2021-2027, Figure 1 summarises this project's potential contribution to the institutional, administrative and growth-sustaining structural reforms in Lithuania. In the long-term, recommendations from this project, together with various other national and institutional reforms in Lithuania, should contribute towards building and sustaining a more effective cooperation between the private sector, universities and research centres in the forming of Science, Technology and Innovation (STI) projects; a more efficient use of public STI funding; and an improvement in the quality of the STI activities in Lithuania.

Figure 1 Current support project in the context of the long-term development of Lithuania



Source: Authors own compilation based on Tender Specifications.

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The project ran from December 2019 until December 2020. The work included:

- background desk research on drivers and barriers for business-science cooperation in Lithuania (reported in the Interim Report),
- a (physical+ virtual) stakeholder workshop to present and refine the findings about barriers and drivers for business-science cooperation in Lithuania (which took place on 5th March 2020 in Vilnius),
- a review of the best practice around business-science cooperation and innovative public procurement in three selected comparators countries – Ireland, Sweden and The Netherlands (reported in the Interim Report),
- two (virtual) co-design workshops to present the possible solutions for building National Science and Technology Programme and for supporting business-science cooperation (which took place on 7th and 14th October 2020),
- a final (virtual) dissemination event which took place on 8th December 2020.

This report is structured as follows:

- Chapter 2 presents a review of the drivers and barriers for business-science cooperation in the selected four thematic areas of the Lithuanian STI system;
- Chapter 3 describes international best practice from Ireland, Sweden and the Netherlands around the topics of business-science cooperation as well as public procurement of innovation;
- Chapter 4 describes lessons learned and best practices collected during the international review;
- Chapter 5 focuses on the conclusions coming from the review of the national drivers and barriers for business-science cooperation and the international best practice review;
- Chapter 6 puts forward recommendations for Lithuania.

The report is complemented by four annexes:

- Annexes 1-3 present detailed information from the three comparator countries;
- Annex 4 contains various background information used for the review of the Lithuanian context, such as a list of literature sources, a list of interviews consulted during the project, information from the workshop with key stakeholders.

The following definitions of key terms have been agreed on with the Ministry of Economy and Innovation and DG REFORM during the inception phase of the project.

Business-science cooperation covers a wide spectrum of activities from education to management, including research and valorisation (as described in the Inception Report). Given that the Tender Specifications for this project called to "provide clear guidance to the MoEI, the MoESS and the other relevant institutional stakeholders for the design and implementation of R&D programmes that would foster the cooperation between the private sector, universities and research centres", the project team interprets business-science cooperation as: (1) joint R&D projects; (2) contract research where both sides – private sector and universities/research institutes can engage in joint projects in the STI field; and (3) commercialisation of R&D results, for example, via licencing.[1]

[1] Academic and student entrepreneurship (spin-off and start-up creation) are NOT included in this study.

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Sectors of Engineering (especially Lasers), Food, Life Sciences and ICT are outlined in the Technical Specification as the focus in the preparation of the National Science and Technology Programmes (NSTP). As the preparation of the NSTPs is done in alignment with the Lithuanian smart specialisation (SS), the definition of sectors follows the definitions used in the SS:

- Engineering industry (esp. lasers) = photonics and laser technologies as part of the Priority "New production processes, materials and technologies"
- Food = sustainable agrobiological resources and safe food as part of the priority "Agro-innovation and food technologies"
- Life sciences industry = all three themes (molecular technology for medicine and biopharmacy; advanced applied technologies for personal and public health; advanced medical engineering for early diagnostic and treatment) under the Priority "Health technologies and biotechnologies"
- ICT = all five themes (Artificial Intelligence, big data and distributed data; Internet of Things; multimodal analysis, processing and deployment; cyber security; and financial and blockchain technologies) under the Priority "Information and Communication Technologies"

Pre-commercial procurement (PCP) is "an approach to public procurement of research and development (R&D) services by which public procurers buy R&D" (split into such phases as solution design, prototyping, original development and validation/testing of a limited set of first products) "from several competing suppliers in parallel to compare alternative solution approaches and identify the best value for money solutions that the market can deliver to address their needs". Usually followed with several goals in mind: "to develop breakthrough innovative solutions for the societal challenges of the future (e.g. in healthcare and well-being, security, clean & efficient energy, climate change); provide a first customer references for innovative companies; facilitate the access of new innovative players (e.g. start-ups, SMEs) to the public procurement market; share the risks and benefits of designing, prototyping, and testing new products and services between procurers and suppliers; create optimum conditions for wider commercialisation and take-up of R&D results; reduce market fragmentation, reducing costs for procurers and creating wider markets for companies".[2] Pre-commercial procurement may strengthen triple helix collaborations between any of the three actors, namely the government, the scientific community or private enterprises. Business-science collaboration can in some instances emerge as a bi-product of pre-commercial procurement.

Innovation public procurement, or Public Procurement of Innovative Solutions (PPI), complements Pre-Commercial Procurement by enabling larger scale deployment of solutions that were developed in small quantity in a preceding PCP. This is achieved by public procurer(s) (one large enough buyer or several smaller buyers in a buyers group) making an early announcement of the innovation needs (with the required functionality/performance and possibly also price requirements) and their intention to buy a critical mass of innovative products if industry can bring them to the market with the predefined price/quality requirements by a specific date.

Public procurement of innovative goods and services relies on inducing innovation by specifying levels of performance or functionality that are not achievable with 'off-the-shelf' solutions and hence require an innovation to meet the demand.

[2] Compiled using the description provided by the European Commission, https://ec.europa.eu/digital-single-market/en/pre-commercial-procurement

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2 Bottlenecks and drivers for business-science cooperation in Lithuania

2.1 Strategic business-science collaboration context in Lithuania

Between 2011 and 2018, the Lithuanian science, technology and innovation (STI) system saw the highest increase in performance within the entire EU, (European Commission, 2019a). The **lack of science-business collaboration has been identified as a major obstacle** preventing Lithuania from successfully advancing its performance in the field of STI (European Commission, 2019a; OECD, 2016). The R&D effort is predominantly ensured by the public sector. At the same time there have been serious obstacles for public R&D commercialisation and systemic collaboration (reflections of path-dependency): overdependence on basic science, an outdated public R&D base and unattractive research careers, lack of social capital and network failures, weak innovation diffusion system, and low motivation to learn (RIO reports 2012-2019; Visionary Analytics 2019a). The R&I institutional system was said to be fragmented, inefficient and lacking an overall strategic framework (RIO reports 2012-2019, Visionary Analytics, 2017, 2019; Büllinger et al., 2017). A large number of recent studies have provided expert recommendations on how to improve the framework conditions and incentives for business-science collaboration (OECD, 2016, 2019; Büllinger et al., 2017; Visionary Analytics, 2017, 2019a, European Commission, 2019b).

Figure 2 represents the timeline of all **major developments** that took place in the Lithuanian STI landscape since 2007. This timeline makes it clear that there have been multiple attempts to reorganise the HEIs (Higher Education Institutions) and research institutes, implement STI strategies and programmes, and change the institutional set-up. However, these attempts have had limited success.

The period between 2007 and 2013 was mostly focused on developing research infrastructures within public universities through the establishment of the integrated science, studies and business centres (the so-called “valleys”). However, knowledge and technology transfer capacities remained underdeveloped and there were few overall incentives for private enterprises to conduct extensive R&D activities in collaboration with HEIs. The establishment of clusters, also funded by the ESIF, (European Structural and Investment Fund), was mainly driven by the funding made available, while partnerships with HEIs were established on purely formal grounds.

The approved Smart Specialisation Strategy together with the new Operational Programme (OP) for 2014-2020 contributed to adopting a more targeted approach. The **2014-2020 policy mix** aimed to:

- Promote joint science-business R&D projects (‘Intellect. Joint business-science projects’ and ‘Inovouchers’), encourage international partnerships, and help businesses participate in international R&D projects through networking activities (Inoconnect LT), as well as provide support for innovative clusters (Inoklaster Lt) – all serving a purpose of supporting business R&D.
- Facilitate demand for innovation through “Pre-commercial procurement LT” which was designed to enable pre-commercial procurement at public institutions. This measure is innovative on an EU scale and is promising insofar as it enables new types of collaborations to emerge. Experts believe (Visionary Analytics, 2019a) this demand-side instrument is a positive step within the Lithuanian STI policy mix, yet without further institutional, administrative and growth-sustaining structural reforms, its impact will be limited. Currently, the Lithuanian public sector’s capacity to innovate remains poor and the quality of public services –

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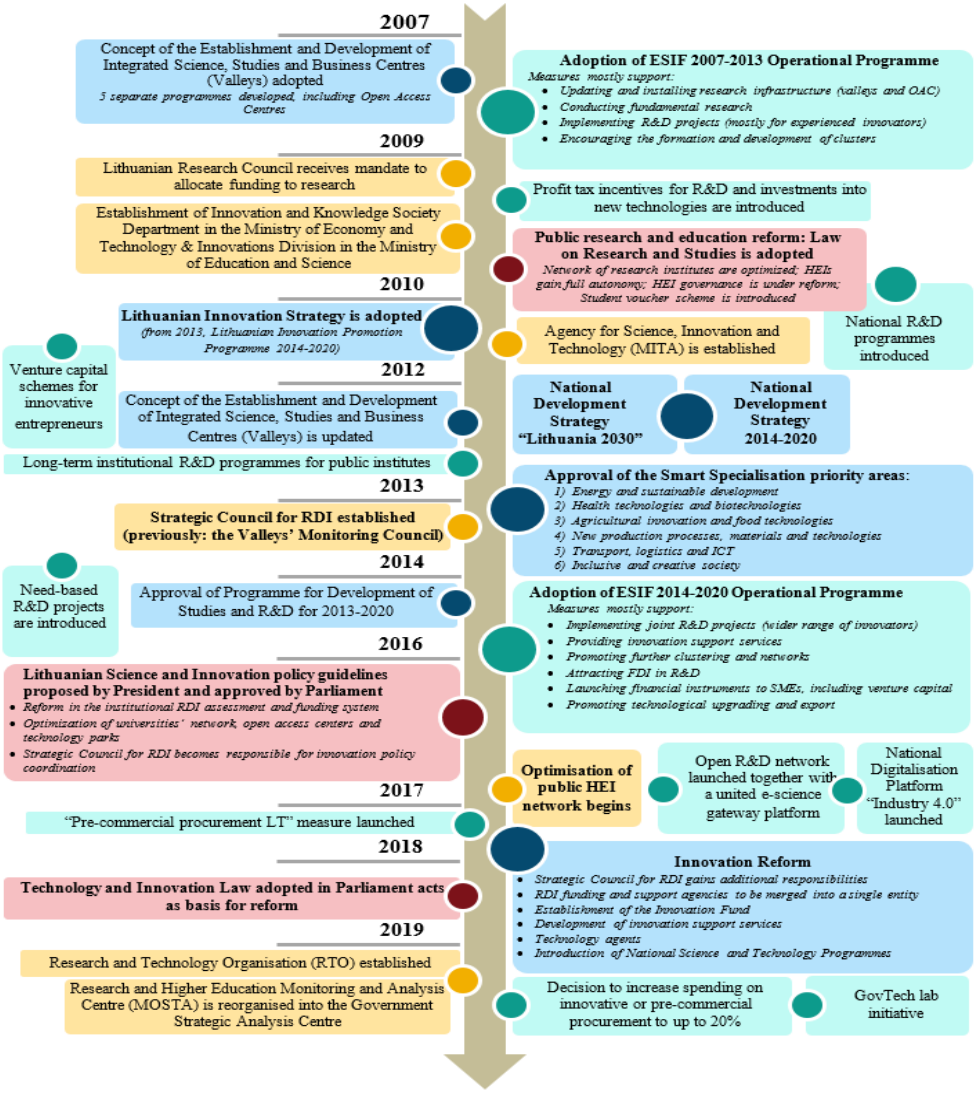
inadequate. Stronger incentives for innovative applications as well as capacity-building activities of public institutions'' personnel are needed to fully realise the potential of demand-side instruments (Visionary Analytics, 2019a).

- Facilitate attraction of innovative FDI (Foreign Direct Investment) (measures 'Smart FDI' and others) by providing support for R&D activities within newly established foreign companies.

Figure 2: Timeline of major events in the Lithuanian STI system during 2007 – 2020



Comments: Colours represent different types of actions: yellow stands for institutional change, blue for strategy change and policy reforms, red represents legal change and teal stands for policy action. Source: Based on RIO Country Reports since 2012. Source: Authors' elaboration (Visionary Analytics).

While issues such as institutional fragmentation, lack of collaboration between businesses and public research institutions, overreliance on EU funding to support R&D, and generally limited innovation capacity, continue to persist, the national innovation system is affected by even more deep-seated **systemic challenges**. Resolving them is all the more complex, because they reinforce one another and by doing so, create a vicious cycle, which makes further positive developments hard to fulfil. Recent studies, evaluations, and policy assessment reports provide ample evidence for issues clustered

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around three key areas, which are discussed below. All three areas are very relevant for the implementation of joint STI programmes as well.

National vision and strategy need major transformations

According to international experts (European Commission, 2019b), the Lithuanian STI system would greatly benefit from a national long-term vision and strategy formulation process. The innovation system and its institutional set-up have become overly complex, and a clear and widely shared direction is necessary to reach consensus and ensure further commitment from all stakeholders involved. The divide between science and enterprise policies has been a major barrier to improving the Lithuanian STI system. This divide has become deeply ingrained, leading to a serious shortcoming within the system, whereby the innovation process related to experimental and technological development, and product commercialisation remains its weakest element. A joint vision of what the innovation system should achieve, accompanied by clear KPIs and assigned responsibilities for all actors involved, is therefore necessary to help mitigate long-lasting disparities.

Policy implementation procedures are rigid and lack efficiency

Almost all STI policies in Lithuania are implemented by following a top-down approach, whereby policies are formalised into strict laws, further implemented by the ministries and their respective agencies. This approach narrows the possibilities and limits opportunities for new types of partnerships, ways of collaborating, policy incentives and bottom-up engagement of the STI community at large. Even though this is slowly starting to shift, policy procedures still emanate from this kind of approach, which makes them formal and inefficient. For example, international experts notice that Lithuanian authorities expend a disproportionate focus to the interpretation of R&D definitions – while these definitions are important for statistical and policy purposes, they are not fit for drafting legislation to specify how to distribute government funds. In this case, procedures take priority over impact to solidify the top-down approach. The administration of ESIF policy instruments follows the same logic, with project application requirements being overly complex and implementation conditions overly rigid. Even if the EU instructions need to be followed for the ESIF measures, there is room for reducing the administrative burden. Finally, inefficient, unclear, and, in some instances partial, procedures erode trust between the public and private sectors. Subsequently, the private sector loses willingness and capacity to engage in STI from the bottom-up, which further leads to even less cooperation and increased tensions. This has been shown in the limited success of the current collaboration programme "Intellect. Business-science projects" (Visionary Analytics, 2017).

Cultural environment that favours STI and entrepreneurship is strongly needed

A general lack of an STI-favourable culture has long been identified by experts as a major barrier to innovation-driven economic growth. Lithuania is said to be rather conservative and exhibit a risk-averse entrepreneurial tradition (European Commission, 2019b). For example, even the establishment of venture capital funds in 2012 has resulted in relatively low-risk investments to companies with stable revenue (Visionary Analytics, 2019b). This is partly explained by a small market that shows limited demand for innovation, and partly by Lithuania's research and education system that, until now, has been underperforming in terms of nurturing local talent and science entrepreneurship. An innovation culture and skills in universities and institutes need to be urgently developed. Business-science collaboration will not work unless the current researchers' career system and institutional funding mechanism are

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changed (Visionary Analytics, 2017, 2019a). The current system does not encourage researchers to focus on commercialising R&D results or providing services for business. Furthermore, the country's education system needs to address systematic issues, which prevent the creation of a critical mass of talented researchers. The shortage of skills and abilities to innovate also affects the public sector's capacity to incentivise innovation through demand-side instruments, and therefore creates a culture of imitation rather than innovation.

In 2018, the Government initiated the Innovation Reform to reduce institutional fragmentation and enable effective utilisation of financial resources. The new **Technology and Innovation Law** came into force in January 2019 and acts as a basis for the reform. In accordance with the new law, the Ministry of Economy and Innovation, has become the only institution responsible for technology and innovation policy. All the institutions in charge of implementation (Lithuanian Business Development Agency (LVPA), the Agency for Science, Innovation and Technology (MITA), INVEGA, Enterprise Lithuania, Invest Lithuania) were to be merged under a single body with consolidated functions. The Ministry of Economy and Innovation plans to establish an **Innovation Fund** that will enable the pooling of all available resources (ESIF and National budget) to effectively foster innovation and ensure the continuity of policy measures. Lack of stability and continuity in policy measure implementation has been a recurrent issue since 2007. The newly established Fund is therefore expected to allow for more sustainable policy budget planning. Both key initiatives were still not completed when this report was produced. Furthermore, the establishment of **joint Science and Technology programmes** is expected to have a major impact on the Lithuanian STI system. These programmes are explicitly mentioned in the Technology and Innovation Law and defined as competition-based programmes that, by mobilising the potential of Lithuanian science, technology and business, address societal needs and relevant challenges. The programmes are set out by jointly by the Ministry of Economy and Innovation (MoEI) and the Ministry of Education, Science and Sports (MoESS), and implemented by HEIs, research and business entities[3].

In response to the ongoing COVID-2019 crisis, some measures were recently introduced by the Agency for Science, Innovation and Technology (MITA) and the Lithuanian Research Council (LMT). MITA has organised a call for ideas, entitled "Life-saving innovation: stop COVID-19" and promises to offer the best candidates financial support that is available under the measure "Inostartas", which targets start-ups. LMT has also launched a call for applied research in this area and has dedicated €700, 000 for this purpose. Finally, a hackathon "Hack the Crisis", which calls for innovative solutions was initiated and organised jointly by the business, investor and start-up community.

2.2 Health technologies and Biotechnologies (Life sciences)

A brief map of the sector

Health technologies and biotechnologies were selected as one of the main RIS3 priority areas because of their high research potential and strong prospects of contributing towards knowledge-driven growth. After the RIS3 review in 2019, this priority area remains divided into the following three thematic priorities:

[3] LR Seimas. Lietuvos Respublikos technologijų ir inovacijų įstatymas. 2018 m. birželio 30 d. Nr. XIII-1414, Vilnius.

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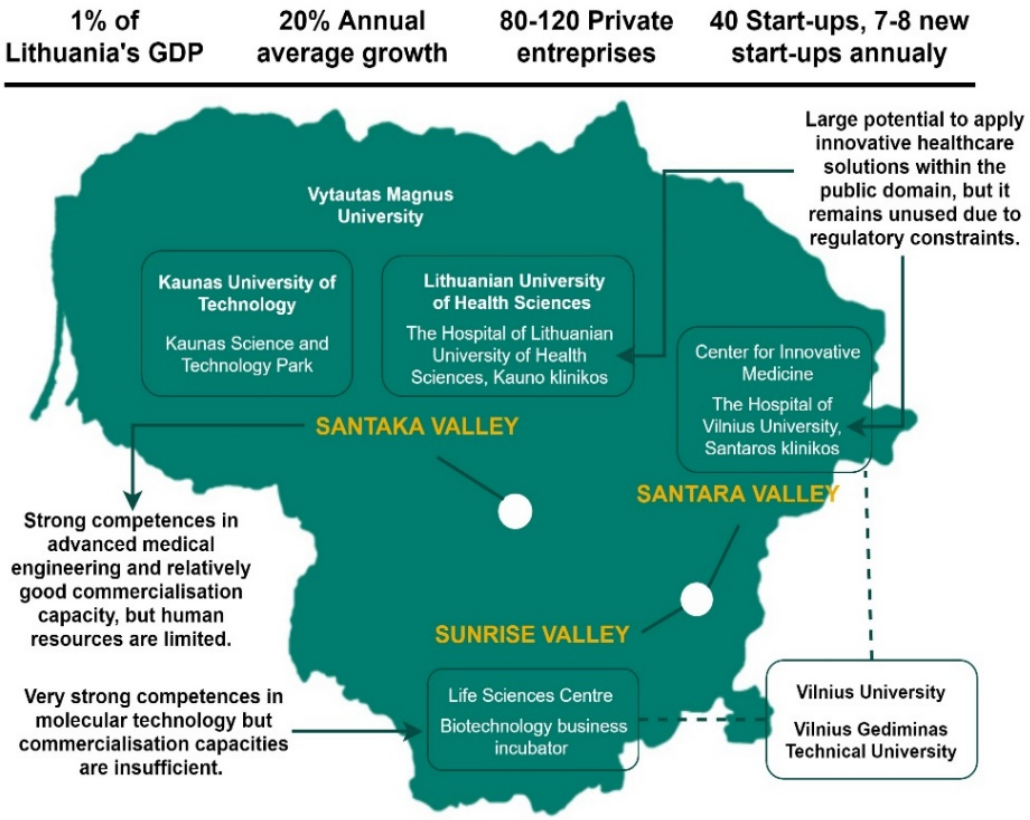
- Molecular technologies for medicine and pharmaceutics
- Advanced technologies for individual and public health
- Advanced medical engineering for early diagnostics and treatment

At the same time, the debate on this priority area has become increasingly focused on life sciences[4], which is broader than the RIS3 priority area[5] and already suggests possible synergies with other areas of expertise. However, within the Lithuanian context the terms defining this particular RIS3 and the life sciences industry are often used interchangeably.

Figure 3: Life Sciences – a map of most relevant sector entities and basic information about the industry



Source: Authors' elaboration, based on Invest Lithuania. Biotech in Lithuania. Available at: https://investlithuania.com/wp-content/uploads/Biotech-in-Lithuania.pdf; and EDP Reports, 2019

Currently, the life sciences sector contributes to approx. 1% of Lithuania's GDP (approx. €413m) and 2% of the export of Lithuanian-origin products. The sector has a few mid-

[4] The definition of the life sciences industry as outlined in the Lithuanian Guidelines for Life Science Industry Development: Lithuanian **industry of life sciences** is comprised of private enterprises, higher education institutions, research entities, and health care facilities, which operate within the areas of pharmaceutics, biotechnology, health informatics, bioinformatics, medical engineering and/ or perform preclinical studies and clinical trials. Entities actively involved in relevant new product development, technology transfer and commercialisation activities are also included.

[5] Life sciences may also include branches of science or industry that deals with plants and/ or animals but these aspects are discussed under the agro-innovation and food category.

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sized, yet well-established locally-owned companies[6] that employ up to 150 people, and many small enterprises[7] and/or start-ups[8] that employ between 3 and 30 people. Almost half of all companies in the sector manufacture medical instruments (43%), and almost a third are active in biotechnology (28%). The rest conduct R&D activities or manufacture pharmaceuticals[9]. It was assumed that the sector employed up to 5,000 employees in 2018[10].

Lithuania has been successful in attracting significant foreign direct investments (FDI) in this area, the largest of which resulted in a successful M&A deal with the US enterprise *Thermo Fisher Scientific*. *Thermo Fisher Scientific Baltics* now remains a leading company within the industry. It employs more than 900 employees and includes the World Excellence Center for Molecular Biology, the largest private R&D centre within the region, with approx. 140 researchers. Another player within the industry is *Teva Baltics* (previously known as *Sicor Biotech*), a pharmaceutical company that is also a result of an M&A deal with the Israeli firm *Teva Pharmaceutical Industries Ltd*. Several mid-size companies such as *Intersurgical*, *Hollister* and *Moog* chose Lithuania as a manufacturing location for medical equipment and devices.

Public research institutions have established competences in all three thematic priority areas, but the area of molecular technologies has recently demonstrated exceptional results. Vilnius University researchers, and more particularly Prof. dr. Virginijus Šikšnys, were involved in the invention of the CRISPR-Cas9 gene editing technology. Experts predict that by 2023, approx. 40% of genome technology will be based on this invention. Accordingly, Lithuanian authorities are willing to exploit this aspect and provide support to commercialisation of related technologies.

While the life sciences industry may be considered an innovation "champion" within the national context, in terms of size, it remains rather small. When compared to other Smart Specialisation priority areas, this particular priority contributes a much lower share of GDP, because, apart from a few leading companies, other enterprises lack scale and maturity. Consequently, the expectations for further sector growth are high – until 2030, the life sciences industry is expected to generate at least 5% of GDP. The expectations for the sector are indicated in the draft for the National Progress Programme. The Lithuanian government is set on making Lithuania a global leader in this industry, and has pledged to devote significant efforts towards achieving this goal.

Business-science collaboration and reported challenges

When compared to other RIS3 priority areas, the life sciences industry benefits from relatively strong business-science collaboration, because many industry companies initially emerged as spin-offs from research institutes and HEIs. In some instances, collaboration is quite systematic. For example, leading sector enterprises participate in setting the study curricula at local HEIs[11], offer doctoral and graduate students'

[6] *Biotechpharma* is considered a large enterprise within the Lithuanian context, yet it employs less than 150 people and may still be regarded as an SME. Other enterprises of this size include *Neurotechnology* and *Medical Technologies* (an American-Lithuanian joint venture company).
[7] Examples of such companies: *Vittamed, Femtika, Profarma, Softneta.*
[8] Examples of such companies include: *Oxipit, CasZyme, Droplet Genomics.*
[9] Data made available by "Enterprise Lithuania", 2016. This includes both locally-owned and foreign-owned firms.
[10] Guidelines for Lithuanian life sciences industry development (2018). Available at: http://eimin.lrv.lt/uploads/eimin/documents/files/Inovaciijos/Strategijos/2018-11-7%20GMI%20gair%C4%97s-%20galutin%C4%97s.pdf
[11] For example, the Life Sciences Centre has recently introduced a new study programme that responds to business needs – the programme requires completion of a study project that the student may choose to complete at the enterprise. In this way, the enterprise may propose themes relevant to its development, while the research institution may supervise the project and provide access to infrastructure.

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internships and scholarships, conduct joint R&D projects and maintain ongoing contact in other forms. In other instances, collaboration is more sporadic given the limited cooperation culture, but entities are nonetheless active. Informal personal contacts with former professors, lecturers or fellow researchers play a big part in initiating activities, but such collaboration does not officially involve the HEI. Overall, personal and professional contacts is the most common way to start cooperation, while designated agencies play almost no part in fostering cooperation (MOSTA, 2017).

Recent reports (Visionary Analytics, 2019a; STRATA, 2019) and stakeholder feedback on business-science collaboration within this RIS3 priority area suggest the following:

- During the 2014-2020 programming period, this priority area received the largest sum of public investment (total sum of €107.5m out of €384.9m) out of other RIS3 priority areas (STRATA, 2019). However, the amount requested was almost twice as large (€186.9m), so the average project success rate stands at 58%.
- In comparison to other RIS3 areas, a large share of R&D projects within the priority area (approx. 50% of all projects) was financed under the "Intellect. Joint science-business projects" measure. The average sum per project is €527,000, however, the scale of collaboration between research institutions and businesses within these projects remains unaccounted for, due to the reasons discussed in the final part of this chapter.
- A much smaller share of projects within this priority area (approx. 30%) was financed under the "Inovouchers" scheme. Stakeholders report that the measure was less attractive to businesses because its scale was much too small, both in terms of financing and duration, to be sufficient for projects within the area of life sciences. Entities would rather conduct more extensive and mature projects under the "Intellect. Joint science-business projects" measure.
- Entities within this priority area were actively using financial support available for obtaining patents. Almost 30% of all the available financial support under the "Inopatentas" measure was provided to both HEIs and businesses within this area. Stakeholders confirm that this measure is important to the sector, however funding for patent maintenance and further protection is unavailable, hence enterprises are not always keen on exploiting this opportunity.
- Four large projects, with project sums ranging between €663,000 and €769,878 for three larger projects, and €269,343 for a single smaller project, were financed under the new pre-commercial procurement scheme. The projects are being carried out by the Vilnius University hospital (Santaros klinikos), Druskininkai municipality (in collaboration with local healthcare facilities and sanatoriums) and the Lithuanian Sea Museum. Given the fact that most healthcare facilities in Lithuania are public and are therefore ideally placed to apply novel advanced technologies for public health, it is unsurprising that such institutions responded positively to pre-commercial procurement. However, the implementation of the instrument has received criticism for selecting projects that are not sufficiently innovative and that only address problems at a local rather than national level. Furthermore, the lack of adequate regulations for introducing novel medical instruments or pharmaceuticals into the Lithuanian healthcare system hinders the development of innovation (Kostkevičius, 2019).

Several challenges that prevent more efficient business-science collaboration also remain prevalent:

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- Stakeholders question the sustainability of current R&D schemes, such as the "Intellect. Joint science-business projects" measure. Enterprises are still reluctant to invest in R&D as well as collaborate with researchers on equal terms. In some cases enterprises are unable to fully exploit the obtained results due to limited absorptive capacities. Stakeholders suggest more intensive industrial PhD programmes or recommend following the German example, where obtaining business experience is a natural part of a person's career track.
- Given the relatively low current maturity of the sector, Lithuanian industry is considered too small to sufficiently sustain a stream of R&D contracts or the purchase of research results on a regular basis from research institutions. As a result, research institutions are keen to collaborate with foreign firms and export their know-how. Both Kaunas University of Technology (KTU) and Vilnius University (VU) have established partnerships outside the Lithuanian industry. However, they are also aware of the need for marketing campaigns and more extensive participation in various trade fairs and industry events abroad for which they report a lack of funding.
- Research institutions, while generally appreciative towards cooperation activities, are nonetheless weary of routine or overly specific tasks. This leads to a narrowing of competences that scientists would rather avoid. Scientists sometimes simply refuse tasks that cannot become a base for a graduate level thesis or project work.

Recent sector-specific developments

Given the large expectations towards sector growth, the MoEI is committed to support R&D activities, boost business-science cooperation and promote technology transfer or other types of commercialisation activities. In 2018, the MoEI Working group[12] proposed new Guidelines for Life Science Industry Development, and a corresponding action plan[13]. The action plan mostly foresees activities until the end of 2023, because they may be financed by the European Structural Investment Funds, under the 2014-2020 programming period measures. Activities after that date, with a few exceptions, were not planned. Three activities, namely providing digital access to data that is stored in biobanks, ensuring the continuity of biobank activities and establishing a mechanism of providing financial support to conduct non-commercial clinical trials, are expected to be implemented by 2025 and 2030 respectively. A Lithuanian National Biobank is expected to be established in the near future. Table 1 summarises key activities relevant to science-business cooperation and pre-commercial procurement under the four proposed Guidelines.

Within the framework of these guidelines, MITA has begun to implement a project[14] that involves innovation support activities. MITA will be organising a series of events, such as thematic workshops, open lectures, hackathons etc., providing consultations for enterprises on open calls for projects, application requirements, partnership or investment opportunities, and inviting experts to give advice on intellectual property rights, patenting, technology testing, business development etc.

[12] A Working group was led by the MoEI representatives and consisted of various industry and research institution stakeholders.
[13] Lietuvos gyvybės mokslų industrijos plėtros gairių įgyvendinimo priemonių planas. Available at: http://eimin.lrv.lt/uploads/eimin/documents/files/GMI_planas_priedas_4-500.docx
[14] MITA. Gyvybės mokslų industrijos plėtros skatinimas. More information available at: https://mita.lrv.lt/lt/veiklos-sritys/mita-vykdomi-projektai/gyvybes-mokslu-industrijos-pletros-skatinimas

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Other developments within the sector are taking place in Vilnius, and involve the key research institution within the region, namely the Life Sciences Centre (Vilnius University):

- The Centre has recently received a sum of €6m from the ERDF to update, purchase and install new scientific equipment, enable the Centre to become a full member of the European Molecular Biology Laboratory (EMBL) and integrate within the Instruct-ERIC pan-European infrastructure.
- The Centre, together with 12 industry partners that include other research entities and private enterprises, established the Life Sciences Digital Innovation Hub. This Hub will be located within the Vilnius City Innovation Industrial Park and should help to promote digital innovation within the industry.
- Given the Centre's aim to encourage spin-off companies, the Centre has partnered with Vilnius Municipality to open a business incubator at Vilnius City Innovation Industrial Park. The business incubator should open its doors in 2022.

Table 1: Key activities as proposed in the Guidelines for Life Science Industry Development Action Plan.

Talent. Strengthen human resources available within industry by attracting and retaining qualified specialists.	**RDI**. Support knowledge development through RDI activities and infrastructure development to ensure sector breakthroughs.	**Business**. Ensure a favourable environment for developing the life sciences industry by encouraging public and private investment, as well as start-up development and growth.	**Value chains**. Encourage business-science cooperation and development of value chains.
- Industrial PhD - Post-doc fellowships at enterprises - Opportunities for researchers from abroad - Opportunities for commercial R&D centre employees to train abroad - Programme for specialists working in health innovation area	- Financial support to R&D, infrastructure development and certification (new measure targeting enterprises within the industry) - Pre-commercial procurement - Commercialisation of R&D results - Consultations on participation in Horizon2020, innovation activities etc.	- Support incubation and start-up activities, introduction of Good Manufacturing Practice standards etc. through the Innovation Fund - Educational programmes to encourage commercialisation of R&D - Expert support in evaluating early prototypes - Start-up loans, risk capital, enterprise support services via accelerator programmes - Recommendations on medical data access via a regulatory sandbox	- Support spin-offs - Support business-science collaboration and follow-up on previously completed joint R&D activities - Regulatory framework for conducting clinical trials

Source: Own elaboration, based on the Guidelines for Life Science Industry Development Action Plan. Available at: http://eimin.lrv.lt/uploads/eimin/documents/files/GMI_planas_priedas_4-500.docx

Identified bottlenecks and drivers

The life sciences industry is rapidly changing due to advancements in both the biochemistry-related areas such as gene editing, micro-fluid technologies, epigenetics and similar fields, and in hardware-related areas such as digital health, mobile healthcare etc. Lithuania is no exception to these trends, and industry stakeholders are willing to exploit these opportunities.

An established reputation for research institutions in the sector remains essential for attracting R&D contracts or ensuring regular acquisition of research results. Public

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recognition and awards often increase appeal, as they serve to build enterprise trust in the research institution. In the life sciences industry, fundamental research remains a major driver for industry growth. Stakeholders report surprisingly high returns to licensing deals and the high-value attributed to fundamental know-how. Spin-off companies are also largely dependent upon the quality of fundamental research, and tend to identify their business opportunity by following up on the earlier stages of research.

Another driving factor in the industry is inter-disciplinary R&D. There are significant overlaps with other RIS3 priority areas, such as ICT applications, food safety, the photonics industry or engineering (incl. medical devices) which could offer interesting development opportunities. At the same time, engineering competences were said to be lacking. Stronger engineer involvement into R&D activities was said to be an important factor for further industry development.

SMEs were said to be flexible, keen on innovation, and showcase considerable potential for developing highly specialised products. Stakeholders point to Israeli, German and North Italian firm examples, where SMEs produce specific tools to address clearly specified problems. An analogous approach is suggested for the Lithuanian life sciences industry – most companies are relatively small and provided with the right tools, may quickly adapt to changing needs.

There are also several barriers that prevent efficient business-science cooperation and, as a result, hinder industry development.

High capital-intensity and need for infrastructure

First of all, the life sciences industry is highly capital-intensive, which means that investment into infrastructure is essential. For Lithuanian industry stakeholders this translates into two key barriers that impede business-science cooperation and innovation development:

- Despite significant investments into science, studies and business valleys (also known as science and technology parks) during the 2007-2013 programming period, and some additional investments throughout 2014-2020, including infrastructure investments in the clusters, laboratory infrastructure at research institutions remains insufficient. The issue is two-fold. On the one hand, since these large investments had already been made, there was little opportunity to update existing equipment. Stakeholders report that there are no clear procedures or means of purchasing additional upgrades, even if their price is not particularly high. This means that expensive equipment may go unused for periods of time, or the purchase of new equipment, necessary for further research, may stall. On the other hand, already existing infrastructure only fulfils the minimum needs for conducting frontier research. Additional investments are needed to ensure that scientific institutions retain their competitive advantage.
- There is a lack of infrastructure at the main research institutions and science parks for developing commercial applications. More specifically, research institutions have exhausted their incubation capacity and currently there are no more laboratories[15] available to start-ups or product development activities. According to stakeholders, if the target for 2030 of having 250 start-ups in the industry is to be achieved, large investments into clean room, Good laboratory

[15] This includes both lack of physical space in terms of square meters, and the lack of laboratory equipment that ought to be installed.

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practices (GLP)[16], GMP[17] or controlled environment system facilities need to be made.

Specifics of product development

Second, the product development cycle in the life science industry is much longer when compared to other industries and in some cases may take up to twenty years. This means that entities are unable to produce results within a project frame that lasts for up to two years. Stakeholders propose that current R&D schemes should be tailored according to stages of product development and timeframes would be adjusted in accordance to the length of each stage[18]. Furthermore, given the product cycle timeframe, Lithuanian investors are seldom willing to wait until clinical trials or validation tests are complete and the new product may enter the market. As a result, access to national risk capital is very limited, and aspiring entrepreneurs must search for funding opportunities abroad.

Regulatory barriers

Specific regulatory issues are a major barrier to industry development, such as unresolved data access and regulation issues. This is an especially relevant domain in the areas of advanced technologies for public health and medical engineering (incl. diagnostics). The development of "smart" technologies, which are able to collect data in real-time and suggest relevant adjustments, has a lot of potential. However, currently both research entities and enterprises struggle to access the medical data that is necessary for conducting R&D activities and clinical trials. Regulation in this area is either unclear or insufficient. In some cases, researchers report having received access to data available within specific enterprises, but this is an *ad hoc* solution that may not lead towards sustainable practices.

Limited or ineffective public policy

Insufficient incentives to introduce innovations into the national health system is an important barrier. The internal market for this particular industry is limited and most enterprises rely on export. However, barriers towards accessing international markets are very high, and enterprises would benefit from first introducing their product on the home market. The Ministry of Health was said to be insufficiently involved in attempts to introduce digital health solutions that increase efficiency, introduce novel pharmaceutical or diagnostic tools that had not been tried elsewhere, and apply advanced solutions in public healthcare facilities, while at the same time being overly focused on administrative tasks. The current legal base is ill-suited for all the activities mentioned above. As a result, practising doctors are seldom willing to offer suggestions on healthcare products, while enterprises are reluctant to offer innovative products on the home market.

[16] Good laboratory practice is a set of principles intended to assure the quality and integrity of non-clinical laboratory studies that are intended to support research or marketing permits for products regulated by government agencies.
[17] Good manufacturing practices are the practices required in order to conform to the guidelines recommended by agencies that control the authorisation and licensing of the manufacture and sale of food and beverages, cosmetics, pharmaceutical products, dietary supplements, and medical devices.
[18] This does not mean that all projects should necessarily be longer, but rather that each project would correspond to a development stage with results expected for that particular stage.

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2.3 Information and Communication Technology

A brief map of the sector

Information and Communication Technology (ICT) was chosen as one of the seven Smart Specialisation Priorities[19] to foster further growth of Lithuania's already strong position in the digital economy. Originally, the sector was grouped together with transport-related themes, but as of March 2019, ICT has become a separate priority area with additional five thematic areas, or keywords (see Table 2), chosen in response to global trends and Lithuanian enterprise strengths.

ICT was the fastest growing economic sector in the country, with value added increasing by 56% during the last five years (2015-2019) (INFOBALT and Enterprise Lithuania, 2020). In 2019, the sector contributed to approx. 3.8% of Lithuania's GDP, which was equivalent to €645m. However, the sector's growth is much slower when compared to neighbouring countries, such as Latvia, Estonia or Sweden.

Table 2: Changes in RIS3 related to ICT

Before the review of RIS3		After the review of RIS3	
Priority area	Transport, logistics and ICT	Priority	Information and Communication Technology
Priorities*	1. Advanced electronic content, content development technologies and information interoperability	Thematic areas	1. Artificial intelligence (AI), big data
			2. Internet of Things (IoT)
	2. ICT infrastructure, cloud computing solutions and services		3. Multimodal analysis, processing and integration
			4. Cybersecurity
			5. Financial and blockchain technologies

Source: Author's elaboration based on the Research and Innovation Strategy for Smart Specialisation amendments made on 2019-07-24.
Note: The priorities related to transport are not presented in the table as they are thematically different from ICT.

Currently, there are around 3,100 ICT-related enterprises in Lithuania, which employ over 33,000 people (Infobalt, Invest Lithuania, 2018)[20]. The sector is mostly comprised of small companies that are focused on relatively low-added value products and services. A large share of companies do not develop their own products but rather offer programming services on demand (Infobalt and Enterprise Lithuania, 2020). Only around ten companies are large enough to employ over 250 people. However, a base of enterprises which employ around 200 people and are keen to innovate has been emerging over the last decade. Examples include a cloud-computing focused company *Blue Bridge*, software developers *TeleSoftas* and *Devbridge*, a vehicle-tracking solutions provider *Ruptela*. Also, the number of start-ups is increasing at a fast pace. In 2019 there were around 720 start-ups, out of which more than a half were using IT solutions.

Out of approx. 60 clusters operating in Lithuania, 18 are related to ICT. Some of these clusters are cross-sectoral, linking ICT to creative industries, manufacturing and engineering. Most clusters are partners with universities and their coordinators are either science and technology parks or private entities. However, the majority of these clusters are small and lack competitiveness in global value chains.

[19] Until March 2019, ICT was part of the Smart Specialization Priority Area „Transport, logistics and ICT". After the interim evaluation of S3 it was agreed to separate ICT from transport as these areas are thematically different.
[20] It is difficult to define the correct number of companies that are based on ICT as they have many cross-cutting activities with other sectors.

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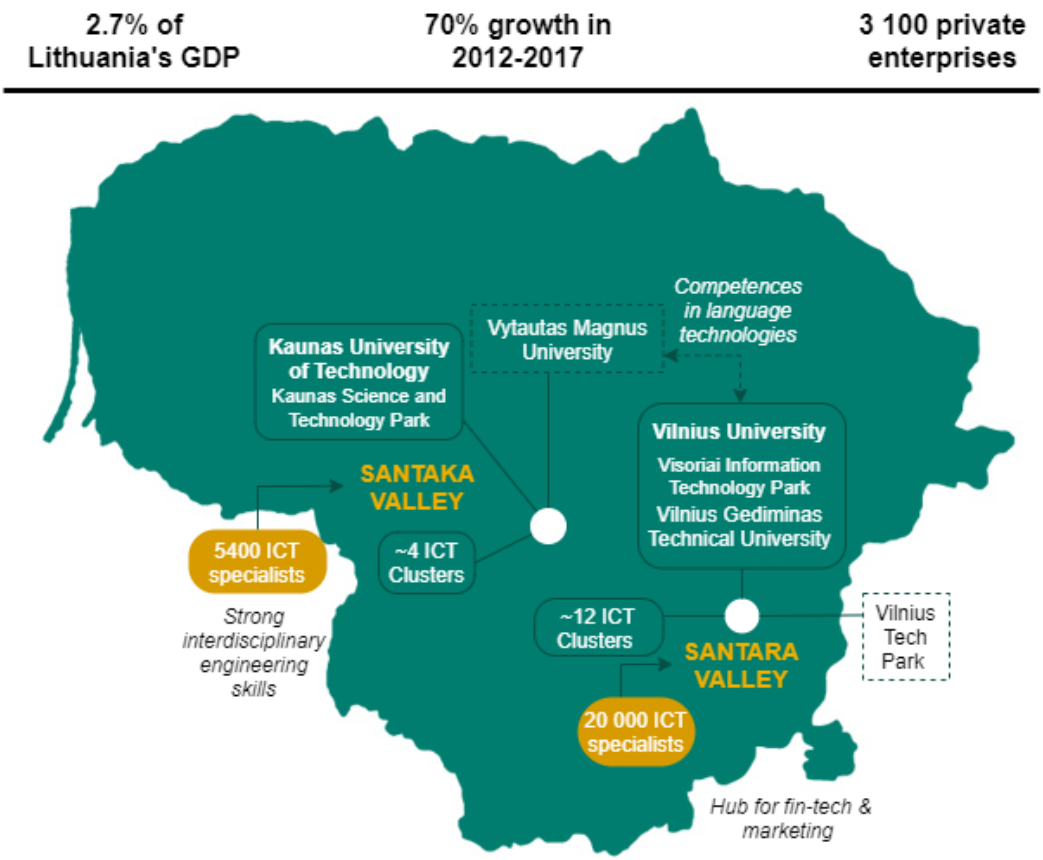
Business-science collaboration and reported challenges

The ICT sector is among the top-performing Smart Specialisation priorities[21] and is regarded as having great breakthrough potential. However, while companies in the sector tend to dedicate larger sums to R&D than in most other sectors, they seldom involve the HEIs in their activities. Furthermore, the sector's contribution to R&D as a share of GDP is still much lower than in other OECD or EU countries (Visionary Analytics, 2020). Recent reports and stakeholder feedback on business-science collaboration suggest the following:

- During the 2014-2020 programming period, the two thematic priorities related to ICT received €64.99m of public investment (16.42% of all RIS3 funding). The success rate of project applications was also relatively high – while the average ratio between the amounts of funding required and granted is 56%, the ratio in ICT is around 70%.

Figure 4: ICT – a map of most relevant sector entities and basic information about the industry



Source: Authors' elaboration based on Statistics Lithuania (2019), INFOBALT and Invest Lithuania (2018), Vilnius Tech Park (2018).
Note: The number of companies, specialists and clusters may vary due to different methodologies of classifying company activities as ICT

[21] The performance indicators of S3 are analysed according to the scheme that was applied before the review of the strategy (see Table 2). Transport-related priorities are not included in the calculations.

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- The thematic priority of *Advanced electronic content* was particularly successful and received €57.06m of public investment, with only *Molecular technology* attracting a larger sum (STRATA, 2019).
- The sector's performance under the measure "Intellect LT. Joint science-business projects" is rather successful and accounts for roughly half of the funding for R&D activities in this area. However, while around 70 projects were financed under this measure, only 12 were implemented in collaboration with research institutions.
- Four institutions are conducting large-scale pre-commercial procurement projects[22] to tackle traffic-related challenges (Vilnius and Kaunas municipalities), visualise spatial data in 3D (Centre of Registers) and create a blockchain platform (Bank of Lithuania). However, given the vague character of R&D in the sector (cf. further in this chapter), many solutions do not require such extensive R&D, and in many instances, pre-commercial procurement might not be the most suitable instrument. Furthermore, highly advanced solutions in Lithuania are often developed by very few companies (sometimes 2-3), in which case competition according to pre-commercial procurement rules becomes almost impossible.

Businesses within the ICT sector mostly tend to collaborate with universities in order to attract talent, hence most partnerships are meant to address rising ICT specialist shortages. Currently, the sector is said to need at least 20,000 additional professionals (INFOBALT and Enterprise Lithuania, 2020). HEIs promote various initiatives that enable students to improve their skills and enter the ICT industry[23], while companies sponsor specific HEI needs[24]. Unfortunately, this has a negative impact on industry's long-term development – almost half of 3,000 students that are admitted to relevant tertiary education programmes each year drop out before graduation. The dropout rate in ICT-related programmes is among the highest in the country and the number of doctoral students is continuously decreasing (Infobalt, Invest Lithuania, 2018). As FDI increases at a fast pace (partially due to global labour arbitrage), students become more willing to enter the labour market and occupy relatively well-paid positions instead of continuing their studies. Some believe this could lead to a situation whereby the country's ICT sector becomes overly reliant on mid-level services and functions, instead of setting global trends and fostering innovation (Reimeris, 2015).

The large differences between wages in the private and public sectors translate to other business-science collaboration issues in the ICT sector:

- Companies tend to hire researchers directly or employ them at the company on a part-time basis more so than in other sectors. This partly explains the low number of projects completed in collaboration with HEI researchers.
- HEIs suffer from a negative image that is associated with uncompetitive salaries and a low visibility of their achievements. The latter is mostly due to informal partnerships that remain a means for additional earnings, yet the role of the

[22] €678,000 and €781,000 are foreseen for tackling traffic-related challenges, €840,645 for visualising spatial data and €850,000 for creating the blockchain platform.

[23] For example, *Devbridge Group* runs the annual sorcery academies that are meant to provide digital skills. Lack of competences required by businesses contributed to high numbers (4,500) of graduates and junior developers retrained by private academies in 2018 (Invest Lithuania, 2018)

[24] For instance, the *INVESTed* programme, run by the KTU, offers businesses publicity and solutions for finding employees among its students. In return, companies are willing to sponsor KTU's activities – for example, in 2015, *R1* (formerly *Intermedix*) invested €100,000 towards the establishment of the largest specialised laboratory in Lithuania at the Faculty of Informatics (Invest Lithuania, 2019).

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researcher remains unofficial and seldom provides an opportunity to secure improved esteem.

Furthermore, other issues hinder research-oriented activities and collaborations:

- The concept of what constitutes R&D in the sector is not always clear. This is due to the particular character of IT solutions and applications – the vast majority of novel products or services are reliant on already existing programming languages and methods, and emerge from identifying ways of adapting these technologies to various fields. As a result, enterprise activities do not always qualify as R&D under the relevant RIS3 priority area, while researchers, who are involved in diverse interdisciplinary activities, are evaluated on the same basis as scientists active in natural sciences.
- Companies and HEIs have very different expectations regarding outputs and results. Companies, especially those without previous R&D experience, tend to expect HEIs to deliver results that are meant to solve a specific IT problem rather than contribute to product development. Only companies with innovation management experience (e.g. companies with R&D departments or innovation-based start-ups) are competent enough to clearly formulate the required tasks and avoid mutual disappointment.
- ICT is much less capital-intensive than other sectors, hence businesses are seldom interested in using the infrastructure provided by HEIs. Most often, HEIs provide the equipment that can be found at private companies as well, so the incentive that exists in other sectors is lacking.
- Evaluation criteria for researchers in the sector limits their participation capacity in various collaboration or research projects. Currently, researcher capacities in the field of ICT are evaluated according to the same criteria as researchers in the field of natural sciences, while the specific aspects of this particular field are not taken into account. For example, neither patenting nor publications in the sector are significant. Patenting is unpopular as innovative ICT solutions are rather kept as commercial secrets. While instead of publishing papers, researchers prioritise participation in well-known international conferences, contributing to prestigious handbooks or developing methodological guides (business entities are also involved in such activities). Furthermore, given that project applications are evaluated on the number of and *Web of Science* citation index, the opportunities for younger researchers are limited. However, young researchers in this field are often better acquainted with most recent sector developments and possibilities for innovation.

Finally, due to all the issues discussed above, the ICT sector has not been an active participant within international R&D programmes. The Lithuanian ICT sector was the second-lowest performer amongst all EU Member States in attracting Horizon 2020 grants (INFOBALT and Enterprise Lithuania, 2020).

Recent sector-specific developments

The Lithuanian ICT landscape is rather fragmented, with many enterprises conducting diverse activities. Yet the sector is highly dynamic and the following recent trends suggest positive developments in the following areas:

- Government institutions are becoming increasingly aware of the importance of ICT to the public sector. While in 2017, public procurement constituted approx. 10% of all the Lithuanian ICT market, in 2019 this share grew to 15% (INFOBALT

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and Enterprise Lithuania, 2020). Along with large investments towards e-services and e-health solutions, up to €5.7m were dedicated to the creation of Lithuania's Open Data Portal that enables access to relevant data from public institutions. In addition, the GovTech Lab has been launched in 2019 to help public institutions address specific challenges and simultaneously offer an opportunity for start-ups to try-out their ideas (Visionary Analytics, 2020). In addition to these developments, Lithuania also aims to become a regional fin-tech hub. Lithuania's success is partly due to its strategic outlook – the Bank of Lithuania has introduced innovative and fast e-licencing procedures, flexible financial terms and created the right environment for innovation by offering regulatory sandboxes and building a platform (LBChain) for blockchain-based solution via the pre-commercial procurement instrument.

- The growing amount of cyber-attacks on state institutions, businesses and individuals opens opportunities for Lithuanian cybersecurity companies. In 2019, Lithuania was ranked 4th out of 194 states on the Global Cybersecurity Index (International Telecommunication Union, 2019). This result reflects the government's trend-setting approach to cybersecurity – the Ministry of Defence has taken action in order to consolidate the state's capacities in this area and is leading a progressive EU-wide PESCO initiative (LRT, 2019). In 2019, the first military-tech hackathon *Delta1* took place, bringing together over 220 participants who generated 40 defence-related solutions[25].
- Although interdisciplinary know-how is still lacking, there are positive developments in adapting AI and IoT solutions to med-tech[26]. Another interdisciplinary field is language technology. With the support of EU funds, ICT scientists and linguists from VU and VMU in cooperation with *Tilde* are developing machine translation and speech recognition products and services. The Lithuanian AI Strategy (2019) suggests that AI and IoT solutions will be fostered to a greater extent in the future by government incentives targeted at five key sectors: manufacturing, agriculture, healthcare, transportation and energy.
- Lithuania's game development field is small but considered to have a breakthrough potential. In the period of two years more than 10 companies from Eastern Europe have relocated to Lithuania due to ease of setting up a business and a convenient location[27]. 21 local and international companies have already joined the Lithuanian Game Developers Association, which organises the annual *LT Game Jam*, which attracted over 400 participants in 2020.

Given the expectations for the sector's growth, the Lithuanian Industry Digitisation Roadmap 2019-2030 was launched after a year-long period of consultations between stakeholders at the National Industry 4.0 Platform. The Roadmap aims to assist the transformation of Lithuanian manufacturing that is still highly dependent on contract manufacture of low value-added products. One of the key measures is the establishment of Digital Innovation Hubs (DIHs), for which up to €18.3m of public funding[28] will be dedicated. At present, there are 10 sector-specific DIHs, ranging from agriculture to life

[25] More information available at: https://www.15min.lt/mokslasit/straipsnis/technologijos/pirmajame-gynybos-technologiju-hakatone-delta-1-triumfavo-dirbtiniu-intelektu-paremtos-idejos-646-1131486?copied

[26] E.g. *Softneta*'s products aid the decision making of healthcare professionals by processing medical imaging (software) and *VILIMED* has patented a vibrational therapy ball that reduces hand tremor (hardware).

[27] More information available at: https://investlithuania.com/key-sectors/technology/gamedev/

[28] More information available at: https://www.esinvesticijos.lt/lt//finansavimas/patvirtintos_priemones/skaitmeniniu-inovaciju-centrai

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sciences. These 'one-stop-shop' competence centres will provide support to companies that are willing to improve their business or manufacturing processes through digitisation.

Identified bottlenecks and drivers

The ICT sector is more dynamic than other sectors, and demonstrates high potential for development. However, tapping into that potential requires taking stock of identified strengths and limitations within the sector.

First of all, the sector is responsive to adopting a problem-solving approach rather than straightforward technology-development. In other words, ICT tools may help address various challenges, which in turn, may steer technology development. However, a more precise and systematic identification of areas where potential applications are expected to emerge, is key.

Secondly, stakeholders are interested in exploring various partnership arrangements that are not necessarily limited by science-business collaborations. This includes Triple Helix collaborations, where the government plays an important role in fostering innovation, as well as B2B partnerships, where enterprises may support other enterprises in resolving specific issues. The partnership arrangements may be categorised as follows:

- In the first case, the government institutions are the driving agents in need of innovative solutions. As such, they may initiate activities either with business or research institutions. As an example, stakeholders refer to a good practice example in Ireland, whereby police officers collaborated with researchers from the University College Dublin to create digital forensic tools (UCD CCI, 2016). It is important to note that instruments such as the current pre-commercial procurement scheme are insufficient to cover these needs, because it is oriented towards enabling enterprises to conduct R&D rather than enable mutual collaborations or involve HEIs.
- In the second case, Industry 4.0 is seen as a major driver for B2B partnerships. There are many enterprises within the Lithuanian economy that would benefit from applying IT solutions to their business models, yet in many instances they are unaware of these possibilities, and in some instances, additional R&D investments would be needed to develop the most optimal solution. The newly established Digital Innovation Hubs are seen as a platform for these types of collaborations.
- The classical business-science cooperation scheme could also be more adaptive to cross-sectoral needs. For example, precision farming relies on a wide array of technological and IT solutions, yet collaboration between the agriculture industry and researchers in ICT remains little explored. The DIHs are also somewhat seen here as part of a solution, but more cross-sectoral collaboration within them is needed.

Finally, interdisciplinary R&D and inter-sectoral know-how is an important driving factor for industry growth, and this driver is even more pronounced in ICT than other sectors. There is a lot of potential in creating ICT products that respond to needs in the fields of manufacturing, transport, medicine, robotics, agro-innovation etc. However, the knowledge-sharing culture between different fields of academia and business communities is only starting to emerge and needs to be strengthened. At the same time, the vertical competence of ICT professionals should not be underestimated – while applications within the sector may be considered horizontal, researchers need to remain focused on specific hardware or software aspects that require in-depth knowledge.

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Two types of barriers are most relevant to this specific sector.

Limited or ineffective public policy

The sector's low capital-intensity and short product development cycle enables trial and error without risking large investments, yet this aspect remains insufficiently exploited. First of all, even if the number of start-ups is continuously increasing and risk capital is becoming more accessible, there is a reported lack of instruments at the earliest stage of product or service development. In other words, stakeholders identified the need for programmes that would enable students or researchers to spend time developing their initial idea before progressing to accelerator programmes or applying for seed stage investments. Previous reports confirm that most risk capital investments are directed at later product development stages. Secondly, applications for funding are accepted only during calls, with long timeframes between the calls, and it can take a few months or even over a year for a project to be approved (Visionary Analytics, 2019a). This is especially relevant to the ICT sector dynamics, which requires fast solutions to stay up-to-date.

Skills and competences

Negative HEI image and high student dropout rates are one of the most crucial barriers that could prevent sector's growth. Stakeholders suggest strengthening PhD programmes within the sector and introducing regulatory constraints to stop students from accepting full-time positions before graduation. Also reports suggest that strengthening IT education in higher vocational schools and colleges is important for building competence in the sector and ensuring that relatively simple technical tasks may be carried out by those without undergraduate or graduate degrees.

2.4 Engineering (focus on photonics and laser technologies)

A brief map of the sector

The RIS3 priority area of 'New production processes, materials and technologies' may be widely considered equivalent to the Lithuanian engineering sector. After the RIS3 review, two of its main priorities were merged into a single thematic priority, but otherwise the priority area remained unchanged (see Table 3: Changes in RIS3 structure regarding new production processes, materials and technologies). Photonics and laser technologies were identified as the area with greatest potential for business-science collaboration as well as further economic growth. The other areas were said to be either lacking in research or industry capacity (EDP reports, 2019). Hence, photonics and laser technologies in this case take priority other thematic areas.

Table 3: Changes in RIS3 structure regarding new production processes, materials and technologies

Before the review of S3		After the review of S3	
Priority area	New production processes, materials and technologies.	Priority	New production processes, materials and technologies.
Priorities	1. Photonics and laser technologies	Thematic areas	1. Photonics and laser technologies
	2. Functional materials and coatings		2. Advanced materials and constructions
	3. Structural and composite materials		
	4. Flexible production systems		3. Flexible production and manufacturing technologies

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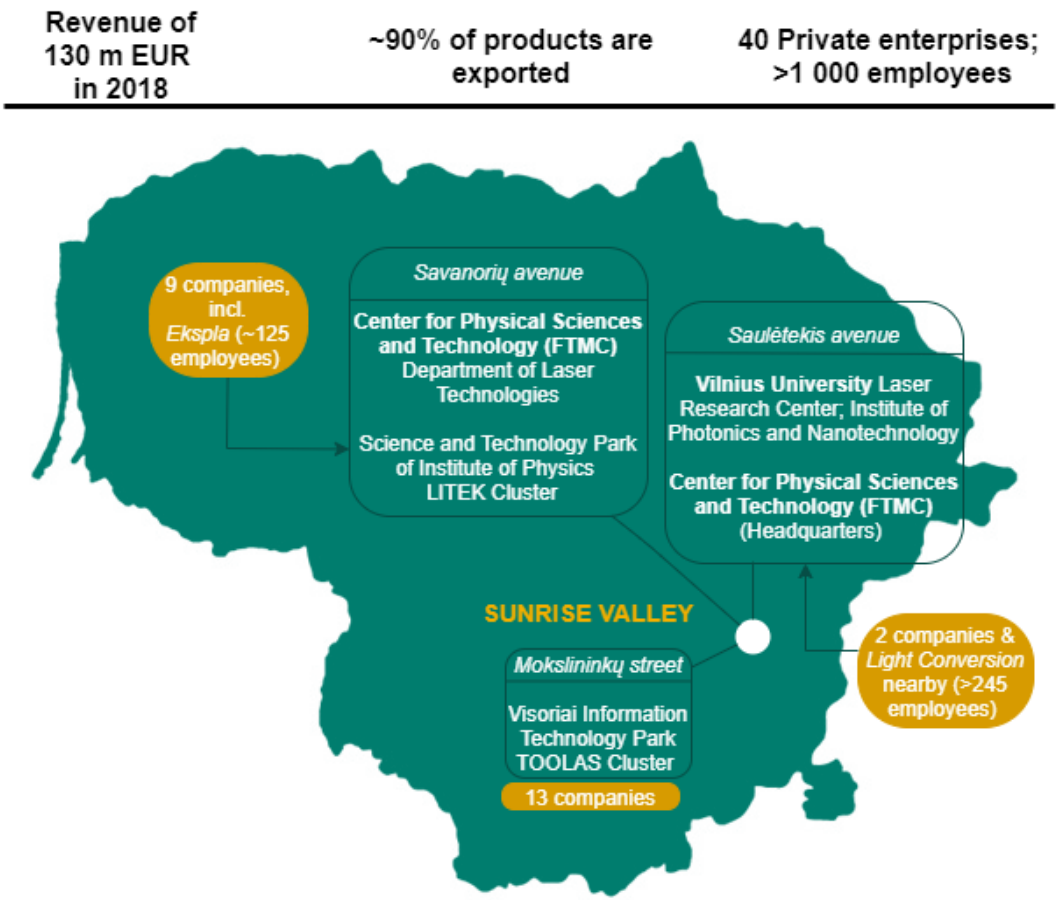
Source: Author's elaboration based on the Research and Innovation Strategy for Smart Specialisation amendments made on 2019-07-24.

Representatives from both industry and academia have agreed that by 2025 the Lithuanian laser sector should contribute to approx. 1% of Lithuanian GDP. This may seem ambitious, given that only 40 companies with approx. 1,000 employees operate in the sector. However, the sector demonstrates exceptional results: for the last 20 years, sector turnover amounted to 10-20% annual growth, while value-added per employee consistently remained three times the national average. In 2018, the sector was worth €130m. Up to 90% of the sector's production is exported abroad – Lithuanian companies enjoy leading positions worldwide as suppliers of scientific lasers, and maintain solid positions in international high value-added value chains of industrial lasers (Lithuanian Laser Association, 2019).

Figure 5: Engineering sector – a map of relevant photonics and laser technology sector entities



Source: Authors' elaboration based on Lithuanian Laser Association (2019)

The VU Laser Research Centre still plays a leading role in conducting cutting-edge research, accompanied by the Centre for Physical Sciences and Technology (abbrev. As FTMC in Lithuanian). The R&D infrastructure and available expertise at both institutions cover a significant part of the photonics-related activities across all TRLs.

Almost all companies have spun off from the two key research entities mentioned above. These companies remain geographically close to their parent institutions, with three key

locations based in Vilnius (see Figure 5: Engineering sector – a map of relevant photonics and laser technology sector entities). Generally, the company activities are concentrated within niche markets, such as manufacture of scientific lasers. Most companies employ between 5 and 30 employees, and only four companies have over 100 employees[29]. On average, 1 out of 10 employees within the sector has obtained a PhD (Lithuanian Laser Association, 2019). Each year, a few start-ups emerge, their founders being either researchers themselves or former employees of already established companies. More than half of the companies in the field (24) are members of the Lithuanian Laser Association and collaborate through clusters. The LITEK cluster connects 14 companies employing laser and engineering technologies, whereas TOOLAS combines the knowledge of photonics, engineering, coating and IT professionals (5 companies).

Similarly to the life sciences industry, while entities active within the area of photonic and laser technologies may be considered strong innovators, the lack of scale prevents them entering new global markets. The sector companies together make up a self-sustained ecosystem but more efforts are needed to boost the sector's capacities and advance the use of laser technology in other domains.

Business-science collaboration and reported challenges

Business-science collaboration within the sector is stronger and more developed than in other Lithuanian industries. Enterprises in the sector dedicate 10% of their expenditure to R&D activities, take part in setting the study curricula at local HEIs[30] and have even contributed to financing R&D infrastructure within research institutions[31]. Close proximity and well-established ties result in effective collaboration, knowledge and service sharing. Such collaboration is both formal and informal and rests on solid mutual understanding.

Recent reports and stakeholder feedback on business-science collaboration suggest the following:

- Photonics and laser technologies has received €27.3m of public funding, **making it the 4th out of 20 priorities in terms of funding received.** The **success rate** (the ratio between the amounts of funding requested and granted) is 76%, which **is the highest among all priorities**. These results reflect the high potential of the priority, considering the small amount of companies working within the sector.
- Most investments were attracted under the measure "Intellect. Joint science-business projects" (approx. €9m). The measure is most popular with larger companies, given that financial and result-related commitments are difficult to ensure for HEIs and small enterprises.
- The measure "Specific targeted research projects in the area of Smart Specialisation"[32] is important for HEIs active in the sector. The measure supports R&D activities conducted by highly qualified research teams. The priority of photonics and laser technologies has attracted €6.65m under this measure (the largest sum of investments among all priorities). The size of the subsidy may be rather large (up to €1m per project), and researchers are required to fulfil many

[29] These companies are Ekspla, Light Conversion, Standa, Altechna Group.
[30] VU Faculty of Physics offers a unique Light Engineering bachelor programme, which provides students with the opportunity to develop their practical skills at FTMC as well as to intern at industrial companies and write their theses there. Half of the graduates of the Faculty of Physics are studying under laser or light technology related programmes. More information available at: https://www.ff.vu.lt/en/studies/undergraduate
[31] More information available at: https://www.ftmc.lt/koherentines-optikos-laboratorija
[32] "Tiksliniai moksliniai tyrimai Sumanios specializacijos srityje".

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conditions, e.g. obtain patents, produce multiple academic papers and participate in conferences. Some researchers consider this excessive, as the obligations may lead to premature patenting and 'paperwork' of low scientific value.

- In comparison to other priorities, the sector is rather successful in obtaining patents. In the period of 2014-2019, 45 patents were issued by the State Patent Bureau within the priority of laser technology, making it the 4th out of 20 priorities (MOSTA, 2018; STRATA, 2019). International patents are not taken into account. However, stakeholders report that the culture of obtaining patents is actually rather low, given that most professionals working in this field see themselves as scientists rather than inventors.
- Both research and private sector entities are successful at exploiting the opportunities offered by direct EU funding. VU, FTMC and Lithuanian laser-related companies are more likely to participate in Horizon 2020 projects than entities active in other Lithuanian industry domains. These entities have also demonstrated potential in space applications via participation in the European Space Agency (ESA) PECS programme (Plan for European Cooperating States) or contribution to ESA activities.

However, despite such positive developments, certain challenges remain:

- Sector stakeholders consistently report a lack of synergies between measures throughout all technology readiness levels (TRL). While this issue seems to affect most Lithuanian industries, this is especially relevant for this particular sector. The existing gaps throughout technology development stages means that research results are applied to much smaller extent than they could be. For example, the measure for research projects mentioned above is not integrated with measures for business R&D. Synergies, such as prioritising applications that are based on previous successful research projects, could make commercialisation easier. This issue is especially relevant when it comes to prototyping or small series manufacturing. Research institutions consider these activities as insufficiently scientific, whereas businesses wish to avoid the risk of investing in a product that lacks technological readiness, hence measures are needed.
- Lack of interdisciplinary know-how (e.g. in medicine, engineering/robotics) limits the opportunities to produce higher value-added products. This is especially relevant given the fact that laser technology is only a means to an end – laser technologies may be used in a wide array of application domains. Lack of highly qualified engineers was said to be one of the key issues, why relevant know-how is not transferred to other domains.
- The sector's demand for a highly-educated workforce remains unsatisfied. Within the last decade, the number of professionals in this sector has doubled. Currently, there are over 1,000 employees in the private sector and over 200 at research institutions. However, it is expected that by 2030, an additional 3,000 employees will be needed as current businesses scale up and new companies emerge. In a recent survey (Lazerių sektoriaus galimybių studija, 2019) the lack of qualified workforce was reported as the most crucial issue for businesses. At the same time, the high demand of employees encourages students as well as advanced researchers to enter the labour market and occupy well-paid positions instead of further pursuing academic careers. This may lead to poorer quality of studies as well as lack of researchers at HEIs.

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Recent sector specific developments

Photonics and laser technologies were acknowledged in the Lithuanian Industry Digitisation Roadmap 2019-2030 as one of the key enabling technologies (KETs) fuelling the development of Industry 4.0. As such, the sector's impact on the economy is not only determined by its direct contribution to GDP but also by its capacity to transform industrial processes in various application areas.

In 2019, sector stakeholders agreed on an agenda for the future that involves three strategic directions, namely: increasing exports by integrating into international laser application value chains, increasing sales in the internal market of Lithuanian manufacturers, and attracting foreign investors (Lithuanian Laser Association, 2019). The following market segments are considered as having the most potential to accomplish this vision:

- **Medicine.** Lasers play an increasingly important part in medical equipment for diagnostics and treatment. Researchers both at VU and FTMC are using the laboratories of nanophotonics to conduct trials that have already demonstrated potential in biomedicine, while *Femtika,* a VU spinoff company, is working towards fabricating micro-robots for medical purposes.
- **High power lasers.** The most promising achievement of recent years is SYLOS1, a laser system that has been designed and manufactured by two of the sector's leading companies *Ekspla* and *Light Conversion* as part of the prestigious ELI (Extreme Light Infrastructure) project. Although SYLOS1 is located in Hungary, the system's prototype *Naglis* can be accessed by Lithuanian researchers and students at VU.
- **Industrial lasers.** Although sector companies are still mostly focused on manufacturing scientific lasers, they are starting to expand their production towards industrial lasers. In 2017, almost half of the sales were made in this segment. Lasers produced by *Ekspla* and other companies (especially those within the TOOLAS cluster) are used for high-speed cutting of thick materials and micromatching (modelling of small devices).
- **Sensors.** Lithuanian solutions within this area, including solutions that apply the LiDAR (Light Detection and Ranging) technology, are globally deployed in fields of security, diagnostics and robotics[33]. This segment of laser technology is expected to have huge implications in the future, especially for self-navigating vehicles and defence.

The stakeholders have agreed that it is essential to focus **on three key pillars to further strengthen the laser technology sector** in Lithuania (see **Error! Reference source not found.**).

[33] Internationally acclaimed innovations are created by *Lidaris, Integrated Optics* and *Brolis Semiconductors*.

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Table 4: Strategic areas and actions to be taken to accomplish the sector's vision

Knowledge	Creating synergies between different segments of laser technology, as well as active implementation of R&D projects in collaboration with research institutions or international partners.
Human Resources	Interdisciplinary higher education programmes; creation of high-value-added jobs; the attraction of specialists from abroad.
Infrastructure	Continued support for the maintenance of infrastructure as well as additional investments in prototype testing, small series manufacturing and end-user product development infrastructure.

Source: Based on Lithuanian Laser Association, 2019.

Furthermore, the industry is involved in the following initiatives:

- The newly established Laser LT Digital Innovation Hub (DIH) serves as a one-stop-shop for manufacturing SMEs that are willing to deploy laser and engineering technologies. The hub consults companies on questions such as what technological solution is the most suitable, which laser technology company or research institution is best to collaborate with, or what kind of public funding opportunities are available. Laser LT DIH is coordinated by Science and Technology Park of Institute of Physics (FIMTP), which works closely together with FTMC and LITEK.
- LITEK is leading a network platform LASER-GO that focuses on cooperation in Photonics for Health. The consortium, co-funded by the COSME programme, consists of six clusters from EU countries that aim to increase their exports overseas.

Identified bottlenecks and drivers

First of all, the transformation towards Industry 4.0 offers an opportunity to strengthen the demand for laser technologies within the home market, which could then be applied to various application domains. For example, the field of medical technologies is an area where this segment of the Lithuanian industry could excel by exploiting possible synergies with the life sciences industry. However, barriers to accessing this particular market are high, especially given certification costs and the timeframe of clinical trials. Furthermore, such applications are also capital-intensive, hence large investments are needed. In other instances, Lithuanian industry has little capacity to adopt laser technologies by integrating them into final products. Stakeholders suggest the following activities:

- Support the development of pilot photonic manufacturing facilities that could be used by innovative SMEs or young research teams. This would encourage relatively cost-effective and widespread means to deploy photonic technology in various fields of application, eventually leading to high volume production.
- Introduce inter-disciplinary study programmes, research groups or internship placements that would include a strong emphasis on developing high-level engineering skills. Currently, stakeholders report a lack of engineering skills in the sector. The engineering required in product development is often carried out by "self-taught" physicists, which limits the capacity for manufacturing end-user machines rather than their separate elements.

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Secondly, given the already relatively strong culture of collaboration and existing mutual trust, stakeholders believe that even closer integration would be beneficial. For example, a scheme to support both fundamental and applied research via joint business and government subsidies seems viable. In this case, business entities would contribute to setting the research agenda and also allocate a certain percentage of their budgets (or a fixed amount), while the government would provide a large share of support. Such endeavours would most likely be long-term and multi-annual, therefore guaranteeing stable support to research entities. On the other hand, simply ensuring better synergies between research grants and business R&D measures could pave the way for successful commercialisation. For example, prioritising project applications that are based on previously successful research projects, could make the development of highly sophisticated and mature technologies easer.

However, certain barriers to further science-business collaboration exist.

Limited or ineffective public policy

Most importantly, if the stakeholder ambitions to expand are to be realised, investments into end-user product development infrastructure are critical. Such investments would raise the sector's added value, because they would enable testing of technology manufactured for more widespread industrial rather than scientific uses. At the same time, public authorities could be more involved in promoting innovation and experimentation on large-scale solutions in such cases where they may act as first users (e.g. innovative lighting for the cities or cancer tissue diagnostics and treatment technologies for hospitals). Entering global markets in the field of industrial applications is extremely difficult, given the presence of well-established large players in this field, hence facilitated access to home markets would be advantageous.

Skills and competences

A major bottleneck for industry growth and development is the lack of a critical mass of researchers and research-oriented engineers at both major research institutions such as VU and FTMC, as well as other HEIs across Lithuania. Similarly to the case of ICT, due to significant differences in salaries between public and private sectors, talented and ambitious individuals opt for a career in private enterprises. This is causing an internal brain-drain phenomenon whereby local research institutions are deprived of talented young scientists.

2.5 Agro-innovation and Food technologies

A brief map of the sector

Although some alterations were made after the review of RIS3 in 2019, the principles of sustainability, safety and efficiency remain of key importance in this particular priority area. The sector's greatest potential is concentrated in the thematic area of sustainable agri-biological resources and safer food.

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Table 5: Changes in RIS3 structure regarding agro-innovation and food technologies

Before the review of S3		After the review of S3	
Priority area	Agro-innovation and Food technologies	Priority	Agro-innovation and Food technologies
Priorities	1. Sustainable agri-biological resources and safer food	Thematic areas	1. Sustainable agri-biological resources and safer food
	2. Functional food		2. Zero-waste processing of biological raw materials into valuable components
	3. Innovative development, improvement and processing of biological raw materials (biorefinery)		

Source: Author's elaboration based on the Research and Innovation Strategy for Smart Specialisation amendments made on 2019-07-24.

In 2018, this priority area contributed to 3.1% of Lithuania's GDP, which is equivalent to approx. €1.3bn. Between 2013 and 2018 the value added in the sector increased by 57.1%, which was larger than the average increase in the Lithuanian economy (17%), but still lowest amongst all other priority areas. The productivity growth is mainly driven by the food and beverage industry, while the agriculture sector's performance remains significantly below Lithuania's average[34]. There is a tendency of farm enlargement – in 2016, around 3.5% of farms used approx. 50% of the country's agricultural land (Eurostat, 2018). However, the efficiency of farms remains low, as it takes several times more land for Lithuanian farmers to produce the equivalent of what is achieved in other EU Member States (Lietuvos agrarinės ekonomikos institutas, 2016). The food and beverage industry produces a major share of the total value created by Lithuanian producers. It has the largest share of employees in the entire manufacturing sector that amounts to 41,900 people (3.1% of total employment). Roughly 1,000 companies operate in the industry (Enterprise Lithuania, 2017). According to sector stakeholders, the sector's performance mostly relies on large companies and lacks strong medium-size businesses with revenue worth €3-10m (EDP reports, 2019).

Kaunas is the central hub for developing food technologies as well as agricultural research. Nemunas Valley connects and integrates the open-access infrastructure offered by KTU, Lithuanian University of Health Sciences (LSMU), Vytautas Magnus University (VDU) Agricultural academy and state research institutions. VDU Agricultural academy has a newly established Knowledge and Technology Transfer Centre, which also includes a business incubator that currently hosts 8 small companies, but otherwise commercialisation capacities remain very limited[35]. Researchers at the Nemunas Valley collaborate closely with members of the National Food and Smart Food clusters (including small enterprises as well as renowned established companies such as the confectionary "*Rūta*" or the grain manufacturer "*Kauno grūdai*"). While these clusters focus on food manufacturing, the Smart IT cluster and its recently established AgriFood Lithuania DIH are focusing on digital transformations in agriculture and food safety technologies.

[34] In 2017, the labour productivity in the food and beverage sector was higher than Lithuania's average (15.6 EUR per hour) and equalled 18.3 EUR per hour, while in the agriculture sector the result was 6.8 EUR per hour (Statistics Lithuania, 2020).

[35] More information available at: https://ktpc.vdu.lt/apie-mus/inkubatorius/

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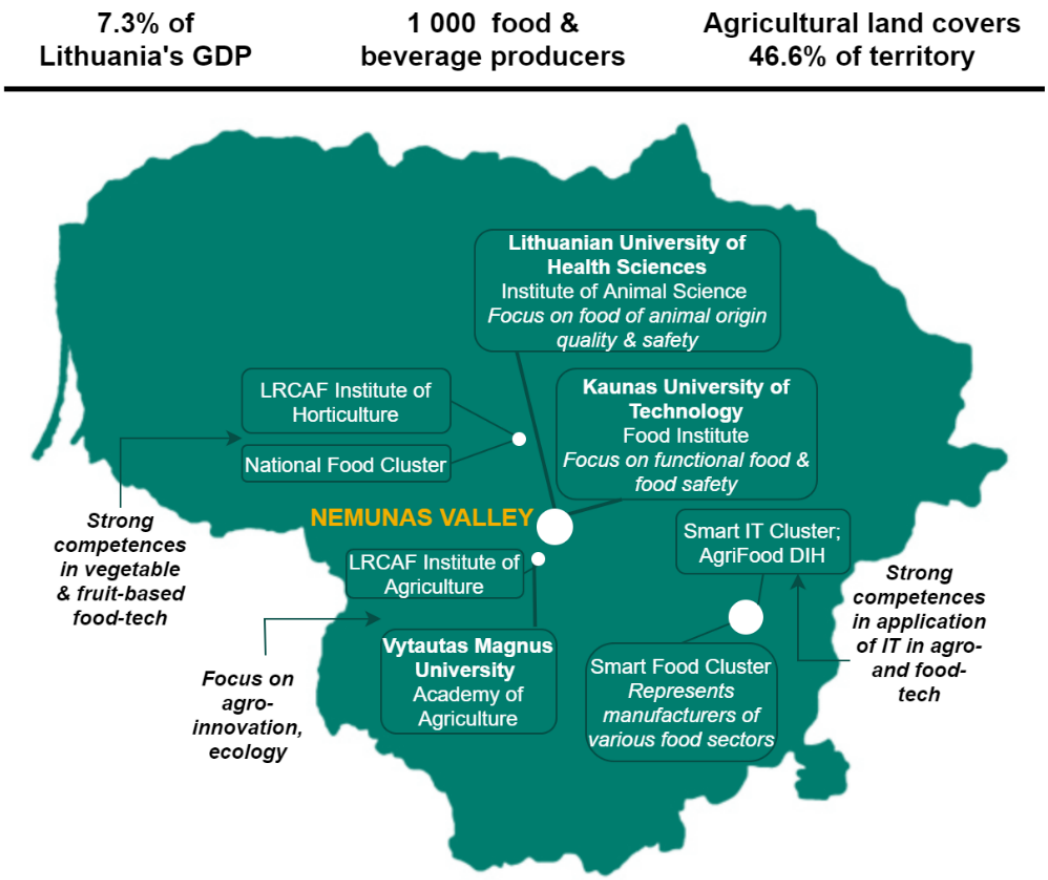
Figure 6: Agro-food sector – a map of relevant sector entities.



Sources: Statistics Lithuania (2017), Enterprise Lithuania (2017), National land fund (2018)

Business-science collaboration and reported challenges

Business-science collaboration in the sector has been mostly based on small-scale studies and routine checks, or continuous partnerships with large and well-known companies that only occasionally wish to commit to larger R&D activities. Generally, the culture of collaboration in the sector is rather low, and despite efforts, the scale of business-science cooperation remains limited. Similarly to other sectors, cooperation is mostly initiated through personal/professional contacts or through reaching out to researchers directly, rather than through designated agencies, with the initiative to cooperate mostly coming from the business side rather than from research institutions (MOSTA, 2017).

However, despite these trends, some positive developments have taken place over the past few years. New innovative companies oriented towards niche markets have begun to emerge, while researchers have been proactively assisting companies with R&D project applications, and, in case of success, conducting joint R&D activities. Research institutions at Nemunas Valley enjoy several established long-term partnerships with members of the National Food and Smart Food clusters, both of which use the services provided at open access centres. At the same time, R&D projects in the sector tend to be more often co-funded by ESIF measures than in all other sectors, indicating that enterprises are still mostly unwilling, or incapable, of conducting R&D their own activities (MOSTA, 2017).

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Agro-innovation and food technologies received a relatively small amount of public funding (total sum of €31.11m, 8.1% of all RIS3 funding) during the 2014-2020 programming period. This may be explained by the following factors:

- A large proportion of the applications for funding were declined. The total amount of requested funding was €67.49m, yet only €31.11m were granted (46% project success rate). Applications were mostly declined because their project activities could not be classified as R&D (Strata, 2019). This indicates that applicants might either lack understanding of R&D (e.g. stakeholders report that some enterprises wished to upgrade their equipment), or the current national definition is not suitable for designating R&D activities within this particular sector.
- The "Innovoucher" scheme was significantly more popular than the "Intellect. Joint business-science projects" measure. While stakeholders generally expressed positive feedback towards the latter measure and said it was relevant to sector entities, the popularity of the "Innovoucher" scheme confirms that the majority of collaborations remain small-scale.
- Companies were reluctant to apply for funding given the requirement for substantial financial commitment and the high risk associated with product development. The co-financing character of R&D measures, and especially the large "Intellect. Joint science-business projects" subsidies, requires companies to invest a significant amount of their own resources that domestic companies from this sector either lack or are not willing to invest.[36] Given that the sector is mostly dominated by large enterprises, for which financing conditions are least favourable, collaborations are rare. Furthermore, after completing the project, businesses must achieve goals related to increased turnover or exports, even though R&D activities carry high risks and both increasing turnover and exports might take a significant amount of time. Food manufacturers tend to stick with traditional products and avoid developing new products that might not sell if customers find their taste or other qualities unappealing.
- The set of R&D policy measures does not respond to business maturity. Measures such as "Innovoucher" or "Intellect. Joint business-science projects" are dedicated to purchasing research services or developing innovative products. However, this may result in 're-inventing the wheel' rather than adapting readily available solutions. The sector is still somewhat more focused on technological upgrading as means to boost productivity and competitiveness, and the need or the ability to develop innovations remains limited. Instead, stakeholders suggest improving cross-border cooperation with HEIs or companies that are willing to share their existing know-how, and improving the mechanisms for adapting technological advancements.

The following other challenges also hold back business-science collaboration:

- Researchers lack deep knowledge in specific areas relevant to local businesses. Companies that conduct R&D activities within the sector often do so within their own in-house facilities (e.g. such companies might include global enterprises like Roquette Amilina or Mondelez, as well as more local yet still large enterprises). They have developed deep expertise that local HEIs or research institutions find hard to surpass. Traditional businesses are often more interested in conducting

[36] The problem is especially relevant to large companies, for which the maximum funding rate under the measure "Intellect. Joint science-business projects" is 50% for research activities and 25% for development or R&D infrastructure. The rates are higher if the project is implemented with partners.

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small-scale studies and routine quality tests, rather than long-term R&D projects. In turn, researchers lack the opportunities to work on more sophisticated projects, and focus on such tasks instead. Given their additional teaching responsibilities, there is little time for exploring new methods, emerging trends, etc. However, research teams are stronger in areas where the industry is less advanced. Stakeholders emphasise that while less innovative businesses could benefit from PhD internship placements to boost their innovation capacity, the conditions for conducting R&D in such companies are poor and bring only limited benefits to the highly competent individual.

- Negative experiences result in lack of trust and growing scepticism towards cooperation. Stakeholders report that unresolved issues regarding intellectual property rights, expectations towards the end-result, low motivation to collaborate and the work culture have caused conflict between research and business entities in the past and, as a result, weakened mutual trust. Both businesses and research institutions point to the lack of transparency in project funding, which serves to reduce trust even further. To protect themselves from unwanted negative experiences, both business and research entities only collaborate with well-known partners and often do so via informal channels. This limits the circle of knowledge-sharing and dissemination, as well as replication, of positive experiences.

Recent sector-specific developments

Recent sector developments, just like business-science collaboration, are still relatively small-scale while larger, more focused and targeted, initiatives struggle to take off. The sector's stakeholders report the necessity to boost the current potential by shifting to international initiatives with a focus on increasing exports of high-value-added products.

The following sector-specific developments have taken place over the last few years:

- An ongoing initiative by *Create Lithuania* encourages agricultural cooperatives[37]. By pooling their resources, farmers may access funding more easily in order to upgrade their processes or buy innovative infrastructure. The project aims to spread information to farmers about the possibilities that joining an agricultural cooperative may provide.
- In 2019, the Ministry of Agriculture launched a *White Paper on Lithuanian Rural and Agricultural Development*[38] which presents the challenges, goals and actions that need to be addressed by 2030. The White Paper encourages farmers to adopt scientifically-proven innovative management as well as technological solutions to increase productivity and sustainability, create end-user products rather than export raw materials, and cooperate with other actors in the food value chain (such as food manufacturers).
- In February of 2020, the hackathon Hack4Climate took place in Vilnius, aiming to contribute to the shift to a green economy. At the event, which was partially financed by AgriFood Lithuania DIH, the participants were encouraged to develop ideas in three topic areas, including agriculture[39].
- The Lithuanian Agro Space DIH, a regional network bringing together Lithuanian research, business and government entities has been launched. The platform

[37] More information available at: http://kurklt.lt/projektai/zemes-ukio-kooperacijos-skatinimas/
[38] More information available at: http://www.lma.lt/uploads/Baltoji_knyga_2019_FINAL.pdf
[39] More information available at: https://ec.europa.eu/lithuania/events/hack4climate-hakatonas_lt

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aims to become a "go to" solution provider for development and transfer of digital technologies within the areas of space, agriculture, manufacturing and the services sectors[40].

Identified bottlenecks and drivers

Irrespective of perceived difficulties in business-science collaboration, sector stakeholders believe there are several unique aspects to this sector that could bring ample opportunity.

Despite a clear tendency towards Lithuanian farm enlargement, on a more global scale, these farms still remain relatively small. This brings flexibility and ease towards experimenting and introducing innovation. Stakeholders believe that Lithuania is ideally placed to become a sandbox for agro-innovation technologies in the entire region. For example, certain advancements, that have been applied in warmer climate areas, could be adapted to the more moderate Northern climates (e.g. Estonian, Latvian, Polish, Swedish), with the Lithuanian agro-innovation industry playing a key role. However, in this case stakeholders stress the need for measures that would enable companies to import and adapt already existing technologies from abroad rather than start from what is available at local research institutions. This type of measure would also be more in line with stakeholder needs in such instances when farmers simply wish to upgrade their technical capacity – according to stakeholder claims, farms would benefit from possibilities to undergo pilot testing of innovative solutions. The results would be monitored for a year or two, and only then they could choose to fully adopt the technology. In all these instances cross-border cooperation, and especially with neighbouring regional countries, such as Estonia, Latvia, Poland or Sweden remains very important, and stakeholders believe more engagement would be valuable.

Access to relevant data was said to be another major driver within the industry. Stakeholders report that Lithuanian institutions hold a large amount of data on farmlands, regular produce, weather forecasts etc., all of which may be used to predict the spread of disease, fertility rates, harvest size etc. This would also enable better food traceability in all stages of the food value-chain and therefore assess food safety as well as quality. However, access to such data is either limited or too costly, hence stakeholders suggest providing regular access to such data for sector stakeholders as it is done in other developed countries.

The following barriers are prevalent within the sector.

High capital-intensity and need for infrastructure

Food manufacturing is capital-intensive, therefore starting or running a company in the food sector is hardly possible without large initial investments into infrastructure.[41] At the same time, the infrastructure available at open access centres does not fully meet business needs. The infrastructure is reportedly unsuitable for in-depth analyses and companies frequently must look for opportunities abroad if they wish to conduct more advanced activities. At the same time, the demand for such infrastructure is rather low, and current facilities are not exploited at their full capacity.

[40] More information available at: http://www.vpva.lt/agrospacedih/

[41] For example, the Denmark-based company *Endobiotech* gained funding of 1.7 m EUR under the measure *SmartInvest LT+* and contributed the same amount from its internal resources in order to build an R&D facility in the outskirts of Kaunas.

Specifics of product development

Seasonal change is reported to be somewhat of a barrier to achieving R&D project results within the expected timeframe. Stakeholders report that timeframes for conducting long-term R&D activities could be more in line with industry needs.

The need to increase exports to new markets is strongly linked to geopolitical changes (i.e. sanctions towards Russia and Brexit) and Lithuania's demographic decline.

2.6 Drivers and barriers for business-science collaboration in STI

This section provides a summary of both cross-cutting and sector-specific bottlenecks and drivers. It has been validated at the workshop with key stakeholders from all four sectors.

Cross-cutting drivers for collaboration are summarised below:

- For companies, cooperation in the field of education is currently a strongest driver for cooperation, fulfilling *internal demand for skilled labour.* Access to additional resources, knowledge, and technologies is a somewhat secondary driver.
- Smart specialisation strategy and access to public funds is a strong external driver.
- *Interdisciplinary collaborations* are increasingly relevant for businesses (e.g. medical technologies and ICT, lasers and engineering, etc.).
- Possibility to address bigger, potentially more intellectually rewarding research questions, also as a way to produce more highly cited publications, is the strongest driver for researchers. Not meeting this condition becomes a barrier.
- Financial motivation due to an underfunded public R&D sector is another driver, however this often leads to individual, not institutional collaborations (see below).
- Both research and business entities often enjoy strong personal contacts that facilitate communication and increase the willingness to cooperate. However, this also has the opposite effect – these personal ties may stop entities from initiating professional activities for personal reasons. Those without personal ties are excluded altogether and find it difficult to initiate joint R&D activities.

The most relevant **systemic barriers** are:

- Limited absorptive capacities of the business sector and supply-demand mismatch (many other systemic challenges identified below also fall under this umbrella).
- Lack of a *critical mass of researchers and research-oriented engineers* in the public sector is the most critical bottleneck for cooperation or research commercialisation. This bottleneck is further exacerbated by a high teaching load, uncompetitive salaries compared to the private sector and internal brain-drain (so called „body-shopping", esp. in the case of ICT industry), and lack of incentives (career, funding criteria, low rates) at the individual level**.** Limited financial incentives push for individual contracts (instead of institutional projects).
- Inconsistent and unsustainable research funding at national level.
- Lack of university flexibility and responsiveness (too slow, too static, too complicated).

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- Poor communication between HEIs and business entities, *weak and underdeveloped tech-transfer capacities,* lack of entrepreneurial and innovation management capacities at the research organisations.
- Negative collaboration experiences in the past, leading to erosion of trust between HEIs and business entities, as well as a negative attitude towards each other.

In addition, there are serious bottlenecks to using the available collaboration programmes:

- *Lack of synergies* between all measures related to R&D (including different agencies, measures targeted at basic research / HEIs, etc).
- Burdensome administration of R&D measures. The "Joint business-science projects" (and follow-up scheme „Eksperimentas") were criticised for low attractiveness to research institutions. The design of the measure does not address the fact that HEIs are publicly funded and cannot co-fund R&D activities on the same terms as business entities. As a result, *business and research entities collaborate unofficially,* with businesses subcontracting researchers under this scheme.
- Transparency issues – there is still mistrust between different parties on who gets funding and on what basis. In the past, several applications were refused, but went on to win EU-level grants.

Table 6: Sector-specific drivers and bottlenecks

Sector	Drivers	Barriers
Life sciences	• Strong (mainly FDI-based) companies and excellent fundamental research. Informal personal contacts – many companies initially emerged as spin-offs from HEIs. • Another driving factor in the industry is inter-disciplinary R&D. There are significant overlaps with other priority areas, such as ICT applications, food safety or the photonics/engineering industry, which could offer interesting development opportunities.	High capital-intensity and need for infrastructure: • Highly capital-intensive – high entry barrier. • The need to update existing equipment, and exhausted incubation capacity. Specifics of product development • Long product development cycle. Regulatory barriers • Unresolved data access and regulation issues (e.g. GDPR). This is especially relevant domain in the areas of advanced technologies for public health and medical engineering. Limited or ineffective public policy • Insufficient incentives to introduce innovations into the national health system, such as digital health solutions, novel pharmaceutical or diagnostic tools, and apply advanced solutions in public healthcare facilities. Skills and competences • Despite high interdisciplinary R&D potential, engineering competences are lacking. Stronger engineer involvement in R&D activities – an important factor for further industry development. Culture of collaboration • "Patents vs papers". Potential tension in collaborations between academics' desire to (strategically) release data

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Sector	Drivers	Barriers
		and materials and companies' need for longer-term secrecy.
Engineering (focus on photonics and lasers)	• Close proximity and well-established ties result in effective collaboration, both formal and informal, and rests on solid mutual understanding. • Acknowledged in the Lithuanian Industry Digitisation Roadmap 2019-2030 as one of the key enabling technologies fuelling the development of Industry 4.0. The following market segments are considered as having the most potential to achieve this vision: Medicine, High power lasers, Industrial lasers, Sensors.	High capital-intensity and need for infrastructure • Barriers for new start-ups due to high capital intensity. Specifics of product development • The lack of scale prevents entry to new global markets. Self-sustained ecosystem but more efforts are needed to advance the use of laser technology in other domains. Limited or ineffective public policy • Lack of synergies between measures, (throughout all TRL levels), is especially relevant in this sector. • Public authorities could be more involved in promoting innovation and experimentation on large-scale solutions in such cases where they may act as first users (e.g. innovative lighting for the cities or cancer tissue diagnostics and treatment technologies for hospitals). High potential for precommercial procurement. Skills and competences • Lack of interdisciplinary know-how (e.g., in medicine, engineering, robotics) limits opportunities.
ICT	• Interest to collaborate primarily driven by enterprises seeking human resources. • Interdisciplinarity, as lack of sectoral know-how leads to collaborations. There are positive developments in adapting AI and IoT solutions to med-tech, language technology. The Lithuanian AI Strategy (2019) suggests that AI and IoT solutions should be targeted at five key sectors: manufacturing, agriculture, healthcare, transportation and energy. • The ongoing COVID-19 crisis seems to facilitate the need for interdisciplinary collaborations. • Government initiatives as another driver for collaboration, for example in these fields: digitalisation of governments services, building a regional fin-tech hub, (an ongoing precommercial procurement project contracted by the Lithuanian Bank), building a regional cyber security centre, etc.	Limited or ineffective public policy The sector's low capital-intensity and short product development cycle enables trial and error without risking large investments, but: • Reported lack of instruments at the earliest stage – before progressing to accelerator programmes or applying for seed stage investments. • Long timeframes between the calls. The ICT sector dynamics requires fast solutions to stay up-to-date. • Lack of incentives (incl. low rates compared to private sector) for young ICT researchers to engage in R&D. • Need for alternatives to precommercial procurement (too complex, not many companies can participate). Skills and competences • Diminishing R&D human resources. „Bodyshopping" – companies tend to hire researchers directly or employ them at the company on a part-time basis more so than in other sectors. The dropout rate in ICT-related programmes is among the highest in the country and the number of doctoral students is continuously decreasing. Culture of collaboration There is a lack of incentives for 'traditional' cooperation routes: • The concept of what constitutes R&D in the sector is not always clear.

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Sector	Drivers	Barriers
		• ICT is much less capital-intensive than other sectors, hence businesses are seldom interested in using the infrastructure provided by HEIs. • Different timelines / expectations regarding outputs.
Food	• Currently, collaboration is limited, and mostly based on: a. small-scale studies and routine checks (the "Innovoucher" scheme is significantly more popular than the "Intellect. Joint business-science projects" measure). b. Continuous partnerships with large companies that only occasionally commit to larger R&D activities. • Access to relevant data, such as data on farmlands, regular produce, weather forecasts etc., could be a driver for collaborations and innovative technologies to emerge.	High capital-intensity and need for infrastructure • Capital-intensive sector. Traditional companies are reluctant because of the large investments needed into production facilities. High need for pilot manufacturing support (Regio-invest type instrument). Specifics of product development • Seasonal change is sometimes a barrier to achieving R&D project results within the expected timeframe. Skills and competences • Difficulties to attract talent due to lower attractiveness of the (public R&D) sector. Culture of collaboration • Maturity of the sector's capacities is the most significant barrier for collaboration. The culture of collaboration in the sector is rather low.

To sum up, it is quite clear that each of the four sectors have very specific characteristics, regulatory framework, contextual factors, collaboration cultures & motives, potential for business-science collaboration. Therefore, sector-specific strategies and approaches to business-science collaboration could be justified although the set of available tools may be generic.

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3 Review of international experience from Ireland, Sweden and the Netherlands

To put the Lithuanian context in perspective and to identify the best practices and direction for the development of business-science cooperation and pre-commercial procurement in Lithuania, the Ministry of Economy and Innovation requested a review of three comparator countries.

The three countries – Ireland, Sweden, and the Netherlands – were chosen by the Ministry of Economy and Innovation as desirable comparators in relation to the purpose of this project. The three countries were chosen for slightly different reasons based on their past and present experience in the Research and Innovation field as well as practices and developments in the area of Public Procurement of Innovation and Pre-Commercial Procurement. The following points of interest were considered:

- Ireland – entrepreneurial development and developments in pre-commercial procurement;
- Sweden – a top innovator; strengths in life sciences, ICT and agricultural sectors; long-standing practice in pre-commercial procurement;
- The Netherlands – one of the leading countries in the food sector (amongst others); experience with Competence Centres.

The full compiled country profiles are included in Annex 1 (Ireland), Annex 2 (Netherlands) and Annex 3 (Sweden). They cover the overall economic and innovative performance of each country, the governance of the research and innovation policy and its implementation, support to business-science cooperation, developments in the PCP and PPI, and lessons learnt from these various activities which may be of interest to Lithuania. Where possible, a particular attention was given to the areas / thematic sectors for which a particular country was chosen as a comparator.

3.1 Economic and innovative performance

Lithuania is the smallest country compared to the three chosen comparator countries. With a population of 2.8 million it is just over half of Ireland (with 4.9 million), nearly three times smaller than Sweden (with 10.2 million) and almost six times smaller than the Netherlands (with 17.1 million) (see Table 7). The latter is the 6th most populous EU Member State and the 2nd most densely populated country. Lithuania is in 21st place by population and 23rd in density of population terms.

Table 7: Comparative economic performance

Economic indicators	Lithuania	Ireland	Netherlands	Sweden
Population (2019) (1)	2.8 million	4.9 million	17.3 million	10.2 million
Population density (2018) (1)	44.7	70.9	504.0	25.0
GDP growth (2018 to 2019) (1)	3.6% to 3.9%	8.2% to 5.5%	2.6% to 1.8%	2.2% to 1.2%
GDP per capita (2019) (1)	€13 880	€60 350	€42 020	€43 900
FDI net inflows (2)	2.4	53.5	27.7	3.0
Foreign-controlled enterprises – share of value added (%) (2)	11.5	33.8	13.5	13.5

(1) Eurostat (2019)
(2) European innovation Scoreboard 2019, country profiles

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There are **some structural differences between the four countries, which is important to keep in mind for the later discussions on the R&D investments, STI policies and business-science cooperation**. All three comparators have higher GDP per capita. However, the GDP growth rates in the three comparator countries have reduced (to a varying degree) between 2018 and 2019; whereas in Lithuania it has increased. In addition to the annual GDP growth, Lithuania scores highly in the turnover share of SMEs and enterprise births, all of which are well above the EU average. However, many economic indicators are well below the EU average, including the employment share in high and medium high-tech manufacturing, the employment share in knowledge intensive services, the turnover share of large enterprises, FDI net inflows, and top R&D spending enterprises per 10 million population.

The FDI question deserves a special attention as some of the comparator countries place a lot of emphasis on foreign-owned companies when designing various R&D support measures. This translates into the scale and nature of the R&D expenditure. In Ireland it is unevenly balanced between indigenous and foreign-owned businesses and the level of private co-funding of R&D expenditure is low by international standards. Although foreign owned companies accounted for only 19% of all relevant firms, they accounted for 64% of all innovation-related expenditure. In comparison in 2019 Lithuania had nearly 23 times lower FDI net inflows than Ireland and nearly 12 times lower than in the Netherlands. This indicator was somewhat similar to Sweden. However, it is worth noting that the structure of the Swedish economy although not that focused on the attraction of FDI benefits greatly from a number of large home-grown enterprises which are strong in R&D.

Such presence of strong R&D performers in Sweden reflects in a number of R&D related indictors (see Table 8). Sweden benefits from an innovation-friendly environment, highly skilled workers, attractive research systems and internationally competitive and innovative large companies. With R&D spending at 3.3% of GDP in 2018, it has the highest R&D spending in the EU; the highest business spending on R&D (2018: 2.35% of GDP) and the second highest public spending on R&D (2018: 0.96% of GDP) in the EU. This means that Sweden is one of the few countries that exceeds the goal of 3% set by the EU in its Europe 2020 strategy and its national ambition was to reach 4% by 2020. Such investments and performance result in the country having strong research and innovation performance in the EU and globally. Among the four countries Sweden leads in top R&D spending enterprise per 10 million population, followed by Ireland and the Netherlands. This indicator in Lithuania stood at zero in 2019. Overall, the expenditure on R&D was the lowest in Lithuania despite an increase between 2017 and 2018. It stood at 0.94 in Lithuania in 2018 compared to 1.15% in Ireland, 2.16% in the Netherlands, and 3.3% in Sweden. In 2018, of the four countries only Sweden was above the EU27 average of 2.19%. All countries are still below their national targets for R&D intensity, although Lithuania being much further behind its target.

More important than a % of GDP is to compare total R&D expenditure (GERD) in euros in order to better understand the volume of the investment going into the R&D. In 2018, Lithuania's GERD was €426m nearly nine times lower than in Ireland (€3.7bn), thirty-six time lower than in Sweden (€15.6bn) and thirty-nine times lower than in the Netherlands (€16.7bn). Similar weaker performance is also observed in relation to the absorption of funds from the EU Framework Programme for Research and Innovation. Of the four countries, the Netherlands has by far the best performance in terms of net EU contribution having so far secured 8.54% of the total Horizon2020 budget bringing €4bn and with 7% of the EU total in term of participating organisations. Together with Sweden they are among the top 10 performers in Horizon2020. Ireland's participation with €907m

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and 1.91% of the total allocations, although might look weak compared to the Netherlands and Sweden, is on course to meet the nationally set target of €1.25bn. Lithuania with €71m or 0.15% of total funding allocated is nearly 13 times lower in achieved numbers than Ireland.

Table 8: Comparative R&D funding performance

R&D indicators	Lithuania	Ireland	Netherlands	Sweden
R&D expenditure (GERD) (2018) (1)	€426 million	€3 716 million	€16 748 million	€15 631 million
Expenditure on R&D, % of GDP (2017 to 2018) (1)	0.88% to 0.94%	1.05% to 1.15%	1.99% to 2.16%	3.3% to 3.3%
Expenditure on R&D, % of GDP, national target	1.9%	2%	2.5%	4%
Top R&D spending enterprise per 10 million population (2)	0.0	55.0	29.0	81.8
Horizon 2020 – Budget share rank (our of EU27+UK) (3)	27th	13th	6th	8th
Horizon 2020 – Net EU contribution (3)	€70.87 million	€907.2 million	€4.06 billion	€1.8 billion
Horizon 2020 – Net EU contribution (% of EU total) (3)	0.15%	1.91%	8.54%	3.78%
Horizon 2020 – Applications (number & % of EU total) (3)	3,305 (0.47%)	13,845 (1.95%)	44,862 (6.33%)	23,670 (3.34%)
Horizon 2020 – Number of participating organisations (and % of EU total) (3)	473 (0.39%)	2,235 (1.87%)	8,411 (7.02%)	4,055 (3.38%)
Government procurement of advanced tech products (1 to 7 best) (2)	3.0	3.5	4.0	4.0

(1) Eurostat (2019)
(2) European innovation Scoreboard 2019, country profiles
(3) Horizon 2020 country profiles, https://ec.europa.eu/research/horizon2020/index.cfm?pg=country-profiles

Difference in performance between Lithuania and the three comparator countries is even more striking when it comes to innovation (Table 9) both globally and in the EU. In the **Global Innovation Index Lithuania ranks 38th compared to the 12th position for Ireland and the 4th and 2nd for the Netherlands and Sweden respectively**.

Lithuania's strength following the GII criteria lie in online creativity (score 43.5, rank 15) and especially mobile app creation (score 98, rank 4), ICTs & organisational model creation (score 68.4, rank 21), and ecological sustainability (score 53.7, rank 14). Its weaknesses are in almost all elements of knowledge absorption (score 28.6, rank 89), especially IP payments (score 0.2, rank 90), high-tech imports and ICT services imports; computer software spending as part of knowledge impact (score 0.1, rank 97); and state of cluster development (score 41.3, rank 90) as part of innovation linkages. Sweden's key strengths are intellectual property, innovation linkages (from patent families to joint ventures/strategies alliance deal to university/industry research collaboration), knowledge workers and knowledge creation (and especially covering firms offering formal training, GERD performed by business and knowledge-intensive employment), number of researchers, ICTs and either business or organisational models creations,

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and online creativity. The highlighted strengths are strengths relative to the other top 25-ranked GII economies to which research talent (as % in business enterprises), ICT services imports and exports, and ICT use are added. The Netherlands' key strengths are Institutions (sore 90.9, rank 8), followed by Business Sophistication (score 63.7, rank 6), while Knowledge & Technology Outputs and Infrastructure both score 61.8 and are ranked 3rd and 14th respectively. Ireland's key strengths are IP payments and FDI net outflows (and knowledge absorption in general) and ICT services exports, closely followed by computer software spending and high- & medium-high-tech manufactures. Exports are 122% of GDP; FDI inflow/outflow and IP payments are at a completely different level to any other EU-country with FDI outflow at 246% per GDP (EU average 60%).

In the specific university/industry research collaboration indicators Lithuania ranks 37th (with score 51.4) comparing with Ireland's rank 11 (score 69.9), Sweden's rank 9 (score 71.8), and the Netherlands' rank 4th (score 75.5).

Table 9: Comparative innovation performance

Innovation indicators	Lithuania	Ireland	Netherlands	Sweden
Global Innovation Index rankings - globally	38th	12th	4th	2nd
Global Innovation Index rankings – among EU27+UK	22nd	7th	2nd	1st
European Innovation Scoreboard, EIS (2019)	22nd (Moderate Innovator)	9th (Strong Innovator)	4th (Innovation Leader)	1st (Innovation Leader)
Digital Economy and Society Index (DESI) (2018 to 2019)	14th (both years)	8th to 7th	2nd to 3rd	1st to 2nd

(1) European Innovation Scoreboard 2019
(2) Global Innovation Index
(3) Digital Economy and Society Index 2019

In the European Innovation Scoreboard, Lithuania is currently ranked as Moderate Innovator (ranked 22nd) compared to Ireland's Strong Innovator position (ranked 7th) and the Netherland's and Sweden's position as Innovation Leaders (ranked 2nd and 1st respectively). Sweden's Summary Innovation Index in 2018 was 147.74 (slightly below 148.47 in 2017). Sweden performs especially well in the numbers of public-private co-publications (357.20), broadband penetration (355.56) and international scientific co-publications (342.80). For Ireland, although its Summary Innovation Index dropped slightly from 119.97 in 2017 to 117.63 in 2018, Ireland outperformed the EU average on most indicators. In addition, its performance has improved relative to that of the EU since 2011. The country performs well in terms of impact of innovation on employment, presence of innovators and quality of human resources.

When looking at strongest and weakest innovation dimensions and their specific indictors some minor similarities can be observed between Lithuania and the three comparators. However, there are stronger differences, which could potentially explain some of the difficult in business-science cooperation in Lithuania (Table 10).

Lithuania, similarly to the Netherlands and Sweden, demonstrates an innovation friendly environment but does not show attractive research systems (as the other three countries do). The latter could potentially explain why the country is not strong in international scientific co-publications or – more importantly for business-science cooperation – public-private co-publications. Unattractive research system in Lithuania might also

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explain the low number of PCT patent applications as well as public-private co-publications. On the other hand, Lithuania is stronger than the other three countries in innovative SMEs cooperating with others and broadband penetration. The former measures the flow of knowledge between public research institutions and firms, and between firms and other firms and includes those firms that had any co-operation agreements on innovation activities with other enterprises or institutions in the three years of the survey period. The latter captures the relative use of the e-potential by the share of enterprises that have access to fast broadband. As the Lithuanian economy is dominated by SMEs and the attitude towards entrepreneurship is relatively high, it is not surprising to see country's relative strength in these indicators.

Table 10: Strong and weak innovation dimensions in the four countries

	Lithuania	Ireland	Netherlands	Sweden
Strongest Innovation dimensions	**Innovation-friendly environment** Linkages	Employment impacts Innovators Human resources **Attractive research systems**	**Innovation-friendly environment** **Attractive research systems** Linkages	Human resources **Innovation-friendly environment** **Attractive research systems**
Strong performance	**Population with tertiary education** Non-R&D innovation expenditures Broadband penetration Innovative SMEs collaborating with others	**Population with tertiary education** Employment in knowledge-intensive activities **International scientific co-publications** Employment fast-growing enterprises	Foreign doctoral students **International scientific co-publications** **Public-private co-publications**	**Public-private co-publications** Lifelong learning **International scientific co-publications** PCT patent applications
Weakest innovation dimensions	**Attractive research systems** Employment impacts **Intellectual assets**	**Intellectual assets** Finance and support Linkages	Firm investments Sales impacts	Sales impacts
Low score indicators	Knowledge-intensive services exports **PCT patent applications** **Public-private co-publications**	R&D expenditure in the public sector Private co-funding of public R&D exp. Design applications	Non-R&D innovation expenditures **Sales of new-to-market and new to in product innovation** Medium to high-tech product sales	**Sales of new-to-market/firm innovations** Private co-funding of public R&D expenditure Medium and high-tech product exports

Source: European Innovation Scoreboard 2019

Finally, in the **Digital Economy and Society Index** (DESI) **Lithuania's position is in the middle of the EU27+UK with its current 14th rank** in 2019 (unchanged from the previous year). It ranks highest (8th) in the fields of Digital public services and Integration of digital technologies due to widespread availability and continuous progress in the

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uptake of e-government services, increase in e-commerce among businesses and cross-border selling. It has improved its score in the Human capital dimension and Use of internet services but still score below the EU average as regards the level of digital skills. **Ireland has improved its DESI over the years** rising from 52.8 (ranked 10th) in 2017 to 57.0 (ranked 8th) in 2018 to the current 7th rank with 61.4 score. It is No.1 in the EU in the Integration of digital technology dimension (especially because of the SMEs' excellence in using e-commerce). The country also records the highest growth in Digital public services with top ranking in open data and second place in services for business users. However, in terms of Connectivity and Human capital it ranks outside the top 10. **Sweden also continues to be one of the leaders in the digital economy**. Its DESI although fluctuating, stayed on the top of the EU ranking moving from 4th rank in 2017 to 1st in 2018 and the current 2nd (overtaken by Finland) in 2019. The country rank remained the same in Connectivity, Human Capital and the Integration of digital technology but decreased in the Use of internet services and Digital public services categories. Sweden has the second highest number of ICT specialists in the EU (6.6% of total employment, 2017 data as reported in DESI, 2019), but still lacks professionals with advanced digital skills. **The Netherlands position in the DESI rankings was 2nd in 2018 but 3rd in 2019.** Its overall score, however, has increased from 66.8 to 68.9, which was due to the improved performance in all of the DESI dimensions. The country maintained the same excellent performance in terms of connectivity; Dutch citizens are very active users of the Internet and have the right skills to do so. However its human capital ranking fell a bit reflecting an increased need for professionals with digital skills (beyond the core ICT industries) and the difficulty recognised by the current Dutch government and all stakeholders of adapting education policies to the complex challenges posed by the digital transformation of all sectors. Despite that the digitisation of Public Services in the Netherlands is among the most advanced in the EU while the country's challenge is to improve the take up of technology by business – although already above the EU average.

These various similarities and, more importantly, differences in various structural dimensions as well as research and innovation performance among Lithuania and the three comparators Ireland, the Netherlands, and Sweden are important to keep in mind when interpreting the approaches the three countries took towards the development and support to business-science cooperation.

3.2 Support to business-science cooperation

Sweden's approach and developments in supporting business-science cooperation

The **Swedish system overall and the governance and implementation of Research, Development and Innovation policy are decentralised**. Historically, national Swedish public administration has been characterised by relatively small government ministries (compared to their international counterparts) and larger governmental agencies with responsibilities for specific policy areas. An example of such an agency is Vinnova, Sweden's innovation agency (set up in 2000) which is driving the innovation agenda in the country. At national level, the research bill and energy research bill (both released every four years, most recently 2016), the national innovation strategy along with the strategy for regional development are key framework documents providing overall guidelines for Swedish innovation policy and regional development up to 2020. A Minister of Enterprise and Innovation was appointed for the first time **in 2015** and **a National Innovation Council with the Prime Minister as the chairman was created clearly indicating an "innovation drive" in politics**. The Council is an important reference body for all things concerning national strategies for innovation, including S3,

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and it has indicated three important areas to target in this work: digitalisation, life sciences and environment, and climate technology. In order to ensure that the conditions for entrepreneurship and innovation in Sweden are efficient and internationally competitive, the same year the government also initiated a review of the regulatory framework regarding innovation and entrepreneurship promotion efforts. The aim of the review was to identify barriers and propose measures for the improvement and development of the innovation and entrepreneurship climate in Sweden.

The period **2008-2016 in Sweden was characterised by a significant increase in the investment into R&D**, totalling SEK 9bn (c.€850m). Over the years there has been a long-lasting debate in Sweden about the alleged inefficiency in turning huge investments into R&D, into innovation and its related growth. Difficulties in attracting business R&D investments have been persistent despite public investments and a strong education system; and product-market regulation and business-science collaboration are below the EU average. To maintain a positive development trajectory, for several years the links between research and innovation have been acknowledged in the governmental research bill. The Swedish Government's Research and Innovation Bill **2013-2016 launched a more selective, quality-based funding approach, with a significantly increased government budget for R&D**. The Bill emphasised academic collaboration with the private sector and society, partly in contrast to its predecessor bills whose focus rested more on strategic specialisation and promoting excellence in research. As a response a series of supply-side support measures – mostly focused on **promoting cross-sectoral collaboration** – were launched but **without any specific measures targeting just business-science cooperation**. The main focus was to move from funding such basic research towards more collaborative models. "Strategic innovation areas" were introduced as a new instrument for meeting societal challenges. Through these efforts, the Government wanted to lay the foundations for new, long-term collaboration projects between universities and colleges, research institutes, business, public sector, civil society and other actors. Part financing from business and public sector was a prerequisite. The 2016 Research Bill has focused a lot on "collaboration". The new Swedish research bill, with priorities and focus for the next four years, is currently being prepared and will be presented in autumn 2020.

The Swedish Innovation Strategy 2014-2020 explicitly highlighted three needs for this strategy: to meet global societal challenges, to increase competitiveness and create more jobs, and to deliver public services with increased quality and efficiency. Development of this strategy involved all ministries within the Government Offices. To stimulate innovation even further, more emphasis is being put on SMEs (especially high-tech) and start-ups to reduce dependence on large multinationals (MNCs) as about 20 Swedish MNCs account for the majority of the investments into R&D from the private sector. This has been on the political agenda for at least two decades and remained unchanged through shifts of government. A 2014 reform launched a limited tax incentive scheme for small businesses hiring R&D staff. Development of SMEs and their potential is also a building block for regional development, which is also the focus in Sweden's use of smart specialisation (S3).

Among the approaches used in Sweden to support innovation the following are evident (in chronological order):

- **Strategic Innovation Agendas** (SIAs): The 2012 Research and Innovation Bill (mentioned earlier) gave Vinnova the task to design strategic, challenge-oriented innovation areas that had strong links with the Swedish research base and would lay the foundation for new, long-term and stronger collaborations among the research players, industry, the public sector and society. The Bill also

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emphasised that it was not up to the government to decide which areas are important and that bottom-up processes are important. This was a shift as conventional practice has been for government/Vinnova to design priority areas on a much more top-down basis. Different configurations of R&I actors generate SIAs in areas of their own choosing. Until 2016, there have been three waves of calls asking for SIAs to be formulated and submitted as part of the process of designating SIPs (see below).

- **Strategic Innovation Programmes** (SIPs): Since its setup, Vinnova, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) and the Swedish Energy Agency funded 17 SIPs in the earlier identified Strategic Innovation Agendas. Whereas the first wave of SIPs focused on areas of traditional strength and areas specifically highlighted in the 2012 Research Bill as deserving special treatment (i.e. the mining and steel sectors), the second and third waves of SIPs had a greater focus on some areas more obviously related to societal challenges, in line with the call for SIAs to focus on challenge-oriented areas.
- **Challenge-Driven Innovation** (CDI): During 2011–2017, projects meeting social challenges identified by Vinnova were funded. Since 2018, the global sustainability goals in Agenda 2030 have been a central starting point for CDI. The projects must meet societal challenges in a way that contributes to Sweden achieving one or more of the global sustainability goals.
- **Strategic Cooperation Programmes**: The government launched four collaboration programmes for the 2019-2022 mandate to further strengthen collaboration between business, academia and government. The Strategic Cooperation Programmes are based on the goal of gathering power to strengthen Sweden's global innovation and competitiveness and meet the major societal challenges. The themes of the four collaboration programmes for 2019-2022 include: Business digital transformation and business; Health and life sciences; Climate change; Competence supply and lifelong learning. It is expected that these horizontal themes and challenges will be reflected in the programmes currently run by Vinnova and other players in the Swedish RD&I system.
- **Vision-Driven Innovation (VDI) environments**: In 2019 Vinnova started establishing five vision-driven environments to meet important health challenges. The innovation environments are established in areas where Sweden has the greatest potential to make a difference: Zero vision for malnutrition in the elderly; An antibiotic smart Sweden; Zero vision cancer; Information-driven healthcare through AI application; and Sweden's leader in advanced therapies in 2030. All five have different approaches and a different constellation of partners. The basis of these initiatives is to have a goal which is clearly stated, which was achieved through a several-steps approach taking onboard the experience from SIPs and Challenge-Driven Innovation programmes where calls aimed at solving a challenge.

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Ireland's approach and developments in supporting business-science cooperation

In contrast to Sweden, **the Irish Research, Development and Innovation (RD&I) system is centralised** with RD&I policies and budgets being controlled and implementation by Departments and their statutory agencies. Science Foundation Ireland (as the statutory body responsible for funding oriented basic and applied research in the areas of Science, Technology, Engineering, and Mathematics), Enterprise Ireland (as the agency responsible for supporting Irish businesses) and IDA Ireland (focused exclusively on the promotion and development of high-quality foreign direct investment) work together on innovation related topics. In addition, Knowledge Transfer Ireland (KTI, hosted by Enterprise Ireland) is the central Technology Transfer Office which supports effective commercialisation and makes it simpler for business and investors to benefit from publicly-funded research.

The development of the RD&I system and policy in Ireland has been gradual starting with a **National Research Prioritisation Exercise** (RPE) in 2010. At that time 14 priority areas were chosen. In December 2015, **Innovation 2020** was published as **Ireland's cross-Government strategy for research and development, science and technology** building on the earlier Strategy for Science, Technology & Innovation 2015-2020. Different government departments and agencies are involved and being accountable for the delivery of the programme and there is a structured way of monitoring and tracking the delivery towards the aspirations. Two changes compared to the previous strategy were around a research prioritisation plan and a very clear regional dimension. **Business-science cooperation as a topic stands on its own.** The strategy also positioned 14 research priority areas within six broad industrial themes of ICT, health and medical, food, energy, manufacturing and materials as well as services and business processes. The mid-term review of Innovation 2020 in 2019 concluded that policy developments since 2015 confirmed the relevance of Innovation 2020 objectives, and that the rational for research prioritisation with 14 priority areas within six broad enterprise themes remains valid. The key changes involved the enhancement or broadening of those priority areas. For example, the ICT theme was expanded to reflect the growing importance of technologies such as robotics, Artificial Intelligence, Augmented Reality and Virtual Reality. The energy theme was broadened to both address climate change and sustainability and to maximise opportunities for companies. The innovation strategy is currently being updated for the next period.

In June 2018, **the Department of Business, Enterprise and Innovation published an investment overview which summarises the strategic investment priorities** with a foreseen capital funding of €3.16bn to 2022 and a planned total allocation of €9.4bn to 2027. A portion of this capital allocation will go to fund research and innovation. In the future funding of research and innovation DBEI highlighted a strengthening of the network of Research Centres and Technology Centres in the regions, developing a National Space Technologies Programme and a national High Performance Computing programme, funding memberships of International Research Organisations, establishing a Disruptive Technologies Innovation Fund, and supporting the development of Technology & Innovation Poles through which Institutes of Technology will partner with companies to develop strategic agendas for their regions supporting SME productivity and innovation, entrepreneurship and start-ups.

Cooperation between firms and public research centres in Ireland continues to face challenges. Indigenous companies show a lower rate of collaboration with academia compared to foreign MNCs. Enhancing collaboration between enterprise and academic research; improving the level and performance of R&D by indigenous enterprises;

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increasing R&D and embeddedness of multinationals in the research system are some of the key goals that are being addressed by various existing support activities and instruments.

Irish policy makers have attempted to address the challenges through various support measures that have some elements of support towards business-science cooperation. They take into account the type and size of companies and have everything from a small amount of funding through to larger programmes which follow research collaborations.

Among the approaches used in Ireland to support innovation the following are evident (in chronological order):

- **Innovation Vouchers**: What the Irish policy makers have realised over the years is that the way to increase the interest of indigenous Irish companies in research and innovation and, as a result, collaboration with the science base, is by increasing the engagement of these companies in R&D. Companies need to be actively interested and actively spending on R&D. Small scale grant-based schemes, such as innovation vouchers, are one way of keeping this interest and practice alive.
- **Knowledge Transfer Ireland (KTI):** Set up in 2013 KTI's role is to help businesses to establish connections with the Irish research base – universities, Institutes of Technology and other State-funded research organisations, collectively termed Research Performing Organisations (RPOs) – to progress innovation and commercialisation of research and IP available in the publicly-funded research system.
- **Innovation Partnerships:** Run by Enterprise Ireland the Programme encourages Ireland-based companies to work with Irish research institutes, resulting in companies accessing expertise and the research centre benefiting in terms of developing skill sets, intellectual property and publications.
- **Disruptive Technologies Innovation Fund** (DTIF): To complement existing initiatives and to support private investment in emerging and enabling technologies, in 2018 the government announced the launch of the DTIF which will invest €500m until 2027. Although at first glance it can come across as a measure to boost innovation, it does also aim to foster collaboration between business and the research base. The Fund supports projects involving SMEs and large firms (including in partnerships with public research bodies) around a "disruptive tech" agenda.
- **SFI Future Innovator Prize**: Although not set up to directly support business-science cooperation, the prize does contribute to this topic. It supports close collaboration between researchers and solution beneficiaries so that relevant, meaningful and important challenges can be identified and validated. With this in mind it is expected that the solutions are developed in collaboration with beneficiaries to maximise their societal impact potential.
- **SFI Strategic Partnerships Programme:** Specifically targeted at funding research opportunities that are not otherwise funded by other national programmes. The key objective is to develop partnerships of scale, hence the expectation is for the partners to bring significant co-funding. At the end of 2018 there were a cumulative 20 Strategic Partnerships with industry with a total industry contribution of over €25m.

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- **SFI Industry Fellowship Programme**: This programme supports post-doctoral researchers or academic members to spend time in industry or an industrial researcher to spend time in academia (for up to a year on a full-time basis or 2 years on a part-time basis). Its purpose is to enhance business-science collaborations through the funding of collaborative research projects and through knowledge exchange and training.
- **SFI Research Centres**: The goals of the 16 SFI Research Centres are to link scientists and engineers between academia and industry to address crucial research questions; to foster the development of new and existing Irish-based technology companies; to attract industry that could make an important contribution to Ireland; and to expand educational and career opportunities in science and engineering. They are set up in thematic areas. To date, the SFI Research Centres have seen an investment of €434m of public money and €235m industry commitment. Centres brought €196m of additional funding, 18 Spoke Awards, 182 licensing agreements, 27 spin-outs and 324 EI Commercialisation Awards.
- **Enterprise Ireland/IDA Ireland Technology Centres**: The history of the EI/IDA Technology Centres starts at the time of the Science, Technology & Innovation 2015-2020 strategy. A detailed consultation with industry took place in order to identify the topics which could be of collaborative interest to groups of companies. The current ten centres are embedded in existing universities but are industry-led in terms of research direction The Centres are also instrumental to the IDA's work. When the IDA tries to convince another wave of inward investment to come to Ireland, the Centres become part of the story and a proposition.

There is **the start of a shift towards mission-oriented or challenge-based funding in the Irish research and innovation policy**. Challenge-based funding was set up by SFI as a solution-focused approach to research funding designed to direct research activities towards critical societal problems. Currently it is organised under the SFI Future Innovator Prize programme. In 2019 calls were opened for the Artificial Intelligence for Societal Good challenge and Zero emissions challenge. The next call is scheduled for 2020 and the initial focus will be on challenges aligned with the Climate Action Plan.

Such a challenge-based approach is still new. The national system has not yet been fully involved and changed to adopt this approach. Current activities are on a small scale but as a starting point provide a good way to test if the approach is working. Nevertheless, the mid-term review of Innovation 2020, also calls, among areas to further enhance economic and/or social impact, to consider mission-oriented funding to address societal challenges, most notably associated with the pursuit of the UN Sustainable Goals, also with some alignment of this funding with EU Research programmes.

The Netherland's approach and developments in supporting business-science cooperation

The development of the Netherlands' approach to research and innovation policy also has its unique elements. The ambition of the country is to be among the top 5 most enterprising and competitive economies in the world. Government policy therefore focuses on stimulating innovation, reducing regulatory pressure and administrative burdens, increasing access to capital market financing, good public services for companies and fiscal support for entrepreneurs.

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Responsibility for science policy and innovation policy in the Netherlands rests with two ministries: the Ministry of Education, Culture and Science (OCW) is responsible for science policy, and the Ministry of Economic Affairs (EZ) is responsible for innovation policy. As a result, these policies are set out in two separate policy documents. In practice, however, these two policy areas are increasingly connected and overlapping. The main R&I policy implementation bodies are the Netherlands Organisation for Scientific Research (NWO), the Royal Netherlands Academy of Arts and Sciences (KNAW), and the Netherlands Enterprise Agency (RVO). Another very important player in the innovation landscape is TNO, the Netherlands Organisation for applied scientific research.

Regarding science policy, in November 2014 the present government published its policy document 'Science Strategy 2025: Choices for the Future' setting up three goals: world-class science in the Netherlands (goal 1); Dutch science more connected with society and industry and with maximum impact (goal 2); and Dutch science as a seedbed for talent in 2025 (goal 3). **Innovation policy**, which complements science policy, also has three goals: The Netherlands intends to be one of the top five knowledge economies in the world by 2020 (goal 1); by 2020 the Netherlands will spend 2.5% of its GDP on R&D (goal 2); and Public and private parties will contribute at least €800 million to the top consortia for knowledge and innovation (TKIs) by 2020, at least 40% of which will come from industry (goal 3).

The innovation element of the Ministry of Economic Affairs' enterprise policy consists of generic instruments for all innovative companies and specific instruments that focus on the top sectors. Most public instruments are focused on SMEs. This involves, among other things, **government funding for SMEs through the SME Top Sectors Innovation Support Scheme** (MIT) and the **Dutch Good Growth Fund for SME projects in emerging markets and developing countries**. A **tax incentive scheme for R&D** has existed since 1994. Under this scheme, the Dutch government compensates companies for a proportion of the wage costs and other costs and expenditure associated with R&D projects. It is intended for Dutch companies engaged in research or development projects, ranging from start-ups, the self-employed and SMEs to multinationals in every economic sector. Companies actually receive these tax benefits when they file their tax return with the tax and customs administration. In 2018 €1.163m was available for this scheme. The other major generic instruments designed to promote innovation take the form of resources that the Ministry of Economic Affairs uses to reduce the problems companies – particularly innovative SMEs at various stages of development – encounter on the capital market. In 2015 these instruments were merged to form the DVI (Dutch Venture Initiative), part of the Future Fund. If an initiative is successful, the company repays the holding or loan to the fund so that the money can be re-invested.

In 2011 the top sectors approach came into the play in the Dutch research and innovation system. Innovation programmes were replaced by an approach focused on nine 'top sectors' (occasionally also referred to in the literature as 'key sectors'). The aim was to tackle obstacles to growth in these sectors, encourage research and innovation through public-private partnership and realise economic impact. Funding to help valorise knowledge was taken partly from the budget of the 'Top Institutes (TO2)' (created prior to 2011) and the NWO. In the Coalition agreement of October 2017 it was agreed to focus the top sector policy more on the economic opportunities offered by three main public themes: energy transition/sustainability; agriculture/water/food; and quantum/hightech/nano/fotonics. While economic impact and remaining competitive are still important, this mission led 'pivot' towards themes more directly addresses

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societal challenges such as an ageing population and climate change and is designed to better reflect the long-term needs of the Netherlands. It makes the top sectors more 'cross-sector' and interdisciplinary and has created new value chains.

The top sector approach introduced a strong regime of significant subsidies to stimulate long term, strategic Public Private Partnerships (PPPs) based on a triple helix model and using a bottom up approach to create the associated programmes. This unique form of collaboration (golden triangle/triple helix) is designed to promote innovation, to attract talent and to ensure a solid position for the sectors in the international context. This approach has remained rather consistent for a number of years despite changes in the different ruling government coalitions. The programmes are often of significant financial size. For example, €5bn total at 50% subsidy is not unusual for the larger top sectors. They are also designed to last for a significant number of years e.g. 4 to 10 years. This requires long-term programming efforts and is seen to be at the heart of their success along with a clear focus on quality ranking as a criteria for awarding money rather than a 'first come first served' approach.

Initially the public-private partnerships (PPPs) targeted more large companies than SMEs. They are now more inclusive and a boarder range of private sector companies have been encouraged to join, having observed that those who engaged early have prospered from the partnership. Inclusion of SMEs has been driven partly by regional innovation strategy and associated EU funding. Regional programmes are now clearly aligned with Smart Specialisation Strategy but based on a PPP model.

It is worth noting that the Netherlands started from a position of little collaboration between academia and industry in 2010. The change in environment towards a much more active engagement is ascribed to long terms and patient investment in to PPPs (Top Sectors) where the programmes are measured in years rather than months. Subsidies and overall size of programmes are very significant, but it has been stated that subsidies for companies alone will not produce sustainable change. Changes in the academic environment and in particular interest in engaging has been linked to an increased awareness of the role that science can play in tacking societal challenges and the part that fundamental research has been shown to play in such programmes.

3.3 Pre-commercial procurement and procurement of innovation

Another topic in which the Lithuanian Ministry of Economy and Innovation were keen to learn from the three comparator countries was pre-commercial procurement or procurement of innovation. According to the EU-wide benchmarking of national innovation procurement policy frameworks of the four countries (Lithuania and the three comparators), the Netherlands has the highest rank (3rd), followed by Sweden (5th), and Ireland (19th). Lithuania (with its 14th rank) in this topic actually performs better than one of the comparator countries (see
Table **11**).

The Netherlands stand out with it structural capacity building and assistance measures, embedded within an action plan for innovation procurement. In Sweden among strengths a clear political commitment for innovation procurement, a presence of the national competence centre (i.e. Public Procurement Agency) and financial incentives for public procurers to engage in more innovation procurements are highlighted. And in Ireland the positive aspect is the topic's presence as a strategic tool in the national policy agenda. Among weaknesses, lack of or weak monitoring system or unclear timeline/resources are mentioned. Lithuania's innovation and public procurement policy framework recognises the strategic importance of innovation procurement which is solidified in a

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spending target. Lithuania has setup capacity building and assistance activities and some financial incentives for a first set of pilot PCP projects. However, potential synergies with other horizontal and vertical policies are underused, the country does not have any specific action plan or monitoring system for innovation procurement and currently all main actions are still limited in scale; and there is lack of IPR policy in public procurement that encourages innovation.

Table 11: Comparative performance in innovation procurement

	Lithuania	Ireland	Netherlands	Sweden
Ranking	14th (Moderate performer)	19th (Low performer)	3rd (Good performer)	5th (Good performer)
Total score	28.0%	19.6%	45.9%	41.5%
Strengths	Innovation procurement recognised as strategically important Set up capacity building and assistance activities / some financial incentives	Innovation procurement foreseen as a strategic tool	Structural capacity building Assistance measures Action plan	Clear political commitment National competence centre Assistance measures and financial incentives
Weaknesses	Underused potential synergies with other policies No specific action plan or monitoring system No IPR policy in public procurement	No structured capacity building measures No dedicated action plan No incentives	Unclear timeline/resources No endorsement Weak monitoring system	No action plan No centralised monitoring system No IPR policy in public procurement

Source: Benchmarking of national innovation procurement policy frameworks across Europe, 2018

Going into the development of the pre-commercial procurement and procurement of innovation more specifically, some elements within each comparator country are worth mentioning.

Sweden's journey in PPI and PCP

The development of innovation procurement has been a long journey in Sweden. Already back in 2011 Vinnova set up some guidance around innovation procurement. In 2012 together with the Swedish Research Agency it was assigned to work on innovation procurement in environmental technologies. Each agency received SEK15m (c. €1.5m) for three years. (This is the only time that special funding for innovation procurement projects has been allocated to Vinnova from the Government Offices.) The goal was to get some example projects – so-called "Strategic Projects" – that could inspire the public sector to apply innovation procurement in their work and create knowledge rather, than to be a broad resource for contracting authorities wishing to try innovation procurement. Among the financed projects are PCPs, PPIs and financial support for coordination activities, pre-studies and procurements in pre-procurement purchasing groups. Apart from Vinnova's funding, there are some buyer's networks, financed at the Energy Agency and the Swedish Environmental Protection Agency. Also, some larger contracting

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authorities such as the Swedish Transport Administration, Region Skåne, Stockholm County Council etc., have internal innovation budgets that are at times used for innovation procurement projects.

On a political level, in 2014 the Prime Minister appointed a Minister for Public Administration for whom the responsibility for public procurement became an important task. In 2015 this new minister created a new separate public agency for "procurement support". This was done in close collaboration with the Swedish National Innovation Council. The mission of the National Agency for Public Procurement (Upphandlingsmyndigheten) is to promote legal certainty, efficiency and social and environmental sustainability through procurement; to strengthen the strategic importance of public procurement; and to promote innovation in the public sector. The need for such a coordinated approach towards public procurement was due to several challenges in the system. Small contracting authorities led to a fragmented demand and lack of resources; and the public sector in many instances also lacked knowledge and resources when it comes to public procurement of innovation. Vinnova and the National Agency for Public Procurement started a cooperation: Vinnova works with financing innovation procurement and the Agency provides all the information and guidelines. From that time Vinnova's approach was to consider how to include innovation procurement projects in the agency's general calls. For example, challenge-driven innovation which is a broad programme and focused on addressing a societal problem could offer the applicants a degree of freedom on how to apply.

Also in 2015, the Procurement Agency received another governmental mission. It focused on starting an early dialogue with the suppliers, helping them to understand the market, what are the possibilities etc. As a result, in the beginning of 2016 the Agency launched a programme with the aim of developing public procurement with regard to innovation and dialogue with the market. It ran until 2019 and focused mostly on support for the phase before innovation procurement: identifying and analysing needs as well as early dialogue with the market. The Programme had three focus areas: methodological support to specific innovation procurement projects; collection and dissemination of knowledge in a form of guidelines and good examples; facilitation of networking and experience sharing among contracting authorities. Between 20-30 projects were funded.

In Sweden there is no specific spending target for innovation procurement. There is no structured system to measure innovation procurement expenditure and to evaluate the impacts of completed innovation procurements. This is partly due to the absence of a national procurement register. However, the projects already funded are used as examples to showcase the results, outcomes and impacts of individual innovation procurement initiatives.

Ireland's journey in PPI and PCP

In Ireland the Office of Government Procurement (OGP) was established in 2014. Prior to that the procurement system was highly decentralised where contracting authorities managed procurement operations on their own. The OGP and its sector partners have put in place framework agreements and contracts through which public sector bodies can buy goods and services. The OGP considers that the frameworks reduce the time and cost associated with procurement by offering facilities that have already been competitively and compliantly tendered.

In addition, to the OGP efforts to improve access for SMEs to public procurement markets, Enterprise Ireland manages a Small Business Innovation Research (SBIR)

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initiative, a pre-commercial public procurement (PCP). Its objective is to stimulate innovative solutions to specific public sector organisations which may benefit from these solutions at a later stage, when goods or services are not currently available or developed from the outcomes of research. SBIR Ireland enables public sector bodies to connect with innovative ideas and technology businesses, to provide innovative solutions for specific public sector challenges and needs. To date SBIR Ireland has launched two competitive calls to the public sector and 20 Challenges were approved for funding.

In 2018 a competence centre for innovation procurement – the Procurement Transformation Institute (PTI) – was established by two private entities, Arvo and iDDea. It is a not-for-profit institution, seeking to provide knowledge and procurement support for the public and private sector. It seeks to increase the awareness of innovation procurement across Ireland – among procurers, policy makers and innovative suppliers. It is driving the modernisation of public procurement in Ireland through competency development plans and peer-to-peer learning for procurers – and suppliers – on innovation procurement. As PTI is still in the early stages of development and does not have any official mandate from the OGP.

The Netherland's journey in PPI and PCP

Finally, **in the Netherlands each contracting authority is responsible for the management of its own public procurement procedure, regardless of its level of authority**. Coordination and policy-making are handled at the central level by the Ministry of Economic Affairs and its Public Procurement Expertise Centre, PIANOo. It was set up in 2005 to professionalise procurement and tendering in all government departments, with a view to improving efficiency and compliance with the rules. It started out as a knowledge network for government procurement officers and contracting authorities – able to source information for the network, and migrated to become a competency centre able to directly deliver knowledge to the network. As of 1 January 2017 PIANOo is part of the Netherlands Enterprise Agency (RVO.nl), which in its turn is part of the Ministry of Economic Affairs and Climate Policy.

PPI in the Netherlands dates back over a decade to the SBIR (Small Business Innovation Research). This was a procurement programme in which the Dutch Government used the power of procurement for finding innovative solutions to societal issues. SBIR challenged companies to put their entrepreneurship and innovative strength into action to develop solutions within a short time span and enabled the government to be a first client for new innovations. PIANOo continues to encourage PPI by publishing guiding principles and offering an 'Innovation tool chest'. This provides practical tools that can be used to conduct a targeted search for an innovative solution or to consciously provide scope for companies to deliver innovative solutions. Besides tools, the innovation tool chest offers sample procedures for a PPI process, and case studies showing how these tools are used in practice.

Understanding the market is also key to innovation procurement and regarded as another strategic goal. **To facilitate connections between innovative businesses and contracting authorities, Dutch authorities have created a number of tools, including an Innovation Market platform** to allow suppliers to promote their products to governments across the Netherlands and beyond.

Alignment between PPI policy and overall top sector policy has never been very strong although there was an attempt in the 1990s to better align public procurement and policy goals and professionalise the service, following significant fraud, detected in

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public procurement in the construction industry. Lack of wide-spread alignment is partly due to the fact that PPI works better for some sectors than others. For example, in the construction, safety and security sectors, where the main client is 'public sector', policy can lead procurement. In others, such a food, procurement of food is largely a private sector requirement, e.g. schools and hospital canteens are privately run. For the food sector, the exception is in 'Defence' where there is a need to feed many people from the public budget. The recent evaluation of top sectors noted that 'market formation based on innovative procurement policy is still a too limited part of the top sector approach: neither the Dutch Ministry of Economic Affairs nor the top sectors themselves vigorously pursue the government's role as launching customer and 'pioneer' in achieving innovation agendas. By taking ownership of a number of typical societal issues, the government could help create (market) conditions for testing and marketing innovations'.

4 A synthesis of lessons learnt

Although the practices supporting innovation (and business-science cooperation) in Sweden, Ireland and the Netherlands are somewhat different, they all build on a long-term traditions and practices in each country. The role that national culture and 'collective country DNA' plays in ensuing the success of business-science collaborations is thus essential. This aspect, including individual and collective consciousness and responsibility for tackling emerging challenges is something that may need to be carefully considered in Lithuania before any good practice or examples are incorporated from the three analysed comparator countries or other countries.

4.1 Design and implementation of research and innovation policies

Strategic approach

Countries that are recognised as innovation leaders are increasingly taking a long-term 'Mission' or 'Challenge' led approach to their business-science cooperation programmes. They develop and communicate a clear high-level vision for the role of science in innovation for a mix of economic benefit and societal challenges. This is particular true of the Netherlands where Missions negotiated between relevant Ministries are then articulated to implementing agencies and their stakeholders to develop priorities and programmes. Sweden has noted that Missions linked to global sustainability goals provide a solid ground for organisations from different sectors to cooperate with each other. On the surface it might appear that mission- or challenge-oriented approach puts away all the previous efforts in, for example, supporting business-science cooperation. Discussions with the stakeholders from the comparator countries highlighted that this is not the case. Introducing a mission or a vision into the research and innovation policies make separate stakeholder groups think less in competitive forms (e.g. in terms of which sector receives more support) or questions some of the support measures (e.g. if business-science cooperation can be encouraged just because there is a financial measure supporting it). On the opposite, mission- and challenge-oriented approach brings business and the research base together in solving a particular mission, often also involving non-governmental organisations and citizens groups.

Key factors for success are perceived to be patient investment that is not disrupted by political change, combined with constant review and flexibility. Support programmes for enterprises need to be dependable and have significant planning and implementation frameworks e.g. 5-10 years. This means seeking strong political consensus on approach so that they are not disrupted by changes in the political system and ruling governments.

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For example, the top sector innovation policy in the Netherlands has survived over a decade of changing coalition governments.

Excellent science is seen to be a prerequisite for long-term success in innovation. This requires investment in to basic/ fundamental research alongside applied research. Focusing on particular areas of science is important and translating this in to centres of excellence through recognised institutions with critical mass. Both Sweden and the Netherlands have taken this approach.

Design and implementation of measures

Strong measures require input at the design and review stages from all relevant stakeholders (not just companies). Sweden has noted that this is particularly true when focusing on societal challenges. Effective measures also have very strong built-in flexibility to enable change based on ongoing review; they are intended to be complimentary and they reflect the specific dynamics and market structure of different sectors. However, Ireland has noted that companies appreciate simplicity in the programmes and so changes need to be communicated clearly.

Sweden has deliberately sought ways to balance the design process between independent experts and implementing agencies.

The Netherlands, who has adopted a policy of matched research funding rather than direct grants for companies, takes an approach of always creating new programmes rather than simply subsiding existing initiatives. This is seen to stimulate change and renewal. However, matched research funding can exclude start-ups who do not have cash reserves to fund their own part of the collaborative research programmes.

Good promotion and communication of measures is critical to ensure that enterprises can distinguish one support programme from another.

Wider issues such as IP ownership and exploitation rights need to have been anticipated before a programme is launched and support put in place to facilitate dealing with these issues e.g. good simple template agreements and support to select and adopt them by participants.

Participants in the large programmes like the Swedish SIPs benefit from being able to use supplementary instruments alongside the main ones.

Selection of projects, monitoring and evaluation

Good practice is seen to have evolved in selection of projects in the last 5-10 years. Most countries do now favour competitive, time limited, but regular calls over rolling ones. The Netherland has focused strongly on quality as selection criteria while Sweden uses independent experts to select projects for funding. This has led to some tensions between the implementing agencies and the experts over ownership of the overall process.

All programmes need clear performance indicators that should be reviewed very regularly at all levels. For example, Enterprise Ireland, insists on starting each Advisory Board meeting of their Technology Centres with the discussion of indicators. However, it is important to ensure that simple input and output indicators reflect a well-designed programme and do not define the programme or act to reduce the impact.

There is an increasing move away from project exit indicators and towards programme impact. Mission-led programmes of a significant duration, such as those in the Netherlands, link milestone and target indicators to national, EU and global targets. This can be challenging and requires sophisticated monitoring and evaluation in terms of

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translating technological advancement in to progress towards a long-term target, e.g. reduction in emissions or animal welfare.

Triple-helix considerations

All three parties from the triple helix need to perceived clear benefit from their interactions in order to get full value from the Triple Helix measures. In particular, policy makers should see their involvement as a way to inform and refine policy rather than primarily as a way to distribute funds.

Many companies have internal R&D activity. The sooner the research possibilities and experience at the involved company is determined and acknowledged the better the cooperation with the academic partners will turn out to be. This is particularly true in countries like the Netherlands where they have large and R&D rich companies who only seek new international partnerships if they complement these existing collaborations, or excel in a certain field.

Permanent transfer an academic partner to a private sector partner, as seen in the Republic of Ireland Industrial Fellowship programme (2014), does not have to be seen as a drawback of the measures. A strong researcher joining a company can have significant benefit for R&D&I in the company and ultimately the national economy. Ensuring that individuals employed in private companies can contribute to higher education and that a strong pipeline of young researchers is being developed, help mitigate for such transfers.

External factors

Foreign Direct Investment (FDI) combined with the presence of multi-national companies (MNC) and local start-ups activity can play a strong role in improving Open Innovation mechanisms in a country. The Republic of Ireland has seen significant activity from start-ups that were launched by experienced management who chose to leave MNCs. A supporting start-up environment, in terms of availability of finance and national IPR framework conditions is normally needed to capitalise on such developments.

International business-science cooperation

Larger companies abroad often have their own links and existing collaborations with academic partners in their own country as well as with researchers at high level universities worldwide. New partnerships should therefore complement these existing collaborations, or excel in a certain field.

Trust is the foundation stone for continued collaboration that yields its full potential. Trust can be built through smaller actions e.g. Innovation voucher activity, that is then extended in to more open ended or more fundamental research collaboration.

Critical mass needs to be built and this can take a long time. It is advisable to start local, go national, and then become international. It may be helpful to consider permanent movement of experts from S to B and ensure that if this happens they can continue to contribute regardless of their employer.

Other influencing factors

The **state of development of the National Innovation System** (NIS) is an important factor in designing programmes. For a country with a well-developed and mature NIS, (e.g. the Netherlands), it is possible to have programmes of both a significant size and duration and with a strong international aspect. For countries at an earlier stage of NIS

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development (e.g. Ireland, it is important to build critical mass and smaller programmes may be more appropriate.

Culture and tradition are seen to play a strong role in S2B activity. Identifying positive aspects in the 'DNA of the country' can provide starting points for rapid and resilient development. Cultural change, even at the S2B level typically takes several 'generations' of researchers. Education from a very young age can help with wider cultural shifts with regard to how science is perceived and innovation sought and embraced. An increased awareness of the societal challenges that the world is facing can be used to accelerate change in both the science and business communities.

4.2 Sector Specific issues

The structure and operation of different sectors varies widely and this needs to be taken in to consideration at the design stage of a measure. In particular, a functional and supporting innovation ecosystem may take much longer to develop for some sectors than others. Building on traditional interactions can be beneficial e.g. the extensions services in Agriculture and Food seen in countries like the Netherlands. It is also beneficial to have recognised specialised institute/ universities who excel in related areas of science such as the Wageningen University & Research (WUR) NL.

The timeline to translate a new idea in to a marketable product/ service can take very different times in different sectors. Agricultural innovation in particular can take a decade to come to market. This also effects the time for which results need to remain unpublished which can have an effect on the S2B relationships. The time-scale for confidentiality should be explored early on in collaborations to ensure that both parties feel that it is not going to become a contentious issue.

Everything that helps a company to understand how a certain innovation behaves in the materials or setups that they use themselves is more useful than the same results in an unrelated species, material or environment etc. For this reason, where possible, it is helpful for research groups to use the 'starting materials' that will be deployed by an enterprise. This is a particular issue for Agri-food, but the principal extends in to other sectors.

4.3 Key lessons learnt Public Procurement of Innovation

Overall approaches

As demonstrated by the Netherlands, deliberate professionalisation of Public Procurement in general is helpful. A useful evolutionary PPI route is to initially establish a PPI network and consciously migrate this to a Competency Center. The Centre offers valuable opportunities for peer learning by exposing a Centre to wider good practice and for knowledge generation. However, it requires a perspective beyond a short project horizon. This approach can be combined with a wider outreach programme of development and dissemination of tool-kits and case studies to encourage take up of PPI practices more widely.

However, as Sweden has noted, there is no one way approaching innovation procurement. Most important is to understand what an organisation and a national agenda are trying to achieve and, in this situation, what is the best way forward? If there is a challenge to solve or a mission to address, organisations need to make strategic choices to decide what type of projects best address the mission.

When an organisation is involved in providing support and guidance to an applicant in the preparations stage of a PPI project they can become quite involved with the project.

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This can cause problems if the same organisation then funds the project. Splitting the provision of information/guidance from a funding function can be beneficial as has been demonstrated by Vinnova in Sweden.

Specific considerations for PPI

A solid preparatory phase, including market analysis and a dialogue, is essential. Needs must be properly identified (by users and end-users), prioritised and developed. It is also important to have a sufficiently deep knowledge of the technology presently available to be sure that a solution to be developed within the project period. A market analysis is also important in order to gain an understanding of the potential suppliers, if only one supplier should deliver alone or if a combination of two suppliers with different competencies need to work together to find a solution. Therefore, a contracting authority needs some basic innovation management skills and strategic thinking in place. Any methods or tools that can help with this are important, such as needs processes (design thinking approaches are usually useful), or a supplier dialogue workshop methodology.

On the buyer's side (i.e. public sector) it is also important to have a mixed group of competences. For example, procurement skills should be available from the beginning of a project, as should people from operations, and from the development functions. Support and involvement from upper management is vital and perhaps even from politicians if the contracting authority is, for example, a municipality or a county council.

Prior to implementation, the organisation should analyse and secure structures, processes and guidelines that support innovation procurement. This is especially important in innovation procurement of digital solutions, where many organisations have IT security regulations that hinder access to sensitive data

There must be a proactive interest in the organisation to take the lead in new, innovative solutions to business-related problems and that there are people in the organisation that are able to develop and run this type of project. The project needs to be well-anchored in its own organisation.

Ownership and exploitation

The organisations who obtain a new product with PPI financing support will own the product developed after the end of the public procurement project. They will be free to commercialise, develop and sell it. It is important to communicate this to potential suppliers so that all the benefits of innovation procurement are better understood and realised in the future. In that sense innovation procurement projects are more interesting than standard R&D projects. Everything which has not been resolved before the start of the project will emerge in an innovation procurement project.

Particular challenges for implementation

The implementation stages of a PPI project can be really quite difficult as processes may need to be changed, there may be an emerging need to obtain more buy-in and discussions may arise about business models, who is applying and why. This is different from a "normal" R&D project where a prototype might be created that looks nice, but it may be difficult to assess if it is actually going to be used and how.

Monitoring and evaluation

Quantitative KPIs to measure PPI are challenging. Qualitative KPIs may be easier to apply but overall, PPI is hard to measure because of the very different definitions and interpretations of innovation.

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5 Conclusions

From the contextual analysis of Lithuania it is quite clear that each of the four sectors have very specific characteristics, regulatory framework, contextual factors, collaboration cultures and motives, as well as their own potential for business-science collaboration. Therefore, sector-specific strategies and approaches to business-science collaboration are justified although the set of available tools may be generic. The comparator countries analysed – Ireland, the Netherlands, and Sweden – have some sectoral focus within some of their existing support measures. However, as presented in chapter 4, over the years they have taken a more strategic and long-term vision of experimenting with a vision-, mission- or challenge-driven approaches to research and innovation policy, bringing not only science and businesses together but also inviting other players in the system to join the activities.

Examples of the support measures marked in **green** show targeted support instruments, such as Ireland's innovation vouchers, SFI Industry Fellowships, Future Innovator Prize or Disruptive Technologies Innovation Fund, where some of these are being implemented around pre-defined missions or visions. The one marked in **red** presents a new approach in Sweden where a vision-driven approach, focused on specific sector but encouraging cross-sectoral solutions, was introduced in 2019. These are so called Vision-Driven Innovation (VDI) environments which at the moment are being tested in the healthcare and life sciences field. Examples marked in **blue** present conversion of sectoral research programmes into the wider strategic programmes around adopted missions and/or challenges. The Strategic Innovation Programmes (SIPs) in Sweden are an example which experience shaped the later Strategic Cooperation Programmes and the Challenge-Driven Innovation (CDI). The Dutch Top Sector policy since 2019 has also been focused around missions but is more importantly an interesting example of sector-specific PPP solutions combining both 'bottom up' and 'to-down' approaches (marked in **brown** in the table).

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Table 12 presents a summary of key developments aimed to support (in one way or another) business-science cooperation in Ireland, the Netherlands and Sweden. There are some similarities in terms of the progression of the research and innovation policy from a more research domains or industrial sectors approach towards policies driven more by overarching societal (whether national or global) challenges and missions. There are also some differences as to how the countries are approaching this. These are marked by different colours in the table.

Examples of the support measures marked in **green** show targeted support instruments, such as Ireland's innovation vouchers, SFI Industry Fellowships, Future Innovator Prize or Disruptive Technologies Innovation Fund, where some of these are being implemented around pre-defined missions or visions. The one marked in **red** presents a new approach in Sweden where a vision-driven approach, focused on specific sector but encouraging cross-sectoral solutions, was introduced in 2019. These are so called Vision-Driven Innovation (VDI) environments which at the moment are being tested in the healthcare and life sciences field. Examples marked in **blue** present conversion of sectoral research programmes into the wider strategic programmes around adopted missions and/or challenges. The Strategic Innovation Programmes (SIPs) in Sweden are an example which experience shaped the later Strategic Cooperation Programmes and the Challenge-Driven Innovation (CDI). The Dutch Top Sector policy since 2019 has also been focused around missions but is more importantly an interesting example of sector-specific PPP solutions combining both 'bottom up' and 'to-down' approaches (marked in **brown** in the table).

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Table 12: Development of support to business-science cooperation in Ireland, the Netherlands and Sweden

	Ireland	The Netherlands	Sweden
Guiding policy developments	2010: National Prioritisation Exercise 2013: Knowledge Transfer Ireland set up to progress innovation and commercialisation of research and IP 2015: Innovation 2020 strategy for R&D, science and technology – business-science cooperation is a topic on its own Over the years various support measures that have some elements of support towards business-science cooperation	2014: Science Strategy 2025 Innovation policy with specific instruments focused on Top Sectors Generic instruments for all innovation companies + specific instruments focusing on the Top Sectors 2019: Mission-driven Top Sector and Innovation Policy: eight ministries and nine Top Sectors agreed on 25 missions to tackle social challenges tackle social challenges of Energy transition and sustainability; Agriculture, water, food; Health and healthcare; and Security	Research and Innovation Bill 2013-2016: move from strategic specialisation and excellence in research to more collaboration with private sector and society) → support-side measures promotion cross-sectoral collaboration (but no specific just business-science cooperation measures) The 2016-2020 Research Bill – focus on "collaboration" **Swedish Innovation Strategy 2014-2020: global societal challenge, competitiveness, job creation**
Key support measures and initiatives	**Innovation vouchers**: to engage companies in R&D **Innovation Partnerships**: encourage companies to work with the research base **SFI Strategic Partnerships Programme**: research-industry partnerships to develop in scale **SFI Industry Fellowship Programme**: to enhance business-science collaboration	2011: **The Top Sectors replacing innovation programmes** → to encourage, increase and realise economic growth through public-private partnerships Stimulation towards strategic Public Private Partnerships (PPPs) based on a triple helix model Subsidies and overall size are very significant	From 2012: **Strategic Innovation Agendas**: challenge-oriented innovation areas with bottom-up processes Introduced to meet societal challenges = foundation for long-term collaboration projects between science, businesses and society
		2013: **Top Sector Innovation Support Scheme** encouraging SMEs participating in top-sector valorisation initiatives	From 2012: **Strategic Innovation Programmes** (SIPs) moving from traditional areas/ sectors to societal challenges **Challenge-Driven Innovation** (CDI): since 2018 global sustainability goals as a starting point
	The start of a shift towards mission-oriented or challenge-based funding **SFI Future Innovator Prize**: solutions to be developed in collaborations to maximise societal impact 2018-2027: **Disruptive Technologies Innovation Fund** (DTIF): boosting innovation through fostering business-science cooperation	2019: **Top Sector to set up Knowledge and Innovation Agendas** based on the 25 missions adopted by the government Pre-condition for funding set up: collaboration between knowledge institutions and businesses	2019-2022: **Strategic Cooperation Programmes** to further strengthen business-academia-government cooperation; with horizontal themes and challenges

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Focus on sectors / themes	**SFI Research Centres**: set up in all six Irish Research Priority Areas of ICT; health and wellbeing; food; energy, climate action and sustainability; manufacturing and materials; services and business processes linking scientists and engineers in thematic areas within Research Centres **EI/IDA Technology Centres**: focused on topics of collaborative interest to groups of companies Set up in 3 out 6 Irish Research Priority Areas: ICT; food; manufacturing and materials; services and business processes	Top Sectors in agri & food; chemicals; creative industries; energy; high tech systems and materials; life sciences & health; logistics; horticulture and propagation materials; water; cross-cutting (e.g. biobased economy)	In healthcare/life sciences field: 2019: **Vision-Driven Innovation** (VDI) environments to meet health challenges

A review in the table above presents four clear types of support measures where a mission-, vision- or a challenge-based approach is applied. These approaches were discussed with the Lithuanian stakeholders from the four thematic areas, i.e. engineering (especially lasers), food, life sciences and ICT, during the co-creation workshops and how these (if at all) can be of use in the Lithuanian context, during the online co-creation workshops which took place in October 2020:

1. **Targeted instruments**: An example from the Enterprise Ireland which introduced the Disruptive Technologies Innovation Fund not only to look for disruptive innovation solutions for the benefits of the Irish economy but also to bring a challenge-based approach to funding of projects.
2. **Vision-driven approach focused on specific sectors but encouraging cross-sectoral solutions**: Vinnova's approach for vision-driven innovation environments in Sweden is to use part of the funding to develop solutions to meet important health challenges by establishing five vision-driven innovation environments in the areas where Sweden has the greatest potential to make a difference.
3. **Conversion of sectoral research programmes into the wider Strategic Innovation Programmes (SIPs)**: SIPs in Sweden evolved from sectoral research programmes intending to promote competitiveness in sectoral areas to programmes which create preconditions for sustainable solutions to global societal challenges.
4. **Sector-specific PPP solutions combining both 'bottom-up' and 'top-down' approaches**: The Top Sector approach in the Netherlands emerged from the desire to use regular financing to encourage public-private partnership, to reduce fragmentation in innovation policy, to increase the involvement of various ministries (rather than just the Ministry of Economic Affairs), and to create a shared vision within the triple helix.

Key background information about these examples is presented further in the text. More detailed descriptions of the comparator countries are available in the annexes.

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Figure 7: Example – Disruptive Technologies Innovation Fund, Ireland

Key objective: To boost innovation and to foster collaboration between business and a research base

Managing organisation: Enterprise Ireland

Who can apply: An application can be led by SMEs, research organisation or a multinational company.

Key elements:

- Projects need to be "disruptive" and benefit the Irish economy
- Ideas at TRL3-7
- Should include minimum 3 partners, incl. at least one SME
- Must fit with the national research priorities for 2018-2023

Level of funding:

- Large project of €5-10m (min €1.5m), incl. match-funding from industry
- Research performing organisations can receive up to 50% funding
- Match-funding from industry

KPIs / monitoring:

- Disruptiveness of technology
- Economic and market impact (in 3-5 years)

Some examples of funded projects:

- Combining Tissue Responsive Probes, AI and Machine Learning to Transform Medical Care
- Enhanced Biocompatibility of Additively Manufactured Biomedical Implants for Improved Clinical Outcomes
- Internet of Things to create secure, remote patient monitoring
- New laser technology to disrupt optical telecoms
- Optimised commercial-scale cultivation of protein-rich biomass from Palmaria palmata

Figure 8: Example – Vision-Driven Innovation environments in health area, Sweden

Key objective: To meet important health challenges

The environments are established in areas where Sweden has the greatest potential to make a difference:

- Zero vision for malnutrition in the elderly (coordinated by Skåne's Food Academy)
- An antibiotic smart Sweden (coordinated by Public Health Authority)
- Zero vision cancer (coordinated Sweden's municipalities an country councils)
- Information-driven healthcare through AI application (coordinated by Lindholmen Science Park)
- Sweden's leader in advanced therapies in 2030 (coordinated by RISE Research Institutes of Sweden)

All five have different approaches and a different group of partners.

Key parts of the process when choosing the vision:

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- Vinnova (Sweden's Innovation Agency) started with a very broad dialogue with various action with 50-80 organisations (incl. companies, government agencies, civil society, patient organisations) participating.
- Several discussions over 1.5 years
- Open call was published after the discussions for which 90-100 applications were submitted. 15 were selected in the first round.
- At the end 5 were selected to build their "environments"

Level of funding:

- SEK 125m (c.€12.5m) over five years, of which SEK 50m (c.€5m) has now been decided for the first two years.

Figure 9: Example – Strategic Innovation Programmes, Sweden

Key objective: Strategic Innovation Programmes aim not only to create economic growth and jobs in Sweden and to create collaborations between academia and industry, but also to contribute to the solution of societal challenges, and for the stakeholders (industry, academia and public organisations) in each strategic innovation programme to develop a shared vision and to work on common objectives

Key parts of the process when choosing the vision:

- Vinnova provided seed funding (where necessary) to the community to work together to formulate Strategic Innovation Agenda (SIA) through consultations with a large number of stakeholders.
- Once SIAs were formulated, the communities were invited to submit proposals for SIPs.
- Proposals were evaluated by the agencies involved in the process (e.g. Vinnova, Formas, Energy Agency)
- Each SIP is managed by an external project coordinator and is overseen by a board of directors. Programme governance is dominate by industry.
- All the SIPs involve a broad range of actors, including universities, research institutes, large companies, SMEs, and public authorities

Operations of SIPs:

- Run as public-private partnerships which organised call for project proposals (1-2 per year)
- Projects funded by the SIPs vary a lot
- The project portfolio contains much that is of interest to academics and industry alike, including examples of work in "breakthrough" technology areas, the production of demonstrators as outputs and plans to include product vendors.

Conditions of funding:

- Initially available for 3 years with a possibility of renewal for a max 9 further years
- Funds available to the research organisation were matched by the funds from industrial participants (including SMEs, larger Swedish-owned companies, foreign-owned companies and companies owned by municipal/county councils).
- The bulk of funding has to be provided by the industrial partners.
- A review every three years planned into the process.

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Figure 10: Example – Top sector in Food and Agri field, the Netherlands

Key objective: To address the lack of collaboration between universities and businesses replacing ad hoc collaborations over a single project with strategic discussions between a university's Executive Board and the management of a company. Both sides should be looking for a long-term relationship and a mutually agreed roadmap.

Key success elements:

- Cooperation between industry, science and government
- Cross-fertilisation between the top sectors, i.e. the Food&Agri top sector can work with the Energy Top Sector. Cross linkages are important in addressing gran societal issues.

Top sector applies a strong 'bottom-up' approach to developing themes and programmes:

- Small Teams (5-6 people) from business, research, government and branch organisations get together to discuss and suggest priorities for the following call
- There are around 14 such programme teams for Agricultural / Horticultural top sectors.
- Alongside the small teams are broader 'sounding boards' (SB) who come together to discuss the emerging proposals. These typically comprise around 15 people, including NGOs, and offer input, but do not make decisions on the final programmes.
- When suggestions for priorities have been refined though the sounding board the head of each Agri-Food team then passes the suggestions to the Councils – one for Agriculture and one for Horticulture.
- The relevant Minister then takes decision on the funding, advised by the associated council.

Application and selection procedures:

- Implemented through the Public Private Cooperation Project – PPS.
- A two-stage application process
- The call usually takes place at the beginning of April when the 'priorities' are published. This call provides space for companies to come up with proposals, together with research organisations, that are in line with the ambitions in the innovation agenda.
- Companies and PROs jointly prepare and submit their idea as a 2-4 page concept note. For example, when the call closes on the 15th May, applicants receive feedback from evaluations in June. If a concept fits to the call then it is invited to make a full proposal by the 1st of September.

Decisions on funding:

- The assessment of project proposals is carried out by independent review committees.
- A decision is taken by the 2nd of November as to which projects will be 'subsidised' by the government.
- Company matched funding can be in-kind or in cash. The Public sector component can come through the Agri-Food Top Sector who has access to research capacity at Wageningen University & Research, made available by the Ministry of Economic Affairs (a total of 27 million for PPPs). On the basis of private expenditures at research organisations, a PPP allowance is also available, approx. €9m per year.

Application and deployment of PPP allowance:

- The TKI applies for an RVO PPP allowance every year.
- The amount requested is based on private investment in research at recognised public research institutions. The basis for the PPP grant is that for every private euro spent in cash to a research organisation, a TKI can apply on average for 30 cents cash of public funding. This money must be invested again in R&D.
- On projects with a low TRL (1-3) TKI Agri&Food works together with the Dutch Science Foundation and different models apply with co-funding from 10-30-50%. The annual subsidy is in the region of €6m.

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- A much more substantial part of the programme is for research in the mid TRL's (4-6) where TKI Agri&Food makes PPP's with the applied research centre Wageningen. Here the co-financing has to be 50% of which at least 50% in cash. The public part here can amount to €32m per year. A notable second R&D partner in this TRL range is the TNO which works through two main PPP programmes: Demand-Driven Programmes or the Knowledge Transfer Programme designed specifically for SMEs.
- In the high TRL (7-9) TK Agri&Food works together with the different regions with the full spectrum of EU programmes (EFRO Interreg etc), as well as special one MIT (SME In top sectors), where Agri & Food has some €10-12m per year on small studies and full R&D projects, organised by the four (NESW) coupled provinces together. In addition, some regions have extra instruments, that they usually align around the top sector agenda.
- A new project proposal may be submitted for this reservation. As much as possible, this should be done through the annual call for PPP projects and the associated conditions.

Monitoring and evaluation

- Until recently the top sector policy followed a quite traditional M&S KPI system, e.g. one reflecting input and output indicators linked to the EIS.
- This is changing following the introduction in 2019 of a more missions driven approach. It is not more driven by content.
- The new policy sets 'goals' for 2030. These are linked, for example, to effects in society, e.g. 50% less food wastage; the elimination of phosphates in the environment from nutrients. It is much more challenging to make these goals fully 'SMART' but they are as concrete as possible. The new monitoring system is driven by these goals but it is currently under construction.
- Alongside setting up the goals there is a strong assessment as to if other aspects of policy will need to change to enable the goals to be reached or a practice to be transferred and adopted e.g. the subsidy regime, regulatory system etc.
- This approach recognises that success from a mission-based approach will be very dependent on parts of the system and the policy framework and instruments may need adjusting quite broadly. This approach commenced in 2020 and requires policy makers to look forward as far as 2030.

The review of the international experience in Sweden, Ireland and The Netherlands and, based on the experience of the international experts team involved in the current project, indicates a gradual shift towards a long-term 'mission' or 'challenge' led approach to STI policy formation and implementation. This also includes business-science cooperation. Such a shift is also prevalent on the European level, with the inclusion of missions in the new Research and Development Framework 2021-2027 Horizon Europe.

Missions are typically large-scale initiatives aimed at solving major societal challenges translated into concrete objectives and targets within a defined timeframe. Mixing the bottom-up and top-down processes, mixing policy measures, ensuring cross-disciplinary and cross-sectoral approached, cross-ministerial participation and involvement of a wider society are common elements in defining the missions towards the delivery on common goals. According to Mariana Mazzucato,[42] who advised the European Commission on the introduction of missions into Horizon Europe, "missions provide a solution, an opportunity, and an approach to address the numerous challenges that people face in their daily lives".

[42] Mazzucato, M. (2018) Mission Oriented Research and Innovation in the EU: a problem solving approach to fuel innovation-led growth, European Commission

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This is not the first time missions have been brought to the attention of the Lithuanian stakeholders. Over the years a number of recommendations from the groups of international experts have been put forward to the Lithuanian stakeholders on how to improve the STI governance and management in order to streamline the process and generate the best impact for the country. Suggestions for a shift towards mission-oriented STI policy formation have already been mentioned in a recent TAIEX report[43] (2019). Experts called for a need to deal with "the inefficiencies of the national innovation system, enhance the system-wide governance of policy actions and increase an increase multilateral collaboration within the system", and in particular mentioned that existing processes with top-down policies imbedded in law impede such multilateral collaboration. The law(s) mandates ministries, which in their turn mandate their agencies to implement various programmes. Such a vertical approach takes away opportunities for a wide range of STI system players to work together in defining their (or wider) needs and setting strategic goals and directions to address those. Among policy implications for Lithuania, experts called for (a) cross-ministerial (MoEI and MoESS) co-funding of STI programmes; (b) a mix of top-down national visions / strategies and bottom-up involvement from companies and society as a way to incentivise business-science collaboration; and (c) an inclusion of non-technological aspects of innovation in STI programmes, thus also incentivising business-science collaboration. Artificially pushing agendas on to the stakeholders – be these researchers or private sector players – will not necessarily be effective in stimulating business-science cooperation. Opportunities for a more bottom-up approach need to be supported. The topic of missions in the STI policy is also central to the currently ongoing OECD review of the Lithuanian R&I policy.[44]

Application of missions to the Lithuanian STI policy has a potential to help address not only business-science cooperation but also other identified gaps in the STI implementation in the country. "An R&D&I map of Lithuania"45 prepared as part of the Lithuania's preparation of the 2021-2027 EU Structural Funds programming describes the challenges in the implementation of the RDI activities and lessons learnt and summarises the remaining gaps that need to be overcome in order to address an identified challenge. Table 13 presents how an application of mission-based approach to STI policy formation can help fill the remaining gaps.

Table 13: Mission-driven approach complementing 'An R&D map of Lithuania'

Challenge (as identified in the 'R&D map')	Identified gaps	How mission-based approach can help address the challenge and fill the gap
RDI capacities and advanced technologies of the business sector		
Low ratio of business	To increase the interoperability of measures, to coordinate and enlarge measures, to	Suggestion to design mission-oriented NSTPs directly addresses this gap. By their definition mission-oriented programmes can combine several

[43] European Commission, SRSS (2019), "TAIEX SRSP series to support the Lithuanian Science, Technology and Innovation (STI) policy: specific view on governance, evaluation and collaboration issues - Final Report with policy recommendations".

[44] https://strata.gov.lt/en/news/29-news/770-oecd-will-analyse-and-help-to-improve-lithuania-s-innovation-system

[45] Ministry of Economy and Innovation and Ministry of Education, Science and Sport (2020) Investing in R&D and the development of an innovative and smart economy: a "map" of achievements, lessons learnt and the remaining development needs, https://esinvesticijos.lt/uploads/main/documents/files/Post%202020/Programos%20rengimas/MTEP%20žemėlapio%20santrauka_EN%20(final).pdf

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investments in RDI to GDP	implement complex STI programs	measures, have larger and more longer term budget
Low level of business cooperation with research institutions	Systemic changes are needed in research and higher education institutions, including the creation of incentives for researchers to work with business representatives, facilitation of conditions for researchers to provide experimental development and business consulting services, especially for young researchers.	Mission-oriented NSTPs do not directly focus on creating specific incentives for the research and higher education institutions or individual researchers. However, putting a mission (or a challenge) as a key objective to contribute to should spark the curiosity of researchers.
Low level of business cooperation with research institutions	Only a few SMEs are able to implement large RDI projects with research and higher education institutions	Mission-oriented NSTPs are not designed to directly address business-science cooperation or focus on SMEs in particular. However, the design of the programmes provides opportunities for different types of collaborations and beneficiaries to get involved. As such, indirectly, some of the projects implemented under the mission-oriented NSTPs will support business-science cooperation and engage SMEs of different sizes.
Low level of business cooperation with research institutions	Cooperation between business and science has been encumbered by vague interconnection between the measures implemented by the Ministry of Economy and Innovation (EIMIN) and the Ministry of Education, Science and Sport	
Insufficiently innovative public sector organizations	To implement targeted RDI programmes by expanding the necessary research carried out by the Research Council of Lithuania, allocating more funding to them and allowing not only research and higher education institutions, but also businesses to participate in them	Mission-oriented NSTPs are designed to involve as diverse stakeholder groups as possible moving away from too narrow focus either on just research and higher education institutions or private sector companies.
Under "Creating high-level knowledge"		
To create conditions for creating high-level knowledge	To avoid fragmentation, i.e. separate calls for specific activities, funding small-scale, short-term projects	Mission-oriented NSTPs move away from small-scale and short-term projects towards bigger and longer-term endeavours

Source: Compiled by authors based on Ministry of Economy and Innovation and Ministry of Education, Science and Sport (2020) Investing in R&D and the development of an innovative and smart economy: a "map" of achievements, lessons learnt and the remaining development needs, https://esinvesticijos.lt/uploads/main/documents/files/Post%202020/Programos%20rengimas/MTEP%20žemėlapio%20santrauka_EN%20(final).pdf

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6 Recommendations

6.1 Summary of the recommendations

As elaborated in the earlier chapter, the study shows that there is a general shift in the international STI policies towards mission-driven approach. Lithuania needs to incorporate these developments nationally if its wishes to design modern and effective science, technology and innovation policies and through that support various activities in the ecosystem, including business-science collaboration. In light of the above, the study team has elaborate different scenarios for Lithuania to do this and suggested several recommendations as presented in Table 14.

A question of how to support pre-commercial and innovation public procurement, as well as innovation development in public sector was a small part in the current study and thematically did not have a strong link with the main topic of the study, i.e. business-science cooperation. As such, the recommendations provided here build on a brief review of the understanding and uptake of the pre-commercial procurement in the four sectors of the Lithuanian economy and good practice collected from Sweden, Ireland and the Netherlands.

Table 14: Recommendations for Lithuania

Recommendations	Descriptions of recommendations
Recommendation 1: Apply mission-orientation to the National Science and Technology Programmes	Apply a mission-oriented approach to the formation of the Science, Technology and Innovation Policy in Lithuania and in relation to the specific support measures or programmes, as the National Science & Technology Programmes. It does not mean that all support measures need to be changed but it can be used well in combination with other support measures.
Recommendation 2: Apply mission-orientation to the sectoral context	Apply one or several of five scenarios for mission-oriented STI policy into the sectoral context in Lithuania.
Recommendation 3: Define missions through a combined top-down and bottom-up approach	Use a combination of a top-down approach (i.e. ministries of Economy and Innovation, Education, Science and Sport, various thematic ministries, the Research Council, MITA as the innovation agency deciding on the missions) and a bottom-up approach (i.e. companies, research and education institutions, clusters, user groups, association, science and technology parks suggesting possible missions and/or challenges) in defining the missions.
Recommendation 4: Link missions with Smart Specialisation strategy	Clearly link missions with the smart specialisation strategy and priorities.
Recommendation 5: Expand a list of beneficiaries in the NSTPs and other programmes and support measures	Create new NSTPs and other programmes and support measures around missions take a boarder approach to involving actors from the STI ecosystem when defining the list of eligible beneficiaries of funded programmes.

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Recommendation 6: Encourage cross-sectoral and cross-disciplinary consortia	Introduce incentives to encourage the involvement of cross-sectoral, cross-actor, and cross-disciplinary teams.
Recommendation 7: Make monitoring and evaluation an integral part during design and implementation of the programmes	Set a well-structured monitoring and evaluation process already as part of the initial NSTPs design process. Strategic reviews linked to additional round of funding should be performed periodically to provide a basis for a go-no go decision by the programme management.
Recommendation 8: Reduce fragmentation and lack of strategic orientation on the national level	Different sectoral ministries to combine their funds towards co-funding the NSTPs; integrate different RDI activities and ensure a stage-based implementation approach; develop a common language and strategy incentivising ministries and agencies to cooperate in implementing a mission-based approach to STI policy.
Recommendation 9: Continue the support for PCP and PPI	Continue to develop the practice of pre-commercial procurement and innovative public procurement as stipulated by the Law on Technology and Innovation.
Recommendation 10: Develop PCP/PPI capacities within the public sector	Develop capacities of the public sector buyers in applying innovative solutions to solving identified problems. Capacity-building support instrument should cover an establishment of a network of 'innovative public procurers', facilitation of a joint problem-setting, targeted practice-oriented training and methodological support,
Recommendation 11: Introduce a buyer-supplier dialogue	For a PCP/PPI process to work, there should be a clear interest and incentives for the public sector to get involved in this process. It is recommended that MITA start working with the public sector organisations in helping them in identifying the needs within their institutions.
Recommendation 12: Increase an uptake through positive examples	Focus on collecting and bringing to light successfully completed PCP/PPI projects as a way to stimulate interest in PCP/PPI both from the buyer and supplier side.

6.2 Recommendation 1: Apply mission-orientation to the National Science and Technology Programmes

It is recommended to apply a mission-oriented approach to the formation of the Science, Technology and Innovation Policy in Lithuania and in relation to the specific support measures or programmes, as the National Science & Technology Programmes. It does not mean that all support measures need to be changed but it can be used well in combination with other support measures.

Based on the performed analysis, five scenarios for the introduction of the mission orientation into the Lithuanian STI policy have been identified. The scenarios are not necessarily mutually exclusive and can be combined. Therefore, all five scenarios are presented as part of the recommendations.

The key elements of the scenarios are presented in Table 15 and more details are presented further in the chapter.

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Table 15: Scenarios for the introduction of a mission-driven approach to the Lithuanian Science, Technology and Innovation Policy

	Scenario 1: 'Traditional' Science and Technology Programme with missions	Scenario 2: Strategic umbrella NSTPs based on the current set of instruments	Scenario 3: A new strategic umbrella NSTP	Scenario 4: Bringing existing instruments closer to missions	Scenario 5: Challenge-based Innovation Fund
Links to S3	Yes	Yes	Yes	Yes	Not necessarily
Links to other support measures	No	Yes (pooling resources)	Not necessarily	No	
Programme vs. project size	EUR 5-10m / EUR 0.2-0.5m	EUR 50m / EUR 0.5-3m	EUR 0.5m-1m p.a. released in stages (intensity reduced over years) Project / activity size decided by the consortium	As currently set for various support instruments	EUR 100m / up to EUR 5m (min EUR 1.5m)
Governance	Simple	Multi-layer, with long-term STI agendas		Simple	
Duration of programme vs projects	7-10 years / 1-2 years	7-10 years / 1-2-5 years (possibility to get funding for continuation)	5-10 years (possibility to get funding for continuation)		1-3 years (for projects)
Beneficiaries (in projects)	Min 3 partners (min 1 private sector partner)	Min 3 partners (with conditions related to specific instruments)	1 or more - core team; no size requirement for whole consortium; broad range, incl. government, users, NGOs	As currently set for various support instruments	Min 3 partners (min 1 from private sector)
Implementing institution	Research Council of Lithuania	Innovation agency (MITA)			Innovation agency (MITA)

Scenario 1: 'Traditional' Science and Technology Programme with missions

Focus on missions:	Yes
Links to smart specialisation:	Yes
Links to other support measures:	No
Programme vs project size:	EUR 5-10m / EUR 0.2-0.5m
Governance:	Simple
Duration of programme vs projects:	7-10 years / 1-2 years
Beneficiaries (in projects):	At least 3 partners (at least 1 private sector partner)
Lead beneficiary:	Research organisation or a private company
Funding institutions:	Ministry of Education, Science and Sport (MoESS) Ministry of Economy and Innovation (MoEI) thematic ministries (i.e. health, energy,
Implementing institution:	Research Council of Lithuania (RCL)

'Traditional' Science and Technology Programme could build on the existing approach taken in the current National Research Programmes (NRP). Eleven NRPs have been funded since 2010 with three still running:

- The Sustainability of Agro-, Forest and Water Ecosystems (2015-2021) NRP has the goal to obtain new scientific knowledge about the consequences of the use of ecosystems' resources and to propose measures to avoid threats coming out from such consequences;
- The Healthy Ageing (2015-2021) NRP focuses on developing new methods for the evaluation and prevention of disease risk factors; for the early detection and

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forecasting of diseases with the use of biotechnologies, nanotechnologies and ICT; and for the treatment of health conditions affecting life duration and reducing social exclusion of the elderly;

- The NRP "Modernity in Lithuania" (2017-2022) was set up to study the processes of modernity and modernisation of the society and their social, political, economic and cultural outcomes. This NRP is linked to the Lithuania's Progress Strategy "Lithuania 2030" which calls its citizens "to build a modern State open to the world and preserving its national identity".

The NRPs are primarily science-focused with the goal to gather new scientific knowledge through a national scale research but do also fund projects leading to the creation of TRL5-6 products. The underlying logic is that this new knowledge will be helpful in resolving a problem of strategic importance for Lithuania and the society. As such the NRPs are set around specific themes and 'problems of strategic importance to the state' but these do not directly comply with the idea of 'missions' or 'challenges'. To turn NRPs into mission-based NSTPs 'missions' or 'challenges' when transforming the current NRPs into the NSTPs need to be introduced.

Benefits:

- This scenario does not require a total re-design: a new programme could be built on the existing "purposeful research" (in Lithuanian 'reikminiai tyrimai') programme implemented by the RCL[46].
- Delivery towards the set missions or challenges would involve a wider stakeholder community thus opening up possibilities for new solutions not restricted by a focus on just one particular scientific field.
- Other ministries beyond the MoESS and MoEI will need to be involved in the process of identifying missions or setting challenges. Similar to the earlier point this will open up new cooperation opportunities and make community more focused on working towards common missions/challenges.
- If a rule is set to involve at least one private sector company in the delivery of a project under the NSTP, this will act as a clear incentive for the cooperation between private sector and other players in the Lithuanian STI system.
- The RCL acknowledges a need for the interdisciplinary research in describing "a problem of strategic importance to the state and the society" which is to be addressed through the NRP. Such interdisciplinarity is also crucial in stimulating cross-sectoral cooperation and needs to stay prominent in the NSTPs.
- As this scenario will largely build on the existing practice, the governance and implementation of the programmes will not require a huge changes of the system. This could be a small and easier step towards bringing missions/challenges into the Lithuanian STI system.
- The NRPs are chosen through an open call for programme proposals. When proposals are assessed, an opportunity to merge several proposed programmes into one is discussed. This is a good practice to ensure the programme is of national scale and purpose. This is also a good opportunity to potentially amalgamate the resources and create a programme larger in size. A procedure is recommended to stay for the NSTPs.

[46] https://www.lmt.lt/lt/mokslo-finansavimas/valstybes-uzsakomieji-tyrimai/reikminiu-tyrimu-projektai/304

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Certain elements (based on the current rules and procedures[47]) are recommended to be adjusted in order for the 'traditional' NRPs to become *mission-oriented* 'traditional' NSTPs:

- Depending on a set mission or challenge, in addition to the MoEI and MoESS more thematic ministries need to get involved in the process, such as the Ministry of Health, the Ministry of Energy etc.
- To deliver on a mission more varied and larger teams are likely to be needed in projects. For that at least three partners are recommended to be part of the projects funded in the NSTPs.
- To support even broader interdisciplinarity, proposals for programmes could be submitted by stakeholders from institutions which are strongly linked to set mission or challenge, e.g. a hospital, a patient organisation, a thematic cluster .
- Achieving a mission or overcoming a challenge can be a lengthy process requiring time. The frequency of the current NRPs is "no less than every five years" for calls to submit proposals regarding the programmes to be implemented. This implies that every five years one programme can be discontinued, whereas some new ones can be started. International practice as well as feedback from the Lithuanian community speaks in favour of fewer but longer programmes with an opportunity for a more varied groups of stakeholders to join the programmes as well as their implementing projects. With this in mind, it is recommended in this scenario for the NSTPs to run 5-10 years.
- An evaluation of programmes after 3 years is recommended to check the progress towards the accomplishment of a set mission or solving a challenge. If needed, an adjustment to the Programme should be made.
- Conditions for leadership of the projects need to be reviewed to allow not only a scientist (as in the current NRPs) but also a private sector as well as other institutions (e.g. hospitals) if this makes a stronger rationale and benefits for the delivery of a set mission or a challenge.

Scenario 2: Strategic umbrella NSTPs based on the current set of instruments

Focus on missions:	Yes
Links to smart specialisation:	Yes
Links to other support measures:	Yes (pooling resources)
Programme vs project size:	EUR 50m / EUR 0.5-3m
Governance:	Multi-layer, with long-term STI agendas
Duration of programme vs projects:	7-10 years / 1-2-5 years (possibility to get funding for continuation)
Beneficiaries (in projects):	At least 3 partners (with conditions related to specific instruments)
Lead beneficiary:	Broad range, incl. government, users, NGOs
Funding institutions:	Ministry of Education, Science and Sport (MoESS) Ministry of Economy and Innovation (MoEI) thematic ministries (i.e. health, energy)
Implementing institution:	Innovation agency (e.g. MITA)

[47] For example, https://www.lmt.lt/en/doclib/uwuaby33pjtdn582k5g8yxr9s2rjxnd4 https://www.lmt.lt/data/public/uploads/2017/03/3-the-description-of-the-procedure-for-the-preparation-and-implementatio....pdf

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This scenario builds on the existing support measures to allow for a smoother transition towards a mission- or challenge-based approach to the STI policy and the NSTPs:

- To start with, MITA, the Research Council and in consultation with the ministries decide on the missions or challenges. This step is similar to the mission-setting approach under Scenario 1. To take the STI community even further, it is recommended to involve a wider stakeholder community into the missions-setting exercise through a co-design process. This process will thus have both a top-down as well as a bottom-up approach.
- New NSTPs are outlined based on the agreed missions and/or challenges. For their delivery long-term STI agendas need to be set up.
- No separate or additional funding is recommended as this scenario builds on pooling the resources of already existing support instruments, i.e. resources allocated to the NSTPs (currently NRPs) and some of the existing research and innovation support measures (e.g. “Intellect”, Innovoucher” etc.).
- What needs to be introduced in the existing instruments are additional assessment criteria which would ensure that funded projects contribute to the progress towards set missions or towards finding a solution for an identified challenge. Such criteria could be, for example, a project is being designed to address a specific challenge or deliver on a specific mission, or a more varied set of stakeholders is being brought into the project depending on the mission/challenge set for the programme. Additional points would be given under these criteria during the evaluation.
- By pooling the resources the programmes have a potential to become large in size thus allowing a conscious decision to focus on fewer programmes but those with a greater potential for impact. The progress of a programme as well as individual projects towards mission achievement or solutions for a challenge need to be monitored and reviewed. A key element should be a possibility for individual projects to get funding for continuation if it is clear that the further work and solutions will bring the accomplishment of a set mission even closer. Individual projects, thus, can run from 1 to 5 years with budget from EUR 0.5m to EUR 3m.
- A composition of partners as well as selection of the lead beneficiary should not be regulated by the Programme. The project applicants need to suggest the most suitable team composition consisting of as many and as varied stakeholders as needed for the delivery of a mission. As such a project can be led not only by a research and education institution or a private company but also by an NGO, a user group, a cluster, a science & technology park, a hospital, a municipality etc.

When thinking about this scenario as a way for the NSTPs to deliver on set missions or find solutions for certain challenges and also in terms of stimulating business-science cooperation, certain benefits are clear as well as some potential friction topics.

Benefits:

- This scenario does not require a total re-design of support instruments as it builds on pooling together existing support measures.
- A link to smart specialisation is clearly achieved as planning of support measures in Lithuania already takes this into account.
- This scenario allows to combine both a top-down and a bottom-up approach for setting the missions or identification of challenges.
- A long-term programme and project duration offers a needed continuity of support measures. The present short-term nature of programmes and projects

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was an issue that the stakeholders consulted during this project identified as a drawback in the Lithuania STI policy setting.

- Bringing multiple and a varied set of stakeholders into the Programme implementation will encourage stronger cooperation (and not only business-science cooperation) and will encourage new solutions to be brought forward.
- Implementation of the Programme by MITA as the innovation agency would permit a stronger emphasis on innovation and the applicability of science to be brought into the programme. Involvement of the Research Council and various ministries would be ensured through the agenda setting missions and challenges.

Critical issues:

- Pooling of existing support measures and resources might be considered complicated by the participating ministries and implementing agencies.
- Allowing for the broad range of stakeholders to get involved in leading the projects under the programme might require reviewing the rules of already existing support instruments, which could be perceived as a disadvantage. However, testing this on a small number of support measures will enable a better understanding of what works and does not work. The STI stakeholders consulted during this project did raise concerns that many of the support measures do not allow many of the stakeholder to take a lead role in the projects, which is considered to be a weakness of the existing STI system.
- Building a strategic umbrella programmes based on the current set of instruments might bring confusion to the stakeholders. A clear communication and explanation as to what exactly is being reviewed/changed and why is needed. The main change will be in introducing an assessment criteria to understand how proposed project helps progress towards the accomplishment of the mission or a solution to the challenge.

Scenario 3: A new strategic umbrella NSPT created around missions or challenges

Focus on missions:	Yes (with funding for initial co-creation of the programme)
Links to smart specialisation:	Yes
Links to other support measures:	Not necessarily
Programme vs project/activity size:	EUR 0.5m-1m per year released in stages (intensity reduced over the years) Project / activity size decided by the consortium
Governance:	Multi-layer, with long-term STI agendas
Duration of programme vs projects:	5-10 years (possibility to get funding for continuation)
Beneficiaries (in projects):	1 or more for the core team; no size requirement for the consortium as a whole
Lead beneficiary:	Broad range, incl. government, users, NGOs
Funding institutions:	Ministry of Education, Science and Sport (MoESS) Ministry of Economy and Innovation (MoEI) thematic ministries (i.e. health, energy)
Implementing institution:	Innovation agency (e.g. MITA)

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The main difference between this scenario and Scenario 2 is around the introduction of a seed funding for the creation of missions and challenges, thus, incentivising a fully bottom-up approach; not relying on existing support measures; and building a programme big in scale and based on constant monitoring.

Benefits:

- Stakeholders are driving the process as they are encouraged to come up with missions or fundamental challenges to be addressed and the solutions to which will bring systemic change to the area this mission or challenge has been identified in.
- To incentivise this process a co-creation programme is to be put in place with funding for community building and missions creation. Such initial co-creation programme can run for not longer than one year and have a funding of, for example, EUR 0.2m. At the end of it various groups will submit their proposals for missions or challenges backed with a bold, inspiring and quantifiable goal to achieve, which different and interdisciplinary actors need to be involved. They will also be expected to develop a strategic research and innovation agenda and prepare a programme plan with first initiatives and activities.
- Programmes with missions need to be ambitious in their size and expected achievement as to avoid a situation when too many smaller and less ambitious programmes are put forward. The aspiration would be to have fewer programmes involving as many interdisciplinary and cross-sectoral players as possible but long in duration and bigger in ambition. This will ensure continuity of the support over a longer period of time, something that stakeholders consulted as part of this project felt strongly about.
- The participants / beneficiaries of the programme can come from all parts of the society. Not all need to be included as partners in the application but need to be included in the building and delivery of the programme.
- Each programme will have a consortium behind it led by a core team. It is up to the stakeholders to decide on the composition and size of the core team.
- A budget for 10-year duration is earmarked by the ministries (via MITA). Funding, however, is released in stages, e.g. every 18 months, every 24 months, every 3 years etc. As a basis for financing of a new stage is an evaluation and a detailed business plan. The idea behind this staged funding is to ensure that the results of the programme's activities steadily move towards the achievement of a set mission or a resolution of an identified challenge. If the achievement is not satisfactory, the implementing agency has a right to stop funding of the programme.
- Intensity of funding from the public side is expected to reduce over the years and contribution from programme owners (either a private sector or a public sector) is expected to reach 50%.
- Programmes run their activities through a call for project ideas, e.g. 1 or 2 calls every year. The orientation and selection criteria of the calls and distribution of funding are decided by the programme leadership but all linked towards the achievement of a set mission or a challenge for the programme.

Critical issues:

- This scenario requires the most dramatic change in the current setup of the Lithuanian STI policy which could be perceived too risky and challenging the status quo.

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- When the length of the programme (e.g. 10 years) does not coincide with the term of the government, there is always a risk about the continuation of the programme when/if the government changes.
- Staged funding release could create certain tensions and intensify political lobbying.
- There is a risk that during the co-creation process the stakeholders will come with missions or challenges of different ambition. This is expected as shown by the international practice. Policy-makers need to be flexible and able to provide support to the stakeholders in guiding them through the process. This requires certain capacity and capabilities by the policy-makers, which might not be yet in place.
- The idea is for the programme funding to gradually reduce over the long-term, which could potentially create certain tensions. Here also a question of state-aide needs to be carefully investigated.

Scenario 4: Bringing existing instruments closer to missions

Focus on missions:	Yes
Links to smart specialisation:	Yes
Links to other support measures:	No
Project size:	As currently set for various support instruments
Governance:	Simple
Duration of projects:	As currently set for various support instruments
Beneficiaries (in projects):	As currently set for various support instruments
Lead beneficiary:	As currently set for various support instruments
Funding institutions:	As currently set for various support instruments
Implementing institution:	As currently set for various support instruments

This and next scenario are not directly linked towards setting up an NSTP as such but are options for the introduction of a mission- or challenge-based approach towards the STI policy.

Benefits:

- Of all of the five scenarios presented here, Scenario 4 is probably the easiest to be tested and introduced:
- It does not require major changes in the current system and is easy to implement as it builds on currently existing or planned individual support instruments, such as the "purposeful research" (in Lithuanian 'reikminiai tyrimai'), GovTech lab, succession of "Intelektas LT", innovouchers and pre-commercial procurement programmes, as well as existing calls for COVID-19 related[48] and similar R&D programmes that already apply additional points for collaborations. Being simple in its governance and approach, this scenario is a good way to warm the Lithuanian STI community up towards the mission- or challenge-focused approach.

[48] http://lvpa.lt/lt/paraiskos/covid-19-mtep-tyrimai-1257.

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- However, it still requires for the missions or challenges to be set on a national level – either top-down; bottom-up or through a combined approach. An approach for mission-setting suggested under Scenario 2 is recommended also for Scenario 4. MITA together with the Research Council and various ministries (not only the MoESS and MoEI but also thematic ministries) decide on the missions or challenges. This initial step should then be strengthened through the involvement of a wider stakeholder community, thus also bringing a bottom-up perspective. As such, a key effort in this Scenario will be around identification of missions or challenges.
- The next step is for the MoEI and the MoESS to choose one or several existing (or planned) support instruments and make them linked with the delivery of a mission or addressing a challenge. This step is similar to the one described under Scenario 2, i.e. an assessment criteria which would ensure that funded projects contribute to the progress towards set missions or towards finding a solution for an identified challenge is introduced for the evaluation of proposals submitted under a call for a specific support measure.
- What this scenario tries to achieve is to introduce the Lithuanian STI stakeholders to the idea of missions or challenges and think about their individual projects from a perspective of how they deliver results useful for the achievement of a set mission or bringing a solution to a set challenge.

Critical issues:

- The main issue linked to this scenario will be most on deciding on the missions or challenges nationally and then deciding on which measures exactly to bring closer to the missions.
- Allowing for the broad range of stakeholders to get involved in leading the projects under the programme might require reviewing the rules of already existing support instruments, which could be perceived as a disadvantage.
- There could be a confusion to the already funded but still running projects. Their beneficiaries might be wondering if the conditions of their project and requirements will be changed.

Scenario 5: Challenge-based Innovation Fund

Focus on missions/challenges:	Yes
Links to smart specialisation:	Not necessarily
Links to other support measures:	No
Programme vs. project size:	EUR 100m / up to EUR 5m (min EUR 1.5m)
Governance:	Simple
Duration of projects:	1-3 years
Beneficiaries (in projects):	Min 3 partners (at least 1 from private sector)
Lead beneficiary:	Private sector
Funding institutions:	Ministry of Education, Science and Sport (MoESS) Ministry of Economy and Innovation (MoEI) thematic ministries (i.e. health, energy)
Implementing institution:	Innovation agency (i.e. MITA)

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This scenario is focused on setting up a fund to support innovative ideas backed by research and working towards finding solutions for a set challenge. Similar to Scenario 4, this solution is not directly linked towards setting up an NSTP as such but is purposefully focused on the introduction of a mission- or challenge-based approach towards the STI policy.

Benefits:

- The Fund will focus on supporting projects involve SMEs and large companies (with innovative potential) in partnership with research and education institutions or other stakeholders needed to find a solution to a set challenge.
- Minimum of three partners with at least one partner coming from a private sector need to be involved in the delivery of a project. Setting this requirement for a minimum size and composition of the team aims to encourage collaboration between business, science and (where relevant) other stakeholders.
- The aim of the Fund should be at funding large-scale projects (i.e. up to EUR 5m) with a minimum project size recommended at EUR 1.5m. These conditions are recommended as a means of encouraging ambitious projects.
- Continuation of the projects can also be planned for. However, in cases when projects are continued, match-funding should be requested both from the private sector as well as research organisations.
- This instrument can build on (or at least have links to) the currently existing or planned individual support instruments, such as GovTech Lab[49] and the 'innovation fund'[50] mentioned in the Law on Technology and Innovation and planned by the Ministry of Economy and Innovation but not yet implemented.

Critical issues:

- As in earlier scenarios, the main issue linked to this scenario will be mostly on deciding on the missions or challenges nationally and then deciding on which measures exactly to bring closer to the missions.
- If the number of ambitious ideas that match set requirements (i.e. ambitious in size and team composition) is not high enough, there might be a temptation to relax the rules in order to spend ('absorb') the allocated funding. Such situation needs to be carefully managed aiming to fund ambitious ideas rather than simply spend allocated funding.
- Continuity of the funded projects can in some cases be risky if the private sector is not ready to co-fund further activities. Proactive and constant dialogue with the private sector will be useful to mitigate this risk.

6.3 Recommendation 2: Apply mission-orientation to the sectorial context

It is recommended to apply one or several of five scenarios for mission-oriented STI policy into the sectoral context in Lithuania.

Although a mission- or challenge-based approach makes the STI policy move away from focus on specific sectors, this study looked into the drivers and barriers for business-science cooperation in the four sectors in Lithuania. This section offers some reflections

[49] https://www.govtechlab.lt/
[50] https://eimin.lrv.lt/lt/naujienos/ekonomikos-ir-inovaciju-ministerijos-iniciatyva-bus-steigiamas-inovaciju-skatinimo-fondas

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on the application of missions and/or challenges to these four sectors and especially from the angle of business-science collaboration.

Figure 11: Suitability of suggested scenarios for the four sectors

	Life Sciences	ICT	Engineering	Agro- and Food
Scenario 1: 'Traditional' Science and Technology Programmes with mission	*	Not recommended	*	**
Scenario 2: Strategic umbrella NSTPs based on the current set of instruments	**	**		**
Scenario 3: New strategic umbrella NSTPs	***	**	***	***
Scenario 4: Bringing existing instruments closer to missions	**	*		*
Scenario 5: Challenge-based Innovation Fund	*	***	*	

Life sciences sector

- Drivers and barriers for business-science cooperation in the life sciences sector in Lithuania are characterised by excellent fundamental research, the presence of many strong companies (including with foreign capital) and strong personal connections originating from the long-term development of the sector in the country. Not specific to Lithuania, this sector is highly capital intensive, with high entry barriers for new innovations, and with long product development cycles.
- The option for the NSTP where the life sciences sector participants can show their greatest potential need to be long-term and ambitious to allow for new research-based ideas to turn into new products and services.

  "We have the large projects in, for example, healthy aging (a national programme) which could have a mission-oriented approach and could act as an umbrella programme, but we also have large projects with another agency, and the third agency […]. Now we have a really scattered ecosystem, so if we pull these resources together, we can have the umbrella programme covering a bunch of topics." (university representative)

  For that both scenarios 3 and 4 are the most suitable options as they have long-term horizon where the collaborations with high potential and over the years showing good results can get further funding.
- To overcome an identified barrier of insufficient incentives to introduce innovations (e.g. digital health solutions, novel pharmaceutical or diagnostic tools or advanced solutions in public healthcare facilities) into the national health system could benefit from stronger integration of health system's stakeholders into the joint activities with the research base and private sector companies. One of the largest weaknesses of the existing approach to policy formation is a narrow

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focus of support measures: some support measures are for the research institutions; others for private companies etc. As highlighted by the stakeholders who took part in this study's workshops:

> *"[…]we should agree where should we go together in life sciences and how we need to implement. We need to have a public discussion and we need to be transparent and have clear rules. For example, hospitals cannot participate in them [sic], but we need hospitals. We should start with a round table and then we will achieve consensus."* (private sector representative)

To overcome this barrier it is critical to ensure that as many beneficiaries have an opportunity to get involved in shaping and proposing projects for funding. And it is should be up to the applying teams to decide which organisation is best to lead a particular project. Such approach towards beneficiaries is present in Scenario 2 (Strategic umbrella NSTPs based on the current set of instruments) and Scenario 2 (A new strategic umbrella NSTPs).

- Increasing the variety of the beneficiaries will help further strengthen one identified driver for business-science cooperation, namely strong (mainly FDI-based) companies and excellent fundamental research. As beneficiaries private companies are present in all described scenarios; and in Scenario 5 (Challenge-driven Innovation Fund) they are recommended to be a lead applicant. An FDI angle can also be brought into new NSTPs inviting foreign actors to participate if, for example, they have presence in Lithuania. Such approach, for example, is taken in Sweden in the Vision-driven "environments" in health programmes.
- Some further barriers for business-science cooperation have been identified in this study but which do not necessarily can be directly addressed through the new NSTPs or specific mission- or challenge-based support instruments. These barriers include a need to update existing equipment or infrastructure, to increase incubation capacity, solve data access and regulation issues (e.g. GDPR) which is especially relevant domain in the areas of advanced technologies for public health and medical engineering. Although examples from international comparators show that some of the existing programme there also allow for funding for the infrastructure, it is recommended that the MoEI and the MoESS carefully discuss this question. Over the last decade a solid proportion of funding was to support various research infrastructure both in the public and private sector. The MoEI has just (October 2020) launched new COVID-19 related measures[51] also provides funding for some type of the infrastructure ("COVID-19 produktai LT"); and the Government's approved "Plan for the DNA of the Future Economy" (1 July 2020-31 December 2021) also includes projects with certain infrastructure funding.
- Interdisciplinarity of R&D was identified as one of the strongest drivers for business-science cooperation in the life sciences field. There are significant overlaps and complementarities with other areas, such as ICT applications, food safety or the photonics/engineering industry, which could offer interesting development opportunities.

> *"For innovation to be disruptive we have to have challenging ideas. To develop such systems is difficult, so you need to look what*

[51] https://eimin.lrv.lt/lt/naujienos/startuoja-dvi-naujos-es-paramos-priemones-verslui-bus-kuriami-ir-sertifikuojami-kovai-su-covid-19-skirti-produktai

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competences you have in the country and organise consortiums where the ideas they bring are challenging[…]. At least try to have one pilot project." (private sector representative)

Creating NSTPs around missions or challenges will create grounds for further exploring, applying and strengthening such interdisciplinarity. For that all the scenarios where programmes or activities are built on missions/challenges should apply. At the same time it will help resolving (or at least reducing) a barrier around a lack of engineering competences in the R&D activities in the sector.

- Development of missions or identification of challenges involving the life sciences community in a bottom-up approach, i.e. where the community itself comes together and set the mission, should not be difficult. The stakeholders consulted during this study mentioned strong information personal contacts with many companies emerging as spin-offs or stat-ups from the research and education institutions. This will be strengthened even further through the exercise of setting missions as prominent in Scenario 3 and also possible under Scenario 2.

Information and communication technology (ICT) sector

- The ICT sector in Lithuania is strongly driven by the relevance of ICT solutions in other domains, hence the sector's potential for interdisciplinary and multi-stakeholder collaboration may result in highly beneficial outcomes for both the sector as such, and the Lithuanian economy as a whole. However, while the ICT sector is generally more dynamic and less capital intensive than other sectors, these aspects had not been taken into consideration when designing R&D policies. Consequently, the lack of appropriate instruments has become a constraint in promoting R&D. Finally, a major barrier for business-science collaboration in the sector remains a comparatively weak position of HEI researchers that often translates to companies "body shopping" for talents.
- The option for the NSTP where the ICT sector stakeholders may participate alongside or in collaboration with other sector stakeholders may be a promising pathway. The mission- or vision-based NSTPs should therefore be an attractive option for sector stakeholders, perhaps more so than in other sectors. However, overly large and very long-term strategic programmes are unlikely to receive positive support because both the current research and business capacities would not be able to sustain satisfactory results.

"Talking about the massive science and technology programmes, I have doubts in our ability to sustain these massive efforts. The business-side, we have a stronger capacity to get to market innovations faster, and we are not driving these activities on research. We would like to have more collaboration with research centres, but it is not critical for us." (Business association representative)

Consequently, scenario 5 (the Challenge-based Innovation Fund) seems the most suitable option for ICT, as the duration of projects is not overly long, while the projects may start on a small-scale and progress to more ambitious collaborations. The challenges being introduced could include the element of

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interdisciplinarity as multi-disciplinary STI stakeholder groups are chosen for setting these challenges.

- At the same time, the variety of groups who may benefit from innovative ICT solutions is very important to bear in mind, when considering this sector. Areas where ICT could bring forth innovation range from healthcare to agriculture, to manufacturing, to financial services or even the public sector. The relatively recent GovTech lab initiative, which has received additional funding from the Lithuania's Plan for the DNA of the Future Economy, in this case exemplifies the potential of connecting the ICT solution beneficiaries with potential solution creators. However, the GovTech initiative is mostly oriented at start-ups, yet the range of these so-called solution creators could be broader and involve both private companies and public research and education institutions, or ideally – their consortia. This approach is somewhat already inherent within Scenario 2 (Strategic umbrella NSTPs based on the current set of instruments), which could also be a possible alternative for the ICT sector, insofar as it enables a variety of beneficiaries to initiate projects that last between 1-2-5 years. The projects themselves follow a pre-defined mission or vision set by a multi-stakeholder group and the composition of partners are not artificially limited. The latter aspect is also very important for the sector, as collaborations within the sector are very likely to extend beyond the classic business-science collaboration.

  "[Within the ICT sector] a broader stakeholder participation is welcome. This is a challenging part, and experience with challenges in "Ikiprekybiniai pirkimai LT" [Pre-commercial procurement] confirms the risk of a single institution in defining the challenge. Still there should be a clear channel owner and user organization, representing a specific solution market in itself." (Business association representative)

- The Digital Innovation Hubs (DIHs) that have been set-up during the last two to three years, are also part and parcel of bringing ICT solutions to other sectors (addressing the Industry 4.0 potential). These entities are considered as one-stop shops for businesses that are willing to introduce digital innovations to their operations. These entities may serve as valuable platforms for realising the pre-defined missions or challenges, as they may bring together interested stakeholders, who are willing to experiment in specific areas. As such, the missions or challenges set by the NSTPs could add momentum and impetus towards the need for, and consequently, the actual setting-up of various collaborations between the ICT sector stakeholders and other sectors, as represented by the DIHs. In this case, the same scenarios mentioned above (Scenario 2 and 5) are equally suitable.
- Given that one of the key barriers preventing successful business-science cooperation in the sector remains the relatively weaker science-side of the equation, Scenario 1 ('Traditional' Science and Technology Programme with missions) is not recommended. This scenario is more suitable for areas where the research community is stronger, e.g. the health sciences or engineering, as these programmes are predominantly science-driven. Furthermore, the concept of what constitutes R&D in the ICT sector is not always clear, and scientific development cannot be regarded in the same way as in other areas of science.

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This has already caused significant issues when it comes to business-science cooperation under a traditional NSTP, and is likely to do so in the future.

- The research side of business-science cooperation may be strengthened by enabling more collaboration-friendly instruments that also prevent extensive "body-shopping". This could be done via a very inclusive mission-setting exercise, where key representatives from education, business and government institutions agree on a viable path, and further strengthened by developing a funding model that should enable private companies to co-invest in more complex research within the field (e.g. research teams), instead of picking-and-choosing single researchers for their projects. The idea to establish an IT competence centre within the area of IoT (the InnoITeam project[52] that had a first phase, but second phase finally did not take off in 2018) provides an interesting option for this. The competence centre was meant to conduct applied research within the area of ICT, to be governed by an inclusive stakeholder governing board and it was to be funded by several sources, including the MoESS (funding to employed researchers), business partners (additional R&D funding), and other stakeholders (including MoEI, other ministries, etc.). A number of challenges were to be addressed in the competence centre, such prevention of various forms of cyberattacks, development of safe IoT solutions or similar. The model itself in some way resembles Scenario 5 as resources are pooled together, yet its governance model is closer to that of Scenario 2 or even 3, whereby multiple stakeholders are involved in steering the entity. However, the outcome of this set-up is largely focused on developing know-how relevant to businesses, yet kept within the confines of the competence centre. Proposing an NSTP that would enable a similar approach to research within the area of ICT would greatly benefit and facilitate sector development in the future.

Engineering sector, with focus on photonics and laser technologies

- Lithuania's manufacturing sector (excluding construction) continues to be relatively important in terms of the contribution to the overall economy (18% of gross value added in 2019, compared to 17% EU27, 15% Estonia and 12% Latvia). At the same time, the contribution of the ICT sector (4%) remains lower than the EU27 average (5%) and of Estonia and Latvia (8% and 6% respectively) and similarly, the Professional, scientific and technical activities sector (which captures specialised engineering and R&D activities) accounts for only 7% of GVA compared to 11% in the EU27 and 9% and 8% in Estonia and Latvia. Hence, there remains scope for a relative development in the Lithuanian economy of novel activities that merge manufacturing processes, engineering skills and advanced digital technologies.
- The role of advanced technologies in driving the development of key manufacturing sectors is potentially significant and photonics and laser technologies is a field in which Lithuania has a relative specialisation (building on a long-standing expertise in designing and producing scientific lasers) as discussed in previous chapters. However, the potential applications of photonics and lasers are much broader than industrial lasers, etc. At European level laser and photonics technologies are viewed as key enabling technologies which can support the implementation of a number of the Horizon Europe missions and to

[52] https://www.innoiteam.com/

the Horizon Europe partnerships, notably the Photonics Europe partnership[53] which has developed a strategic roadmap for the period 2021-2027. The wide range of applications of photonics technologies including lasers is underlined in this roadmap which explores the potential in areas as diverse as Industry 4.0, Smart farming, medical technologies and healthcare. For instance, "a new generation of laser-based production systems, including additive manufacturing, will bring forth new manufacturing and inspection processes that are essential for extraordinary energy and resource-efficient solutions, e.g. lightweight construction" of vehicles"[54]. Similarly, lasers and LiDAR (Light Detection and Ranging), hyperspectral imaging and many other types of sensors, as well as energy-efficient LEDs are a key component for more environmentally sustainable and productive farming.

- This vision of the potential transformative role of photonics and lasers is shared by Lithuanian stakeholders and is integrated in the current Lithuanian Smart Specialisation Strategy (S3). As noted above, four main 'market segments' are considered to be particularly promising from a Lithuanian perspective: medicine, high-power lasers, industrial laser and sensors (LiDAR, etc.). Moreover, the Laser LT DIH provides a potential platform for broader application of laser technologies into existing Lithuanian manufacturing firms.
- Despite the promising basis for laser and photonics, the bottlenecks identified in this study suggest the need for a larger-scale strategic medium-term initiative that foster a cross-sectoral and multidisciplinary development and application of these technologies.
- Considering the scenarios, the best-fit for laser and related engineering activities would appear to be the launch of a new strategic umbrella programme (Scenario 3) that would provide a seed funding phase to identify between 2-3 strategic initiatives at national level (including, where relevant, collaboration with Baltic Sea region and European actors in the field).

> *"The traditional approach has been to test some small ideas, selecting 'low-level' projects to test potential. However, three years is not enough to develop serious ideas. In the laser field, I've seen how strategic programmes can work in Japan[55].They bring together cross-cutting ideas and players in a really big initiative coordinated by an agency. This would be a good thing, but we need to prepare for it."* (Lithuanian stakeholder expressing views during the co-creation workshop, October 2020)

> *"There are some ideas that can be of this type which are multidisciplinary and multisectoral, for applications of lasers in health, food and green industry. Such a mission-based approach could help us develop these bigger projects, especially as ICT also intersects with lasers."* (Lithuanian stakeholder expressing views during the co-creation workshop, October 2020)

- Each strategic initiative should be designed through a consortium-based approach with partners at lower TRL levels in development of technology solutions working closely with inter-disciplinary partners to test and pilot

[53] See: https://ec.europa.eu/digital-single-market/en/industrial-innovation-and-cooperation-european-level
[54] https://ec.europa.eu/info/sites/info/files/research_and_innovation/funding/documents/ec_rtd_he-partnerships-for-photonics.pdf
[55] See for instance: https://www.jst.go.jp/impact/en/program/10.html or https://www.jst.go.jp/impact/en/program/03.html

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applications that provide specific solutions or high-value products that respond to industrial or societal challenges: medical, environmental solution, etc. Each strategic initiative would begin by defining the expected outcome (medium-long term effects) in terms of the expected societal or economic impact (including notably the export potential of high-value products or services) through the application of laser and related technologies. Each strategic initiative would combine a mix of technology development, piloting (e.g. pilot photonic manufacturing facilities) and scaling up (industrial investment, training of engineers, etc.) over a 5 to 7 year period, providing a more substantial and long-term funding framework than currently provided by individual projects.

Agri-innovation and Food technologies sector

- Sustainable agro-biological resources and safe food are part of the S3 priority "Agro-innovation and food technologies" in Lithuania and this is therefore an important 'sector' for the country. S3 also provides some early indication of important challenges build on existing national strengths and that would require the involvement of this sector.
- The main drivers and barriers for business-science cooperation in the agri-food sector in Lithuania are characterised by the capital-intensive nature of the sector, which can mean that significant investment is needed to realise innovation; the seasonal nature of the work which can act as a barrier to use of policy instruments that have a short duration and do not launch at the 'right' time; and the low maturity of the sector's capacities, (skills and competencies), which acts as a barrier to collaborations where the science side is more advanced. The first two aspects are faced by other countries and while the capital intensive nature cannot easily be overcome, extending the duration of the STI programmes can help to address the seasonal nature of the sector. To quote some of the national stakeholders:

  "innovation and research takes a long time in the sector" "research cannot be short-term, we know that business in agriculture needs answers very fast, but it's 'outside' research, so at least 3 years are needed". "Agro food is a very conservative industry, it is the least digitalised, it has least research investments, seeing what the EC is doing".

- The main driver for business-science collaboration for this sector in Lithuania is the close proximity and established ties with large companies. This is positive as it gives the sector a 'culture of collaboration' that can be built on in the future, e.g. a basis for trust and an understanding of how the main actors can best interact. This sector is also benefiting from interdisciplinary collaborations and access to data; there is an indication that better access to data could act as a catalyst for business-science cooperation.
- Based on experience from other countries and feedback from national stakeholders, NSTPs for this sector need to be long-term, e.g. spanning several years; involve multiple partners (not 'just' a company and a research group); and build on opportunities for more interdisciplinary research and broader 'challenges'. The perceived poor fit to the existing instruments suggests that Scenario 3 (A new strategic umbrella NSTP), with a significant time duration, approved and delivered in stages, would be beneficial to this sector. Again, to quote from national stakeholders:

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*"Changing drastically [*to a mission/challenge approach*] could affect and would bring a different affect and we can build on top of what we have…….it is a great idea to implement it via a cross-sectoral approach, it would bring together different sectors and their knowledge"*

"When considering an umbrella programme……it could be a good idea to pilot this. In many cases we don't see a lot of scaling up of innovation so it would be interesting to bring a bigger scale project, government institutions, not just one ministry".

"A minimum of 3 partners is the right way for agricultural research, including different stakeholders, farmers, companies and research institutions"

- A shift towards a long-term mission led activities for this sector, with much longer programmes and a wider variety of actors should help to overcome some of the issues related to the capital intensive nature of innovation. It will 'spread' the costs across more organisations and time and, perhaps even more importantly, offer the possibility to innovate in ways that do not require so much investment in to PP&E (property, plant, and equipment). Innovation based more on applying ICT solutions and addressing innovation in the value and supply chains may bring economic and wider benefits without the need to invest in infrastructure.
- In a similar way to the 'Top-Sector' approach of the Netherlands, the country and the sector will need to decide how much they are driven by economic gains and how much they see wider impact and benefit from joining forces to address societal challenges related to, for example, food security, sustainable agriculture, marine and maritime and inland water research, and the Blue Economy. Broadening the scope for interdisciplinary innovation may also allow them to participate in programmes focused on wider challenges including health and well-being and climate action, environment, resource efficiency and raw materials. In the longer term, a broader approach to innovation for economic benefit and a closer alignment with EU societal challenges may better equip actors to join more EU funded programmes where the issue of capital investment can also be overcome through entry in to larger funding programs and access to stronger partners.
- Because challenge based research is seen as a long-term activity, designed to deliver innovation over a period of years and not months, it has the potential to very directly address the seasonal challenges experienced by the Agri-Food sector. A period of 3 years (cited above), is still below the minimum 4 years and well below the maximum 10 years targeted by the Netherlands 'top-sector' programmes. Such a shift to long R&D programming periods, seen to be at the heart of Dutch Top-Sector success, would require a significant change in how Lithuania currently allocates funding for R&D&I. It would also require significant change in how different Ministries and funding agencies work together to set Missions, develop and agree priorities for each call as well as a very different set of indicators to the current norm.
- Finally, a move towards broadening the scope of innovation may allow the more advanced research actors, i.e. those with greater skills and competencies, to apply them fully through interdisciplinary, challenge led research programmes, for example for the energy 'sector', without being held back by the low maturity

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of capacities in the traditional core sector of Agri-food companies. Again to quote from the stakeholder discussions:

> "*The food cluster in Belgium are working on strategic interventions: food clusters are looking at industrial efficiency and sustainability (use of energy), the application of food technology and the natural environment….food is a huge area of potential for Lithuania.* ***How do we maintain the quality and increase the productivity****? The productivity is improved by using less resources etc."*

Broadening the areas in which 'Agri-food related R&D' can be applied holds the promise to realise presently untapped research potential in the Lithuanian R&D base.

6.4 Changes to governance and implementation

In addition to the recommendations related to the four thematic areas, there are a number of recommendations covering the overall governance and implementation of the STI policy in Lithuania.

6.4.1 Recommendation 3: Define missions through a combined top-down and bottom-up approach

It is recommended to use a combination of a top-down approach (i.e. ministries of Economy and Innovation, Education, Science and Sport, various thematic ministries, the Research Council, MITA as the innovation agency deciding on the missions) and a bottom-up approach (i.e. companies, research and education institutions, clusters, user groups, association, science and technology parks suggesting possible missions and/or challenges) in defining the missions.

To bring the missions into the STI policy first requires deciding on how the missions can be set (i.e. top-down vs bottom-up) and actually defining the missions or challenges.

The European Commission defines a mission as "a mandate to solve a pressing challenge in society within a certain timeframe and budget"[56]. Missions should:

- be bold and address societal challenge, thus often related to a sense of urgency;
- have concrete targets ideally expressed in qualified and/or quantified terms and which are possible to be monitored along predefined milestones;
- involve research and innovation, i.e. "a problem-solving approach to fuel innovation-led growth" to use the European Commission words
- be cross-sectoral, cross-actor, and cross-disciplinary
- bring multiple competing solutions.

Such definition calls for very easily understandable missions where different parts of the national ecosystem can relate to in coming up with the solutions. Here are some examples of the missions or challenges used in the comparator countries analysed as part of this study:

- Zero emissions challenge – to develop disruptive solutions that accelerate progress towards net-zero greenhouse gas emissions in Ireland by 2050

[56] https://ec.europa.eu/info/horizon-europe/missions-horizon-europe_en

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- Zero vision for malnutrition in the elderly – no elderly in Sweden will be malnourished in 2030
- Zero vision cancer – to eliminate cancer as a cause of death and to transform cancer into a curable or chronic disease in Sweden and globally
- Climate-neutral agriculture and food production in the Netherlands – In 2050, the agricultural and horticultural sector will be operating climate neutral; emission of greenhouse gases (by then significantly-reduced) will be compensated by additional CO2 capture in the soil in nature; the sector will no longer use fossil raw materials and will have become a provider of sustainable energy.

To drive this process in Lithuania different ministries together with other policymakers such as the Research Council and MITA should jointly agree on mission statements brining their expertise. These could be framed around the S3 priorities for the country as a starting point (see Recommendation 5 below). For example, a mission related to the agro-innovation and food technologies priority might involve the Ministries responsible for Agriculture, Food, Research and Innovation (Ministry of Agriculture, Ministry of Education, Science and Sport, and Ministry of Economy and Innovation). A mission linked to the Health technologies and biotechnologies priority might also involve the Ministry of Education, Science and Sports and Ministry of Economy and Innovation but also the Ministry of Health. Once a top-down mission had been defined, then a bottom-up approach can be taken to translating missions in to themes and programmes.

It is critical to make this process as flexible as possible. The expectation should be that the stakeholders will challenge and argue the missions suggested by the policy-makers. This should be welcomed as a way to at the end decide on the missions which truly capture the views of the whole community. Such a co-creation approach is needed to move away from a purely top-down approach when one ministry or a Research Council decides on the priorities towards the empowerment of a wider set of stakeholders in the system. New types of actors will be attracted for the delivery of a mission and new connections will be built.

The co-creation approach to setting the missions and bringing variety of ecosystem actors together would also fit nicely into the recent strategies approved by the Lithuanian Government, such as 'Lithuania Co-create'[57] (the country's image building and positioning strategy) and the National Development Plan that emphasizes innovation as a horizontal priority.

An opportunity for introducing a mission-based approach into the STI policy was already there at the time of the preparation of the Plan for the DNA of the Future Economy[58] approved in June 2020. It had a certain element of co-creation: an initial Plan was prepared under the leadership of the Ministry of Finance involving other ministries, the Government Strategic Analysis Centre and Invest Lithuania and then presented for the public debate resulting in proposals amounting to about €400m. The Plan does not have a set mission or a challenge to be addressed but has taken a traditional approach long embedded in the Lithuanian STI system by focusing on five priorities: human capital, digital economy and business, innovation and research, economic infrastructure, and climate change and energy. If this Plan is to continue beyond 2021 it is strongly recommended to structure it around one or several missions or challenges, under which

[57] See (in Lithuanian) https://lietuva.lt/lietuvos-pristatymo-uzsienyje-2020-2030-m-strategija/
[58] https://finmin.lrv.lt/en/news/the-government-approves-the-plan-for-the-dna-of-the-future-economy

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all the currently funded activities around five priorities can easily be accommodated but in a more synergistic effect.

During the co-creation workshops, run with the Lithuanian stakeholders, an opinion was expressed on several occasions that the recommendations from this study although interesting and promising come too late in the process of preparing for the next programming period. Although this might be a potential risk, it does not mean that the mission- or challenge-based approach cannot be introduced or tested. For example, the work around setting the missions with the STI community can take place and once missions are set they can be included as an assessment criteria when deciding on which projects to fund under various calls.

6.4.2 Recommendation 4: Link missions with Smart Specialisation strategy

It is recommended to clearly link missions with the smart specialisation strategy and priorities.

At European level, a range of recent policy papers and reports have explored how to align future (2021-2027) smart specialisation strategies (S3) in terms of their contribution to meeting sustainable development goals, contributing to European level missions (as defined for Horizon Europe) or to broader policy agendas such as the Green Deal. This has led for a call for a shift in policy logic from S3 to smart specialisations strategies for sustainable and inclusive growth (S4)59. Foray (2018) notes that S3 Mission-oriented Policies should provide firms (and other actors) :

> *"…with incentives to explore the new opportunities, without dictating to them the content or direction of their projects, provided that these projects fall within the framework of the transformative activity in question; continuously evaluating progress, blockages, and surprises; ensuring the diffusion of information to the industrial base concerned; and reacting to the entrepreneurial discovery process by making decisions regarding the continuity or interruption of projects"*[60].

Mission-driven approaches that seek to address selected societal challenges can be the basis for identifying novel combinations of specialisations within an economy that are of a cross-sector and multi-disciplinary nature. Moreover, a mission-driven approach should intuitively take into account the needs of groups in society, expanding the triple helix (public sector-higher education/research-business) towards a quadruple helix approach. The bottom-up entrepreneurial discovery process (EDP), based on a multi-stakeholder principle, at the heart of S3 can be complementary to the aspirational high-level goals set by challenge or mission-oriented policies. The EDP process can thus be used to identify potential solutions and coalitions of stakeholders to address the mission or challenge set via the NSTP.

6.4.3 Recommendation 5: Expand a list of beneficiaries in the NSTPs and other support measures

It is recommended that the new NSTPs and other programmes and support measures created around missions take a boarder approach to involving actors from the STI ecosystem when defining the list of eligible beneficiaries of funded programmes.

[59] See, for instance, https://ec.europa.eu/jrc/en/publication/place-based-innovation-sustainability
[60] Dominique Foray, Smart specialization strategies as a case of mission-oriented policy—a case study on the emergence of new policy practices, Industrial and Corporate Change, Volume 27, Issue 5, October 2018, Pages 817–832, https://doi.org/10.1093/icc/dty030

Limiting beneficiaries to a research and teaching institution and one private company does not enable a committed involvement of the number or variety of actors needed to innovate for economic or societal good. This is both true of designing the best projects and testing and adopting the resulting new ideas. In a similar way, programmes that exclude the private sector or other stakeholders from involvement do not receive full the benefit that comes from wider, active involvement of stakeholders. An example of a current instrument where such a drawback is visible is "purposeful research" as well as some calls under the Plan for the DNA of the Future Economy. According to the Research Council rules only higher education and teaching institutions are eligible to lead an application but the benefits of bringing other type of stakeholders into the lead can bring much stronger results. Consider, for example, a topic under the call "Short-term (purposeful) research in the health, social and other areas, analysis and implementation of diagnostics (in agreement with the Ministry of Health), related to COVID-19"[61]. One of the topics funded under here is focused on "The use of Artificial Intellect and digital technologies in improving the quality of teaching in response to COVID-19". This topic presents an excellent opportunity to bring experts from the ICT, health and education communities in coming up with the best possible solutions. Taking an experience from the comparator countries analysed during this study, it does not really matter which type of organisation leads a particular project if the project fits well with the agenda and delivers the most relevant results. In case of the Lithuanian example, a restriction for the application to be led by a higher education and research institution automatically narrows down the opportunities and risks to miss out on some potentially excellent ideas, for example, from the private sector.

The COVID-19 pandemic has actually presented a great test bed opportunity for introducing a mission-based approach into a STI system. Here, it is not about the support of one particular sector but about finding solutions to overcome the key health challenge, which has also become a societal and an economic challenge. As mentioned above some support measures have been launched in Lithuania related to the COVID-19 pandemic situation but these largely missed a mission orientation but instead focused on either a specific groups of beneficiaries or specific actions. For example, the support measure "COVID-19 R&D"[62] narrowly focused just on private companies as beneficiaries, not allowing multiple partners and aimed at COVID-19 related R&D activities and (or) certification of new products and technologies.

6.4.4 Recommendation 6: Encourage cross-sectoral and cross-disciplinary consortia

It is recommended that incentives are introduced to encourage the involvement of cross-sectoral, cross-actor, and cross-disciplinary teams.

One of key benefits in the mission-based STI comes from the involvement of the cross-sectoral, cross-actor, and cross-disciplinary teams in delivering solutions for the set missions. However, when such approach is new in the national STI system it might be difficult to either (a) interest a particular stakeholder group to join a project team or (b) motivate the lead organisation to include other types of stakeholders.

To tackle this it is recommended to introduce certain motivational aspects into the evaluation and implementation. For example, when programmes are designed to target or encourage particular stakeholders to be involved, e.g. SMEs, or companies that have

[61] https://www.lmt.lt/lt/doclib/ewlu97awnhwhmhnuq144a8cm7nm7y81m
[62] https://eimin.lrv.lt/lt/naujienos/startuoja-dvi-naujos-es-paramos-priemones-verslui-bus-kuriami-ir-sertifikuojami-kovai-su-covid-19-skirti-produktai

not previously been involved in innovation activity, this can be reflected in the evaluation criteria for the calls. Additional evaluation points can be given for each 'desired' stakeholder group.

New approaches to enabling direct benefits for a wider group of stakeholders could be investigated. For example, the Top Sector programmes in the Netherlands does not give grants to companies but for each 1 euro 'spent' by a company the State gives some 25 euro cents (varying depending on TRL and programme) to fund the research undertaken for the project by the research and higher education partner. This is a way of subsiding research without actually giving a grant to private companies.

6.4.5 Recommendation 7: Make monitoring and evaluation an integral part during design and implementation of the programmes

It is recommended to set a well-structured monitoring and evaluation process already as part of the initial NSTPs design process. Strategic reviews linked to additional round of funding should be performed periodically to provide a basis for a go-no go decision by the programme management.

The long-term agendas set by mission type policy interventions require a well-structured monitoring and evaluation that should be in part of the initial road-map design process. Each mission should be structured with respect to both a narrative vision (a statement of intent or objectives) and short, medium and long-term effects (targets, quantified to the extent possible) to be achieved by the interventions.

The definition of key milestones in the mission road-maps should be accompanied by verifiable outcomes. Ideally the intervention should be framed by a 'theory of change' that sets out how the innovation pathways proposed for implementation will lead to significant and transformational change in the economy over the time horizon agreed.

At the level of the implementing actions and projects, the consortia in charge should be subject to periodic (e.g. every 2-3 years) strategic reviews (e.g. by an international panel of experts) that provides a basis for a go-no go decision by the programme management. For those actions that have performed to expectation, a go decision should lead to an additional round of funding (public-private sources, including equity investments depending on TRL levels) to further develop the initiative.

6.4.6 Recommendation 8: Reduce fragmentation and lack of strategic orientation on the national level

To address the fragmentation and lack of strategic orientation of the existing collaborative efforts it is recommended that different sectoral ministries combine their funds towards co-funding the NSTPs; integrate different RDI activities and ensure a stage-based implementation approach; develop a common language and strategy incentivising ministries and agencies to cooperate in implementing a mission-based approach to STI policy.

There are four main challenges related to the effectiveness of the business-science cooperation policies (and as such future NSTPs). There is a fragmentation and lack of synergies between measures; lack of collaboration measures that are designed and implemented as an integrated package; lack of strategic orientation of the funding agencies; and a lack of professional boundary-spanning capacity to coordinate and facilitate collaborative efforts. There is a demand for more integrated packages of instruments that support the progressive development of business-science collaboration

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and the NSTPs over time. To address the fragmentation and lack of strategic orientation of the existing collaborative efforts, it is recommended that:

- Different sectoral ministries combine their funds through allocating up to 20% share of their procurement budget to co-funding the NSTPs. The basis for this has already been established by the newly approved National Development Plan until 2030 which explicitly outlines innovation as a horizontal principle for implementing all policies[63]. Furthermore, the National Council for Science, Technology and Innovation has approved that by 2030 at least 20% of all procurement budget by all public institutions should go to innovative, precommercial procurement or 'purposeful/on-demand' R&D[64].
- Implement composite measures that integrate different RDI activities (across all development phases) and ensure a stage-based implementation approach. Successful implementation of one phase would result in a simplified application for the next phase. It is a sort of re-evaluation of the potential of the original idea and testing if the idea is still valid to be implemented.

There are three recommendations which were proposed by expert groups of earlier studies which are still valid today and are essential for successful implementation of the recommendations listed in this report. These are:

- Incentivise ministries and agencies to cooperate, and develop a common language and strategy to implement a mission-based approach (TAIEX report, 2019).
- Reassess services of business agencies and create a single Innovation agency would also contribute to increased synergies (Visionary Analytics, 2019[65]; Bullinger et al, 2018[66]).
- To address the need for professional boundary-spanning capacity, create a single national interface structure, as well as further efforts to strengthen operations within TTOs, DIHs, cluster organisations and other collaboration platforms (Bullinger et al, 2018[67]).

6.5 Recommendations on pre-commercial and innovation public procurement

6.5.1 Recommendation 9: Continue the support for PCP and PPI

It is recommended that Lithuania continue to develop the practice of pre-commercial procurement and innovative public procurement as stipulated by the Law on Technology and Innovation (2018).

There is no doubt that promoting innovation by procurement has two-folded effect: the public sector can use its procurement behaviour to stimulate businesses to develop new products and/or services, while these new innovative products and services can help the public sector to increase the quality of its services and reduce its costs.

A dedicated support measure, which in the 2014-2020 programming period 2014-2020 was called "Pre-commercial procurement LT", as a demand-side instrument has been innovative and enables new types of collaborations (Visionary Analytics, 2019a). It also

[63] References: https://epilietis.lrv.lt/lt/konsultacijos/del-2021-2030-metu-nacionalinio-pazangos-plano; https://epilietis.lrv.lt/uploads/epilietis/documents/files/2%20HORIZINTALIEJI(1).pdf
[64] Reference: https://strata.gov.lt/lt/naujienos/8-naujienos/570-susitarta-del-reiksming-inovacij-reformos-zingsni
[65] https://www.visionary.lt/reports-2/science-technology-innovation/evaluation-of-measures-fostering-business-rd-under-the-2014-2020-operational-programme
[66] https://rio.jrc.ec.europa.eu/sites/default/files/report/SS%20Lithuania_Final%20Report.pdf
[67] https://rio.jrc.ec.europa.eu/sites/default/files/report/SS%20Lithuania_Final%20Report.pdf

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has the potential to contribute to the strengthening of business-science cooperation and to the delivery of missions (if such an approach for the Lithuanian STI policy as suggested in this report is taken forward). These two types of contribution should not necessarily be set as the key objective for the PCP/PPI but where and when possible, need to be stimulated. Some of the PCP calls launched in 2020[68] by MITA give some interesting examples to illustrate these types of contribution. Here are just two of these examples:

- Two universities (General Jonas Žemaitis Military Academy of Lithuania and Mykolas Romeris University) in August 2020 launched a PCP to create of an ecosystem for the training and research of national public security professionals, looking into such areas as information security, information and hybrid threat analysis, integrated information space monitoring and analysis of potentially criminal content. If solutions for this request come from the private sector this will be a good example of a business-science cooperation and, hopefully, will lead to further cooperation in the future.
- Kaunas City Clinics in July 2020 launched a PCP to create an automatic risk identification and monitoring system for diabetes. Cases of diabetes in Lithuania are rising; and diabetes is a serious disease leading to many serious health complications (incl. death). For the sake of this example, let's imagine that Lithuania chooses a national STI mission focused on the reduction of diabetes cases. In such a case this PCP from Kaunas City Clinics would fit nicely into the delivery of this national mission.

Bringing PCP/PPI into the delivery of national missions is possible but would require certain flexibility in how the mission programmes are set. For example, in Sweden challenge-driven innovation is a broad programme focused on addressing specific societal problems. The way programme was set up offered the applicants a degree of freedom on how to apply, incl. going a PCP route.

6.5.2 Recommendation 10: Develop PCP/PPI capacities within the public sector

It is recommended to develop capacities of the public sector buyers in applying innovative solutions to solving identified problems. Capacity-building support instrument should cover an establishment of a network of 'innovative public procurers', facilitation of a joint problem-setting, targeted practice-oriented training and methodological support.

The success of the support measure requires further institutional, administrative and growth-sustaining structural reforms in order to increase its impact. As noted by experts (Visionary Analytics, 2019a) capacity-building activities of public institutions need to be strengthened.

Over the last few years Lithuania has implemented a range of capacity-building to raise awareness and increase the competences of public procurers. For example, the MoEI published the Guidelines on innovation procurement in 2014. MITA implemented project "Promotion of new type of public procurement – PCP and PPI" focused on lectures, trainings, consultations, identification of experts to assist public procurers, preparation of methodologies. Following the Law on Technology and Innovation in 2018 MITA was authorised to act as a national competence centre and has subsequently participated in some of the activities of the EU-funded project 'Procure2Innovation – European network of competence centres for innovation procurement" thus bringing international

[68] https://mita.lrv.lt/lt/veiklos-sritys/programos-priemones/ikiprekybiniai-pirkimai/paskelbti-pirkimai

experience which can further be utilised nationally. In parallel, Lithuanian Innovation Centre worked on the topic of PCP/PPI and earlier in 2020 published the Guidelines for the implementation of innovative public procurement[69] as part of the Interreg-funded iBuy project.

Despite all of these efforts the conclusions of the study SMART 2016/0040, that benchmarked national policy frameworks and investments on innovation procurement across Europe[70], state that, as of early 2019 many capacity-building activities were not in place in Lithuania. These included a lack good practice examples, template tender documents and of networking activities. In addition, several of the proposed activities were "not conceived yet to mainstream innovation procurement at large scale across all sectors in the whole country".

It is recommended to further develop capacity-building within the public sector in order to grow a proactive interest in public sector organisations to take a lead in applying innovative solutions to solving identified problems. A capacity-building support instrument should cover the following:

- Establishment of a network of 'innovative public procurers' as it is crucial to have people in the organisations who are able to develop and run this type of project and make it well-anchored in the organisation.
- Facilitation of networking and experience sharing among contracting authorities, where needed grouped by their type, e.g. municipalities, hospitals, fire stations etc.
- As part of these specific groups of buyers, facilitation of joint problem-setting, i.e. buyers from the same groups (e.g. municipalities) gather together with an aim to find out and discuss common problems. Solutions for these common problems can then be procured jointly by several municipalities.
- Targeted practice-oriented training courses for potential public sector buyers which have not yet participated in the PCP activities.
- Methodological support to the PCP/PPI projects
- Collection and dissemination of knowledge in a form of guidelines and good examples

6.5.3 Recommendation 11: Introduce a buyer-supplier dialogue

For a PCP/PPI process to work, there should be a clear interest and incentives for the public sector to get involved in this process. It is recommended that MITA start working with the public sector organisations in helping them in identifying the needs within their institutions.[71]

One of the successful PCP/PPI practices identified in the comparator countries was around the support for a preparatory phase which included a market analysis and a so called 'dialogue with the suppliers'. This phase is crucial in order to get the most suitable, innovation and cost-effective solutions to a problem identified by the public sector organisation. Needs must be properly identified (by users and end-users), prioritised and developed. It is also important to have a sufficiently deep knowledge of the technology

[69] Lithuanian Innovation Centre (2020). Inovatyvių viešųjų pirkimų įgyvendinimo gairės, as part of Interreg iBuy project, https://lic.lt/wp-content/uploads/2020/09/Inovatyviu-viešųjų-pirkimų-gairės.pdf

[70] European Commission (2019). Benchmarking of national innovation procurement policy frameworks across Europe; and SMART 2016/0040: The strategic use of innovation procurement in the digital economy – Country Report: Lithuania

[71] A similar observation about the importance of identifying the needs was made in a recent report: Lithuanian Innovation Centre (2020) Inovatyvių viešųjų pirkimų įgyvendinimo gairės, as part of Interreg iBuy project, https://lic.lt/wp-content/uploads/2020/09/Inovatyvių-viešųjų-pirkimų-gairės.pdf

presently available to be sure that a solution can be developed within the project period. Therefore, a market analysis is needed to gain an understanding of the potential suppliers, if only one supplier should deliver alone or if a combination of two suppliers with different competencies need to work together to find a solution

It is recommended to apply "Dialogue with the suppliers" in Lithuania to bring contracting authorities with potential suppliers to help understand the market. This can be organised as a range of facilitated brokerage events between a buyer and a supplier. Future users can be also be invited to these events. Over time, the dialogue with the suppliers can also include an online form. A dedicate online platform where suppliers could promote their products to public sector buyers could be created. This should be implemented only when the practice of innovative public procurement is well understood and embedded in the national system.

A dedicated support instrument could be create to facilitate market analysis and dialogues with the suppliers. Funding can be allocated, for example, from an instrument designed and funded by the MoEI. Or – even better – this support instrument can funded by thematic ministries as part of their innovation budget, e.g. MoH funding a scheme "Pre-commercial procurement in healthcare systems" (author's suggested title).

MITA in its role as a national competence centre should perform the role of a broker and a facilitator in these events. Special attention should be placed on supporting public institutions on deciding which ideas to take further or to stop the process altogether if solution does not deliver. This could help dealing with situation described by the Lithuanian stakeholders during one of the workshops in the current study:

> *"We participated in the first stage, we got the highest evaluation. They* [public sector buyer] *decided to go to the second stage, but the idea was not feasible at all. […] public sector is very weak in this field, but it has no sense, we are spending a lot of money developing 'whatever'."*

Such consultations with the market need to be reflected in light of the Lithuanian Law on Public Procurement, which was not reviewed during this study. If certain clauses in the Law prevent an open dialogue between the public sector buyers and the suppliers, we recommend reviewing the Law rather than rejecting an idea of the market consultations, which have proven to be extremely successful and valuable in other countries.

6.5.4 Recommendation 12: Increase an up-take through positive examples

It is recommended to focus on collecting and bringing to light successfully completed PCP/PPI projects as a way to stimulate interest in PCP/PPI both from the buyer and supplier side.

Companies might not necessarily be immediately interested in the PCP/PPI opportunities. Their understanding of and interest in the topic needs to be cultivated over time. Examples of successfully completed PCP/PPI projects, especially when a private company commercialised the delivered solution, is one way to motivate. Supporting a constant open dialogue between the public sector buyer and companies (as suggested earlier) is another such approach. This way companies could also offer certain feedback to the public sector buyers on their procurement process and requirements set for the requested solution, thus making them an active player in the PCP/PPI process.

If growing by example is taken as an approach (at least at the initial uptake stage) it will also help address a question of quality. The PCP projects in Lithuania have a phase-based approach. To start, with a concept is created, followed by a prototype; finally a small scale 'product' is produced and tested. The aim should not be to move from stage

1 to stage 3 at all costs, but to create a fully working and the most sensible solution for a problem. With this in mind, we recommend the introduction of a stage-gate system and not to be afraid to stop the project. As pointed by a stakeholder consulted during this study:

"The institution [public sector buyer] is responsible for the quality, so ideas might not be great at the start, but they pass. But then if they don't work out, kill them. But now, they [public sector buyers] are motivated to have projects and spend the money, so they continue on doing it"

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Annex 1 International comparator - Ireland

This summary presents a review of the best practice analysis in Ireland in the topic of business-science cooperation and pre-commercial public procurement and procurement of innovation.

1.1 Macroeconomic and innovation performance context

Ireland is a small country with a population below 5 million and large variations in regional employment. The country is experiencing strong economic growth with GDP growing by 8.2% in 2018. This was largely boosted by multinational companies operating in Ireland. Although real GDP growth is slowing due to the uncertainties linked to Brexit, it was estimated to have grown strongly in 2019 (5.6%) (European Commission, 2020). Today Ireland is not by any means a laggard country. The GDP per capita is 84,575 USD (in Purchasing Power Parity, PPP) making it one of the wealthiest EU countries. Over the years the growth has been driven not only by the local demand but also by exports and strong performance from the Foreign Direct Investments (FDI). Ireland exports mainly pharmaceuticals, medical devices and software-related goods and services, largely produced by foreign-owned companies. Over the years such companies have increased their share and mostly dominate in the highly productive sectors of the Irish economy (RIO, 2017).

Ireland has a good innovation performance in a range of areas – including SME innovation rates, share of the population with higher education, employment in knowledge intensive sectors and high technology exports (OECD, 2019). In the Global Innovation Index (GII) list, Ireland ranks 12th on a global scale (two positions down since 2018) and 8th in Europe (GII, 2019). Its key strengths are IP payments and FDI net outflows (and knowledge absorption in general) and ICT services exports, closely followed by computer software spending and high- & medium-high-tech manufactures. Exports are 122% of GDP; FDI inflow/outflow and IP payments are at a completely different level to any other EU-country with FDI outflow at 246% per GDP (EU average 60%). The country is classified by 2018 European Innovation Scoreboard (European Commission, 2019b) as “Strong Innovator” in 9th position just below the “Innovation Leader” countries. Although its Summary Innovation Index dropped slightly from 119.97 in 2017 to 117.63 in 2018, Ireland outperformed the EU average on most indicators. In addition, its performance has improved relative to that of the EU since 2011. The country performs well in terms of impact of innovation on employment, presence of innovators and quality of human resources (Indecon, 2017).

The country’s Digital Economy and Society Index (DESI) has improved over the years raising from 52.8 (ranking the 10th) in 2017 to 57.0 (ranking the 8th) in 2018 to the current 7th rank with 61.4 score (European Commission, 2019a). Ireland is number 1 in the EU in the Integration of digital technology dimension (especially because of the SMEs’ excellence in using e-commerce). The country also records the highest growth in Digital public services with top ranking in open data and second place in services for business users. However, in terms of Connectivity and Human capital it ranks outside the top 10.

Participation in Horizon 2020 is on course to meet the €1.25bn target (DBEI, 2019). As of October 2018, Ireland won €632.1m in contracts with over 1,500 successful participants, which is more than the seven years of the previous Framework Programme. It accounts for 1.69% of total funding allocated until October 2018 (€35.5bn) under Horizon2020 and well ahead of the *“juste retour”* of 1.2%. Success rates in applications

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was at 15% – also higher than the EU Member State average – with the highest success rate (20%) under the SME Instrument (DBEI, 2019).

Although Ireland has enjoyed robust economic growth over the past years, (also helped by reforms), some challenges still remain (European Commission, 2020). The growth prospects of the country are somewhat at risk due to the uncertainties brought in by Brexit as well as high dependency on foreign-owned multinationals.

The scale and nature of R&D activity (with GERD 1.16% per GDP and a policy target of 2%) is uneven between indigenous and foreign-owned businesses and the level of private co-funding of R&D expenditure is low by international standards (Indecon, 2017). The latter together with a relatively low volume of R&D expenditure by the public sector, (which was scaled back in the aftermath of the financial crisis), were also identified as weaknesses during the 2018 OECD review. Whereas in 2009, the government R&D budget (GRDB) amounted to 0.63% of GDP, this declined to 0.32% in 2017 and is estimated to have fallen to 0.30% in 2018 (according to provisional data) (DBEI, 2019). This is low by international standards, where the average OECD country spent 0.51% of its GDP on GRDB in 2016. The 2019 European Semester Report for Ireland (European Commission, 2020) noted that a weak performance in terms of R&D funding, the structure of public support for business R&D and cooperation between firms and research bodies need to be addressed and innovation among Irish indigenous firms could be improved. Even though foreign owned companies accounted for only 19% of all relevant firms, they accounted for 64% of all innovation-related expenditure (European Commission, 2020). Other reported weaknesses are expenditure on education, government funding/pupil secondary, domestic credit to the private sector, market capitalisation, intensity of local competition, high-tech imports, and creative goods & services (GII, 2019).

A recent OECD review (OECD, 2019) contains a number of recommendations paramount to the further development of the Irish research and innovation system and, as such, can contribute to the business-science cooperation. These include:

- Strengthen cooperation between companies (especially smaller ones) with the research base and other relevant innovation players (such as commercial labs).
- Adapt the R&D tax credit instrument to encourage innovation collaborations by SMEs by increasing the share of subsidies that flow to smaller firms involved in outsourcing R&D tasks to research and technology organisations, and considering shifting resources to large firms for R&D undertaken with SMEs and Irish technology centres.
- Further develop strategic collaborative R&D and innovation programmes in specific sectors through the Technology Centres programme covering strategic sectors for the Irish economy where R&D and innovation intensity is lower than could be expected, such as the food industry and the bio-economy
- Consider additional targeted support for the technology validation phase for SMEs to fill a gap in the pipeline from concept to exportable product or service.
- Encourage more public sector bodies to participate in SBIR Ireland innovation challenges for pre-commercial public procurement.

1.2 Key STI features

The Irish Research, Development and Innovation (RD&I) system is centralised. Therefore the RD&I policies and budgets being controlled and implementation by

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Departments and statutory agencies (RIO, 2017). **The main research and innovation actors** in Ireland include:

- the Department of Business, Enterprise and Innovation (DBEI) and the Department of Education and Skills (DES) – both responsible for leading National Strategic Outcome 5 – A Strong Economy Supported by Enterprise, Innovation and Skills (NSO5) as written in "Project Ireland 2040", the Government's vision for the development of the country over the coming decades;
- seven universities (accounting for approx. 80% of research funding) advancing knowledge through teaching and scientific research and 14 Institutes of Technology (IoTs) focused on teaching and purpose-driven research;
- a number of other third level and postgraduate institutions, several of which provide specialist training and focussed research in disciplines such as medicine and art;
- Science Foundation Ireland (SFI) – the statutory body responsible for funding oriented basic and applied research in the areas of Science, Technology, Engineering, and Mathematics (STEM). It sits under the Department of Business, Enterprise and Innovation and has the largest among various agencies annual budget (€199m for 2020). A relatively young agency, SFI was established in 2003 with initial priority areas of life sciences and ICT;
- Enterprise Ireland (EI) – the government agency responsible for supporting Irish businesses in the manufacturing and internationally traded service sectors. They are particularly interested in collaborations where industry defines a problem to be solved with the help of academia.
- IDA Ireland was founded in 1949 and since 1994 has been focusing exclusively on the promotion and development of high-quality foreign direct investment in Ireland. The policy aims at attracting investors from a range of sectors which are seeking the best location for their Advanced Manufacturing, Global Business Services and R&D operations.
- The Irish Research Council (IRC) funds research across all disciplines and research areas from humanities, social sciences, business, law and STEM
- Health Research Board (HRB), a government agency responsible for funding, co-ordination, and oversight of medical research in Ireland.
- Knowledge Transfer Ireland (KTI) is the central Technology Transfer Office which supports effective commercialisation and makes it simpler for business and investors to benefit from publicly-funded research. Enterprise Ireland houses KTI and provides the majority of the team. It also funds the majority of the KTI activities with the Irish Universities Association funding parts of the activities.

The development of the RD&I system and policy in Ireland has been gradual. In 2010, Ireland initiated a **National Research Prioritisation Exercise** (RPE) and published the Report of the Research Prioritisation Steering Group in 2012. At that time 14 priority areas were chosen and the implementation strategy was established in the Action Plans published in July 2013. In 2016 the Research Prioritisation Action Group was merged into the Innovation 2020 Implementation Group. Its remaining actions and progresses is being report under the Innovation 2020 progress reports.

Published in December 2015, **Innovation 2020 is Ireland's cross-Government strategy for research and development, science and technology** which sets the

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basis for RD&I in Ireland. In the research policy area, new sectoral or thematic research strategies were also developed: the National Policy Statement on the Bioeconomy was launched in March 2018, the National Marine Research and Innovation Strategy (2017-2021) was introduced in 2017; and the Report of the Energy Research Strategy's Group was published in 2017.

Innovation 2020 was built on the national Strategy for Science, Technology & Innovation 2015-2020 but also took a new direction. Innovation 2020 is a "whole government strategy" covering the implementation of 140 actions by Enterprise Ireland, Science Foundation Ireland, the Local Enterprise Offices and a number of other departments and agencies. All of these different government departments and agencies are involved and being accountable for the delivery of the programme and there is a structured way of monitoring and tracking the delivery towards the aspirations. Two changes compared to the previous strategy were around a research prioritisation plan and a very clear regional dimension. Business-science cooperation as a topic stands on its own. The strategy also positioned 14 research priority areas within six broad industrial themes of ICT, health and medical, food, energy, manufacturing and materials as well as services and business processes.

The mid-term review of Innovation 2020 (DBEI, 2019) concluded that policy developments since 2015 confirmed the relevance of Innovation 2020 objectives, especially the one linked to the increase of innovation across national enterprise base by increasing the number of R&D performers as well as the R&D intensity for those who already innovate. It also confirmed that the rational for research prioritisation with 14 priority areas within six broad enterprise themes remains valid. The key changes involved the enhancement or broadening of those priority areas. For example, the ICT theme was expanded to reflect the growing importance of technologies such as robotics, Artificial Intelligence, Augmented Reality and Virtual Reality. The energy theme was broadened to both address climate change and sustainability and to maximise opportunities for companies. The refreshed Priority Areas are as follows:

ICT	Health and Wellbeing	Food
• Future networks, communications and Internet of Things • Data Analytics, Management, Security, Privacy, Robotics and Artificial Intelligence (including Machine Learning) • Digital Platforms, Content and Applications, and Augmented Reality and Virtual Reality	• Connected health and independent living • Medical devices • Diagnostics • Therapeutics	• Food for Health • Smart and Sustainable Food Production and Processing
Energy, Climate Action and Sustainability	**Manufacturing and Materials**	**Services and Business Processes**
• Decarbonising the Energy System • Sustainable Living	• Advanced and Smart Manufacturing • Manufacturing and Novel Materials	• Innovation in Services and Business Processes

The innovation strategy is currently being updated for the next period but the process has somewhat slowed down due to the COVID-19 pandemic.

In June 2018, **DBEI published an investment overview which summarises the strategic investment priorities** with a foreseen capital funding of €3.16bn to 2022 and a planned total allocation of €9.4bn to 2027, which will deliver the NSO over the period 2018-27. A portion of this capital allocation will go to fund research and innovation (DBEI,

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2019). In 2018, research expenditure (less block grant) by the research performing organisations (RPOs) was approx. €599m (vs. €563m in 2017) covering the total expenditures on all types of basic and applied research from all funding sources, such as government, industry, non-profit foundations etc. The University sector accounted for most of the research expenditure at approx. 77% (€463m). The Institutes of Technology sector accounted for approx. 11% (€65m). The Specialist Institute sector (RCSI, NCAD, NCI) and the State Research Bodies (Marine Institute and Teagasc) accounted for the rest. This is a similar profile to previous years. (KTI Annual Report, 2018).

In the future funding of research and innovation DBEI highlighted a strengthening of the network of Research Centres and Technology Centres in the regions, developing a National Space Technologies Programme and a national High Performance Computing programme, funding memberships of International Research Organisations, establishing a Disruptive Technologies Innovation Fund, and supporting the development of Technology & Innovation Poles through which Institutes of Technology will partner with companies to develop strategic agendas for their regions supporting SME productivity and innovation, entrepreneurship and start-ups (DBEI, 2019).

Since the launch of Innovation 2020 research, enterprise and skills priorities and policies have evolved to respond to the changing policy context. **In 2019 the cross-government strategic framework Future Jobs Ireland was launched** to define a new economic pathway for Ireland. The aim of this framework is to support innovation and technological change, improve the SME productivity, enhance skills, increase labour force participation and smooth transition to a low carbon economy. Innovation is seen as key to enterprise growth and diversification and to positioning Ireland at the forefront of disruptive technologies (DBEI, 2019).

To complement existing initiatives and to support private investment in emerging and enabling technologies, in 2018 the government announced **a launch of a Disruptive Technologies Innovation Fund** (DTIF) as part of Project Ireland 2040. It will invest €500m until 2027. The operation of the call is going through Enterprise Ireland but the Fund sits under the DBEI.

Related to the Fund there is **a shift towards mission-oriented or challenge-based funding**. The aspiration of the Fund was also to be challenge-based but this has not yet been manifest in the calls description. Challenge-based funding was set up by SFI as a solution-focused approach to research funding designed to direct research activities towards critical societal problems. Currently it is organised under the SFI Future Innovator Prize programme. In 2019 calls were opened for the Artificial Intelligence for Societal Good challenge and Zero emissions challenge. Next call is scheduled for 2020 and initial focus will be on challenges aligned with the Climate Action Plan (SFI, 2020). The key principles in setting up challenge-based are these:

- Funding should address one specific challenge. These should be visionary and inspirational but achievable and should lead to transformations in the economy and society if addressed successfully.
- Challenges need to be defined through collaborations between different stakeholders, including innovators, beneficiaries and end-users.
- Funding should focus on delivering solutions.
- Funding should be stage-based, with tight delivery timeframe and competitive.

Such a challenge-based approach is still new. The national system has not yet been fully involved and changed to adopt this approach. Current activities are on a small scale but as a starting point provide a good way to test if the approach is working. Nevertheless,

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the mid-term review of Innovation 2020, also calls, among areas to further enhance economic and/or social impact, to consider mission-oriented funding to address societal challenges, most notably associated with the pursuit of the UN Sustainable Goals, also with some alignment of this funding with EU Research programmes (DBEI, 2019).

1.3 Business-science cooperation

Cooperation between firms and public research centres continues to face challenges (European Commission, 2020). Indigenous companies show a lower rate of collaboration with academia compared to foreign MNCs. Enhancing collaboration between enterprise and academic research; improving the level and performance of R&D by indigenous enterprises; increasing R&D and embeddedness of multinationals in the research system are some of the key goals that are being addressed by various existing support activities and instruments (RIO, 2017).

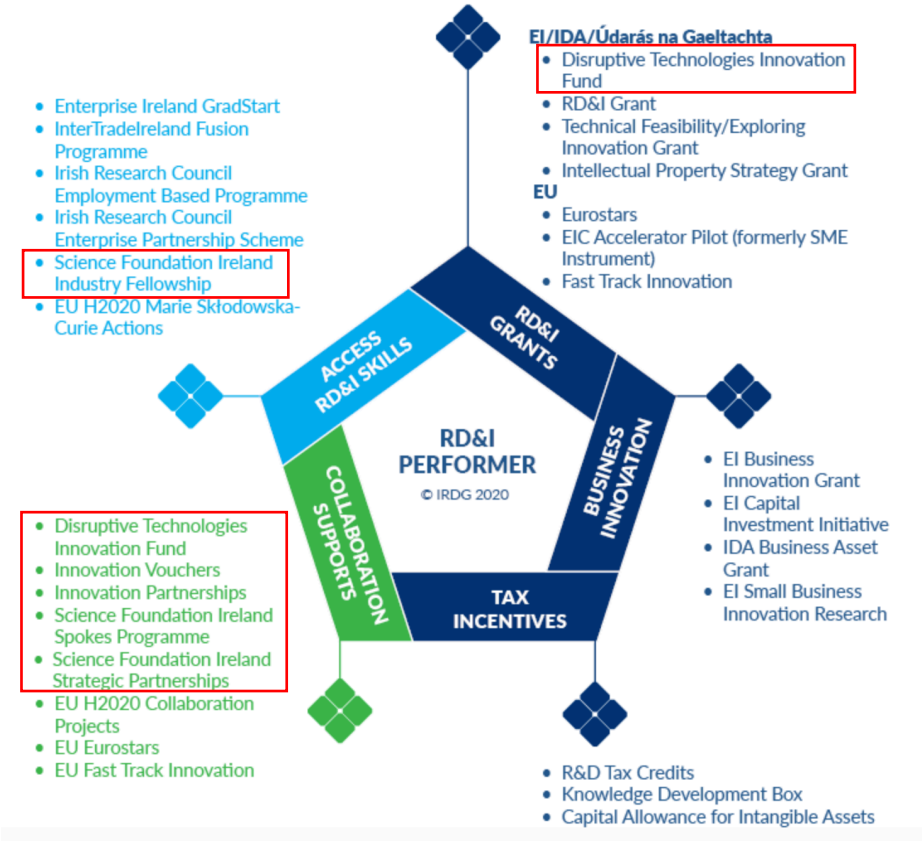
As a result of the recommendations from a Government-led task force on business science collaboration (DJES, 2012), Knowledge Transfer Ireland was set up in 2013. Its remit is to help businesses to establish connections with the Irish research base – universities, Institutes of Technology and other State-funded research organisations, collectively termed Research Performing Organisations (RPOs) – to progress innovation and commercialisation of research and IP available in the publicly-funded research system.

Since 2014 KTI has been running an Annual Knowledge Transfer Survey (AKTS). According to the latest annual review of business interaction and commercialisation from publicly-funded research in Ireland, the number of industry-related Collaborative Research Agreements signed (part and wholly funded by industry) has increased in 2017 by 9% to 745. Of these, the number of Collaborative Research Agreements signed that relate to projects fully funded by industry has risen from 427 in 2017 to 445 in 2018 and the proportion of fully funded agreements dominated, at 60% of the total. When the Innovation Voucher funded projects are included, the total number of agreements signed that related to R&D projects rises to 1,293 (from 1226 in 2017). In 2018, the number of Consultancy Services Agreements signed with industry increased by 22% to 818 from 670 the previous year (KTI Annual Report, 2018).

The total number of collaboration agreements (including innovation voucher funded projects) and consultancy services agreements executed with industry in 2018 was 2,111. This represents an increase of 11% on 2017. Overall the RPOs have signed collaboration agreements with 1,077 different companies and there were 365 repeat engagements with the same company, or companies, within the past three years, an increase of 19% on the previous year. There were 1,824 research collaboration projects (wholly and part-funded) with industry live at 31 December 2018, and an increase of 3.8% on 2017 (KTI Annual Report, 2018).

Irish policy makers have attempted to address the challenges through various support measures that have some elements of support towards business-science cooperation. They take into account the type and size of companies and have everything from a small amount of funding through to larger programmes which follow research collaborations. The overall package of all possible support measures for an RD&I performer is illustrated in the picture below created by the Industry Research and Development Group (IRDG), an industry-led group representing companies involved in RD&I activities from different sectors, including electronics, software & telecommunications (ICT), financial services, food, software, engineering, healthcare & life sciences, plastics and utilities.

The project was funded by the European Union via the Structural Reform Support Programme and implemented by EFIS Centre and Visionary Analytics in cooperation with the European Commission's Directorate General for Structural Reform Support.



Source: Industry Research and Development Group (IRDG), 2020, http://www.irdg.ie

What are missing from the picture are the SFI Research Centres, the EI/IDA Technology Centres, EI Technology Gateways, and SFI Future Innovator Prize which are all contributing to the development of business-science cooperation. These various measures– and their impact, where known – are presented further.

Support Instrument / Programme	Organisation in charge	Who can apply	Level of funding	Reporting / KPIs	What is covered
Innovation Vouchers	Enterprise Ireland	• Small and medium-sized **limited** companies registered in Ireland from all sectors (excl. agricultural) • Companies with in excess of €300,000 funding from EI in the previous 5 years not eligible for a fully funded Standard Innovation Voucher • Company could have one 'active' voucher at a time	€5,000-€10,000	• Summary of project activity undertaken by researcher(s) • Technical Report from the performed activity	• Salary costs of researcher(s)s, small items of equipment and materials, small amount of travel

Support Instrument / Programme	Organisation in charge	Who can apply	Level of funding	Reporting / KPIs	What is covered
SFI Industry Fellowship Programme	Science Foundation Ireland	• Academic Fellow when applying for an academia-to-industry fellowship • Academic Mentor when applying for an industry-academia fellowship	• Max €100,000	• Potential for long-term collaboration • Enhancement of the career perspectives and employability • Results of the work, incl. IP	• Teaching buyout • Some mobility allowance • A salary contribution in case of postdocs • Indirect or overhead contribution to the applicant's Research Body
Innovation Partnership Programme	Enterprise Ireland	• Application is managed by a PI in the participating research institute • Companies, which are registered clients of Enterprise Ireland, IDA Ireland, Local Enterprise Office, Údarás na Gaeltachta	• Up to 80% of cost of research work • 20% from company • Funding from EI will normally not exceed €220,000 • Capped at €100,000 for start-ups and HPSUs	• Project duration up to 24 months • Interim report for projects longer than 12 months • Final report, incl. technical report and final financial accounts • Technical report covers summary of results, benefit to the research group, benefit to the country (scientific, educational, economic and social), benefit to the company incl. tangible results, steps for commercialisation	• Salaries (at least 60% of the project cost) • Materials and equipment (20-25%); travel (10%); small amounts towards consultancy
SFI Spokes Programme	Science Foundation Ireland	• An applicant may only be Centre Directors of the SFI Research Centres	• Expected contribution from partners: min 50% cash contribution under the Rolling call; 30% under the Fixed call • There is no min or max project size	• Value of the research to the expansion, development and sustainability of the SFI Research Centre • Potential economic and societal impact (e.g. benefit s of research to the industry partner and host institution, benefit to Ireland)	• Contributions to salaries/stipends of research staff hired specifically to carry out the research programme • Materials and consumables, equipment and travel • Access to facilities and services • SFI approved access charges
SFI Strategic Partnerships	Science Foundation Ireland	• Academic applicant	• 50% from industry (in cash) and 505 from SFI	• Economic and societal impact	• *Not found*
SFI Research Centres	Science Foundation Ireland	• Funding application is led by a future director of the Centre	• €1-5m/year in direct costs to up to 6 years • Min 30% must come from industry, at least 1/3 in cash	• Journal and conference publications; • MSc/MEng and PhD graduates • % trainee department to industry • Participations and coordination in major EU initiatives • ERC awards granted • Funding from non-exchequer, non-commercial sources • % Industry costs share (cash and total) • EI Commercialisation Awards • Licence agreements • Spin-out companies formed	• Costs of the operational team, a core budget (1/3 of total) for research (research staff and research consumables) • Some funding for equipment (capital and non-capital)

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Support Instrument / Programme	Organisation in charge	Who can apply	Level of funding	Reporting / KPIs	What is covered
EI/IDA Technology Centre	Enterprise Ireland / IDA Ireland	• Academic institution (based on the detailed description of needs from the industry)	• Initial funding approx. €1m	• Funding from industry, growth in a number of participating companies, licences, revenues from them, spin-offs, new products and process • Exact metrics are negotiated with each centre • One KPI important for all is Economic Value Add (EVA) with EI's goal of 4-to-1, i.e. each 1 EUR from the state funding should bring 4 EUR.	• Mostly salaries, a bit of capital equipment • (NB: A new capital equipment call in 2020 allows for purchase of equipment)
EI Technology Gateways	Enterprise Ireland	• Institutes of Technology	• Access of companies is funded via competitive programmes (e.g. Innovation Vouchers)	• Funding share from companies is one of the primary metrics	• Mostly salaries, travel and a bit of money towards promotion
Disruptive Technologies Innovation Fund	Enterprise Ireland	• An application can be led by SMEs, research organisations or MNCs	• Min funding request should be €1.5m over 3 years • Research performing organisations can receive up to 50% funding • Match-funding from industry	• Disruptiveness of technology; economic and market impact (in 3-5 years)	• Salaries, materials, travel and subsistence, contractual research
SFI Future Innovator Prize	Science Foundation Ireland	• Teams of researchers / postdocs from research organisations	• €20k (concept for 3 months); €200k (seed for 9 months) and (€1m Prize for 12 months)	• Solution to a challenge; transformative societal impact	• *Not found*

Source: compiled by the authors based on information about individual programmes:
- SFI Research Centres – Annual Report 2018 and https://www.sfi.ie/funding/funding-calls/
- Innovation Vouchers, https://www.enterprise-ireland.com/en/funding-supports/Company/HPSU-Funding/Innovation-Voucher-FAQs.pdf
- Innovation Partnership Programme Brochure 2020, https://www.enterprise-ireland.com/en/Research-Innovation/Companies/IPP-Brochure.pdf

Innovation Vouchers

What the Irish policy makers have realised over the years is that for the indigenous Irish companies to get interested in cooperation with the science base, it is crucial to start with for these companies to be involved in research and innovation activities. Only when the companies themselves are engaged in R&D will their interest in business-science cooperation grow. Companies need to be actively interested and actively spending on R&D. Small scale grant-based schemes, such as innovation vouchers, are one way of keeping this interest and practice alive.

The main objective of the Innovation Voucher scheme is to increase interactions between publicly funded research organisations such as the universities and Institutes of technology and small and medium-size businesses in Ireland.

Two types of vouchers are available: Standard €5,000 vouchers can be applied for during regular open calls and Co-funded Fast Track Applications where the value of the voucher is €5,000 and the company contributes 50% of the project costs in cash (hence, total

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budget of €10,000). By end of 2018, 558 innovation vouchers were redeemed to solve small business problems (Enterprise Ireland, 2018).

Innovation Partnerships

Run by Enterprise Ireland the Programme encourages Ireland-based companies to work with Irish research institutes, resulting in companies accessing expertise and the research centre benefiting in terms of developing skill sets, intellectual property and publications. In 2017, a record 85 innovation partnerships were approved, 36 of which were between EI client companies and higher education institutes. In 2018, the numbers were 55 and 25 accordingly (Enterprise Ireland, 2018).

The application to Enterprise Ireland is managed by a Principal Investigator in the participating research institute. Up to 80% of the costs of research work to develop new and improved products, processes or services, or generate new knowledge and know-how can be covered. All projects require the company partner to provide minimum cash contribution of 20% of the total project cost. Funding from Enterprise Ireland will normally not exceed €220,000.

The applications process includes two phases. In phase 1 an applicant either submits an Outline Proposal Document or applies for an Innovation Partnerships Study (a small 100%-funded grant to a limit of €9,000). In phase 2 a Full Application is submitted. In 2020 Full Proposals can be submitted towards one of 11 deadlines. Outline Proposals and Feasibility Proposals can be submitted at any time.

Disruptive Technologies Innovation Fund

Enterprise Ireland administers a recently set up Disruptive Technologies Innovation Fund. Although at first glance it can come across as a measure to boost innovation, it does also aim to foster collaboration between business and a research base. The Fund supports projects involving SMEs and large firms (including in partnerships with public research bodies) around a “disruptive tech” agenda. The projects selected should last up to three years and be large-scale projects in the range of €5-10m total cost, inclusive of enterprise co-funding, and should fit within the research priorities for 2018-23 (for the first phase of funded projects to 2022) and be at TRL3-7. Collaboration is an essential requirement (with minimum 3 partners) as is the participation of at least one SME and the project proposals must demonstrate they will be sufficiently “disruptive” and benefit the Irish economy (all consortium participants must be based in Ireland to receive funding, but non-Irish based organisations may participate). Two calls (in June 2018 and June 2019) have been launched so far resulting in €140m funding across 43 projects with 159 partners. Some examples of funded projects include: AI and machine learning to help treat Gastro-Intestinal diseases; additive manufacturing (using 3D printing) for medical devices; Internet of Things to create secure, remote patient monitoring; new laser technology to disrupt optical telecoms. Projects are led either by SMEs/startups, a research performing organisation, or a multinational.

SFI Future Innovator Prize

The SFI Future Innovator Prize is another support instrument which although was not set up to directly support business-science cooperation, does contribute to this topic. The prize supports close collaboration between researchers and solution beneficiaries so that relevant, meaningful and important challenges can be identified and validated. With this in mind it is expected that the solutions are developed in collaboration with beneficiaries to maximise their societal impact potential.

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It consists of three phases: Concept, Seed and Prize award. €20,000 at the Concept phase is awarded for team building, scoping and concept validation. After an interview, shortlisted teams receive €200,000 to further validate and prototype. The finalist get an overall prize of €1m. The Prize began in 2018 and 12 awards were made in 2018 under the 1st Call with a €3.1m prize fund (SFI, 2018).

SFI Spokes Programmes

The SFI Spokes Programme supports the addition of new science or business partners and projects to SFI Research Centres. This allows the Research Centres to expand and develop new priorities and ensure that the research is cutting edge and brings industrial relevance. The programmes also facilitate the linking of different Research Centres. It can also be used as a way to encourage clusters of SMEs to join the consortium where an individual might not otherwise have the financial means to do so.

At least one industry partner (either new or existing) with co-funding should be involved in the application. Companies participating in the EI/IDA Technology Centre are encouraged to participate as industry partners in the SFI Research Centres Programme.

The Programme operates through two calls – fixed and rolling. The fixed call is currently closed but the Rolling call is open until further notice. The Spokes Programme will be the focus in 2020 under the SFI Research Centres development (SFI, 2020).

SFI Strategic Partnerships Programme

The SFI Strategic Partnerships Programme is specifically targeted at funding research opportunities that are not otherwise funded by other national programmes. The key objective is to develop partnerships of scale, hence the expectation is for the partners to bring significant co-funding. At the end of 2018 there were a cumulative 20 Strategic Partnerships with industry with a total industry contribution of over €25m. In 2018 only one award was made under this Programme. FINTECHNEXT is a €3m fintech research collaboration between Fexco (a multinational financial and business solutions provider), University College Cork and SFI. This 4-year project will involve 12 newly appointed researchers.

The Programme is open on a rolling basis to applications. In 2020, this Programme will continue to support co-investment partnerships with the private sector including industry, charitable organisations in areas not covered by existing SFI Research Centres.

The SFI Industry Fellowship programme

This programme supports post-doctoral researchers or academic members to spend time in industry or an industrial researcher to spend time in academia (for up to a year on a full-time basis or 2 years on a part-time basis). Its purpose is to enhance business-science collaborations through the funding of collaborative research projects and through knowledge exchange and training. A LinkedIn group “SFI Industry Fellowship Programme” was set up to facilitate networking.

A maximum grant of €100,000 is available to fund the salary and other costs of the researchers in a company. Since the launch in 2013, over 149 industry partnerships have been established, with 50% of the awards made have been with SME partners.

SFI Research Centres

The goals of SFI Research Centres are to link scientists and engineers between academia and industry to address crucial research questions; to foster the development

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of new and existing Irish-based technology companies; to attract industry that could make an important contribution to Ireland; and to expand educational and career opportunities in science and engineering.

SFI Research Centres are set up in thematic areas. In terms of engagement with the companies, it is mostly provided via a one-to-one support. MNCs are heavily involved in the Research Centres but the work is also done with SMEs. Centres are based in HEIs with the exception of VistaMilk which is hosted by Teagasc, a state agency providing research, advisory and education in agriculture, horticulture, food and rural development in Ireland. Researchers, however, are drawn from across various universities and IoTs to form a critical mass of focussed research expertise.

Currently there are 16 SFI Research Centres. The initial seven were set up in 2013. They were an amalgamation of clusters and Centres for Science, Engineering and Technology (CEST) which were larger versions of clusters and which were expected to engage with companies (via in-kind contributions) who would benefit from research. For example, there were five centres linked to data analytics which came together. In 2015 an additional five centres were funded with €355m from the state and €190m from industry. An additional four were established in 2017 bringing €74m public investment over 6 years with an additional €40m from industry. In October 2017 SFI approved the establishment of another centre in agri-food which at that time had 45 industry partners with a €16m contribution. In 2019, a final four centres were announced.

ICT	Health and Wellbeing	Food
• ADAPT: SFI Research Centre for Digital Medical Technology • CONNECT: SFI Research Centre for Future Networks & Communications • Lero: SFI Research Centre for Software • Insight :SFI Research Centre for Data Analytics	• FutureNeuro: SFI Research Centre for Chronic and Rare Neurological Diseases • CÚRAM: SFI Research Centre for Medical Devices • APC Microbiome Ireland • SSPC: SFI Research Centre for Pharmaceuticals	• VistaMilk: SFI Research Centre for Digitalising Dairy Production and Processing
Energy, Climate Action and Sustainability	**Manufacturing and Materials**	**Services and Business Processes**
• BiOrbic: SFI Bioeconomy Research Centre • BEACON: Biological resources as alternative materials to finite fossil resources • iCRAG: SFI Research Centre in Applied Geosciences • MaREI: SFI Research Centre for Energy, Climate and Marine	• CONFIRM: Smart manufacturing IT and industrial automation systems • Deantus: Innovative techniques and processes in Additive Manufacturing • I-Form: Advanced Manufacturing Research Centre • IPIC: photonics • AMBER: Advanced Materials and Bioengineering Research (2019) • IPIC: Irish Photonic Integration Centre	• none

Source: compiled by authors matching SFI Research Centres with the Irish Research Priority Areas

To date, the SFI Research Centres have seen an investment of €434m in public money and €235m industry commitment. Centres brought €196m of additional funding, 18 Spoke Awards, 182 licensing agreements, 27 spin-outs and 324 EI Commercialisation Awards. For every €1 invested by the State in the SFI Research Centres, approx. €5 is leveraged back to the economy (SFI, 2018).

A contract is signed for 5 years. During the first few years the Centres must develop their research plans which should help them attract the best companies and more companies.

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There is no requirement to bring companies until the last two years of the initial funding period. Initial funding is given for three years and then the Centre has to apply for the final two years. The two crucial assessment criteria for the last two years are impacts and 25% of budget should come from industry (underpinned by legal agreements, e.g. consortium agreements). When the funding is confirmed for the next 5-year phase, the objective for the budget to be 1/3 from SFI, 1/3 from industry and 1/3 from other sources (e.g. competitive international). Over the 5-6 years SFI can invest €30-40m into a Centre.

EI/IDA Technology Centres

The story of the EI/IDA Technology Centres starts at the time of the Science, Technology & Innovation 2015-2020 strategy. A detailed consultation with industry took place in order to identify the topics which could be of ***collaborative interest to groups of companies***. The topics that came back from businesses were different to those that would have been suggested by academia. This was exactly the goal as the objective of the Enterprise Ireland Technology Centres is to respond rapidly to industry-defined needs and conduct market-relevant R&D in partnership with collaborating groups of companies. Collaborations between several participants are considered to bring a bigger value than projects between an individual researcher/s and one company. The Centres are also instrumental to the IDA's work. When the IDA tries to convince another wave of inward investment to come to Ireland, the Centres become part of the story and a proposition.

With one exception, all of the centres are embedded in existing universities but are industry-led in terms of research direction. Currently there are ten centres.

ICT	Health and Wellbeing	Food
• CeADAR: Ireland's Centre for Applied AI • LEARNOVATE: Leading Learning Innovation	• n/a	• DPTC: Dairy Processing Technology Centre • FHI: Food for Health • MTI: Meat Technology Ireland
Energy, Climate Action and Sustainability	**Manufacturing and Materials**	**Services and Business Processes**
• n/a	• IMR: Irish Manufacturing Research • IComp: Irish Centre for Composites Research • MCCI: Microelectronic Circuits Centre Ireland • PMTC: Advanced Technology Solutions in Pharmaceutical Manufacturing	• IVI: Innovation Value Institute

Source: compiled by authors matching SFI Research Centres with the Irish Research Priority Areas

There were 16 Centres at some point but a number of them have been discontinued. One centre did not bring a desired multiplier effect; another centre became too academic and lost contact with industry; and, for example, the Centre in cloud computing has served its purpose as after five years cloud computing became the norm. These are three typical reasons for discontinuing the centres. The researchers were re-absorbed into the existing research institutions. Only one of these discontinued centre fully disappeared.

Technology Centres are all membership based. The expectation is that 5-6 companies will be there from the beginning but when the centre is formed, other companies will join. For the mature centres, memberships may become of decreasing importance and the model can evolve. But in the beginning it is important to get the financial commitment from the companies. At the end of 2018, 844 companies were involved with the EI/IDA

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Technology Centres. Of these 525 were full members in the centres (EI, 2018). Although the membership in the centres did not change compared to 2017, there was an increase in company involvement from 785 in 2017.

The initial funding from the State is approx. €1m for 5 years. The funding changes over the years and depending on the performance of each centre. For example, after a recent review of the Manufacturing Centre it was agreed to allocate €23m over 5 years from public funding. The annual spend on Technology Centres by Enterprise Ireland is more or less the same – €18m for all centres. The funding model of Technology Centres is a 1/3 model: 1/3 core funding from Enterprise Ireland, 1/3 from industry (showing that industry is interested to be involved and spend) and 1/3 international competitive. This model is not possible from day one, taking several years to build.

The Centres get a 5-year contract with Enterprise Ireland and are reviewed at year 3. At this time a decision about funding for the next 5 years is made. If the performance is poor, the contract is terminated. If the performance is average, the Centre is allowed to operate until the end of year 5.

Considering both the SFI Research Centres and the EI/IDA Technology Centres programmes some observers point to an overlap in activities and engagement with industry between these two programmes. (OECD, 2018).

EI Technology Gateways

Enterprise Ireland also coordinates a network of 15 Technology Gateways that sit in 11 Institutes of Technology and which started with a regional focus. The goal of Technology Gateways is to deliver technology solutions for Irish industry and act as local access points to the Irish research infrastructure. Gateways deliver very much shorter contract-research work and only exist to serve external clients. Since 2013, these Gateways have completed more than 3,200 industrial projects with a total value of €30m (where 50% came directly from industry). In 2018, 435 projects were completed with over 500 different companies working on more than 740 projects (EI, 2018).

Currently there are 15 Technology Gateways.

ICT	Health and Wellbeing	Food
• COMAND: Connected Media • Nimbus: Embedded Computing & Software Systems • WiSAR: Wireless Solutions • TSSG: Mobile Services	• MiCRA: Biiodiagnostics • MET: Medical & Engineering Technology • Shannon ABC: Applied Biotechnology • PMBrc: Pharmaceutical & Healthcare	• n/a
Energy, Climate Action and Sustainability	**Manufacturing and Materials**	**Services and Business Processes**
• n/a	• APR: Applied Polymer Technologies • CREST: Coatings Innovation • PEM: Precision Engineering & Manufacturing • IMaR: Intelligent Mechatronics & RFID • SEAM: Engineered Material Technologies	• Design+Applied Design • CAPPA: Innovation Through Light

Source: compiled by authors matching EI Technology with the Irish Research Priority Areas

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Their projects are funded through the programmes of Enterprise Ireland and directly from companies. They range from €5k-10k (in case of Innovation Vouchers) to €200k (in case of the Innovation Partnership Programme) direct. How the companies choose to interact with the Gateways are different. For example, a company can apply for an innovation voucher and then go to the Technology Gateways. Now, approx. 50% of their income comes from industry via projects ranging €10,000-30,000. A round of the Programme involves Government investment of €26.75m for the period 2018-22 (OECD, 2018).

1.4 Public procurement of innovation

To improve efficiency and strengthen control of public procurement in Ireland, the Office of Government Procurement (OGP) was established in 2014. Prior to that the procurement system was highly decentralised where contracting authorities managed procurement operations on their own. In 2015, over 86 public service bodies (PSBs) were spending on procurement. The OGP It was created to coordinate public procurement for four key procurement sectors – Health, Defence, Education and Local Government. The OGP and its sector partners have put in place framework agreements and contracts through which public sector bodies can buy goods and services. The OGP considers that the frameworks reduce the time and cost associated with procurement by offering facilities that have already been competitively and compliantly tendered.

The overall annual procurement spending in Ireland is estimated at €12bn, of which €8.5bn is for contracts for goods and services. The 2017 Public Service Spend and Tendering Analysis report shows that 94% of expenditure is with firms with an Irish base and that 52% of spend is with SMEs.

In addition, to the OGP efforts to improve access for SMEs to public procurement markets, Enterprise Ireland manages a Small Business Innovation Research (SBIR) initiative, a pre-commercial public procurement (PCP). Its objective is to stimulate innovative solutions to specific public sector organisations which may benefit from these solutions at a later stage, when goods or services are not currently available or developed from the outcomes of research. SBIR Ireland enables public sector bodies to connect with innovative ideas and technology businesses, to provide innovative solutions for specific public sector challenges and needs. An SBIR Challenge is divided into two phases. During Phase 1, up to 6 companies undertake a technical feasibility study to understand the challenge and identify a potential solution to solve the problem. During Phase 2 – a smaller number of companies protype a specific project, through extensive R&D.

To date SBIR Ireland has launched two competitive calls to the public sector and 20 Challenges were approved for funding. A first pilot challenge was launched by Enterprise Ireland in 2014 in collaboration with the Sustainable Energy Authority and the Electricity Supply Board concerning smart solutions for vehicle charging. Following two further pilots, in 2017, SBIR Ireland launched seven challenges in partnership with Irish Public Sector bodies and in 2018 a further 11 challenges. For 2020 five challenges were approved.

Challenge	Public organisation	Details
Climate action: Innovating a circular economy for soft public waste in Ireland	Environmental Protection Agency	• Looking for solutions to counter the problem of plastic waste and opportunities for closed-loop reuse systems, • The goal is to reduce the carbon footprint of schools by cutting plastic waste generation • Total fund €240K

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Challenge	Public organisation	Details
Health: Reducing the incidence and impact of inpatient falls within the hospital	Mater Misericordiae University Hospital and National Orthopaedic Hospital Cappagh (as part of Ireland East Hospital Group)	• Aims to address the prediction, detection and prevention of falls in the Mater Hospital (to start with) with the potential to extend a solution nationally. • Total fund €200K
Health: Improving the care of, and empowering Chronic Obstructive Pulmonary Disease (COPD) patients in the community	Tallaght University Hospital	• Looking for a solution to improve COPD patient self-management and incentivise affected patients to take control of their health. • Total fund €200K
Biodiversity: Innovative solutions to map coastal seaweed resources in Ireland	Marine Institute	• Seaweed is an underutilised natural resource and a technology-based solution is needed to enable future determination of its distribution in inter-tidal areas across Ireland • Total fund €300K
Transport: Vehicle Capacity Information for bus and coach passengers with a focus on improved accessibility	National Transport Authority	• Looking for solutions to encourage and support mobility impaired passengers when using public transport in Ireland • Total fund €200K

Public sector partners include Irish Rail, Dublin and Cork airports, the County Councils of Cork, Dun Laoghaire Rathdown, Clare, Fingal, Limerick and Dublin City Council, Smart Dublin, the Department of Public Expenditure & Reform, the Office of Public Works and the Health Service Executive. The SBIR initiative appears to be generating interest from both national and regional/city authorities to attract SMEs to develop innovative solutions to identified needs. Further steps are needed to encourage additional counties, cities and other public agencies to make use innovative public procurement method.

In 2018 a competence centre for innovation procurement – the Procurement Transformation Institute (PTI) – was established by two private entities, Arvo and iDDea. It is a non-for-profit institution seeking to provide knowledge and procurement support for the public and private sector. It seeks to increase the awareness of innovation procurement across Ireland – among procurers, policy makers and innovative suppliers. It is driving the modernisation of public procurement in Ireland through competency development plans and peer-to-peer learning for procurers – and suppliers – on innovation procurement. As PTI is still in the early stages of development and does not have any official mandate from the OGP.

1.5 Lessons learnt for Lithuania

Ireland has a relatively young national innovation system and, thus, understands a strong need to continue to develop its RD&I base, especially its level of business RD&I, and its skills and capacity for innovation. In addition to public investments in RD&I, it places a lot of emphasis on improving its indigenous firms, linkages across and among both foreign MNCs and indigenous firms, and cooperation of industry with the research base.

In terms of the development of specific sectors in the economy, Ireland excels globally in a number of specific scientific fields. According to the statistics gathered by Clarivate Analytics Ireland excels globally in immunology; agricultural sciences; nanotechnology; materials sciences; microbiology; neuroscience and behaviours; molecular biology and genetics; basic medical research; and chemistry (SFI, 2018).

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In the sectoral development nationally a lot happened as an unanticipated by-product of the focus on FDI and a strong interest of MNCs in Ireland. An indigenous software industry has developed in Ireland as an unanticipated by-product of the focus on FDI (Barry, 2008). FDI investments by ICT MNCs led to improved technical and business skills and were supported by education policies with a strong focus on science, engineering and technology. Four very early indigenous software companies were established by IBM employees and another was a spin-off Braun (the white and electronics goods manufacturer). The FDI investments into the development in the pharmaceutical / medical device sector in Ireland started with Pfizer's investment in 1969 which later included not only the manufacturing but also a global financial services centre and a global treasury operation. GSK and Merck entered in the mid-1970s. The former included manufacturing at three sites, European trading operations and sales and marketing functions as well as R&D collaboration with University College Cork (supported by the SFI). The latter started with a large-scale manufacturing plant extending to a corporate platform focused on clinical research, regulatory affairs and marketing to a new state-of-the-art sterile facility. DePuy (as part of Johnson & Johnson) started in Ireland in 1997 and in 2008 it opened an innovation centre to develop next generation orthopaedic products and processes. In early 2019 an investment of €36m into the 5-year R&D project support by the DBEI through IDA Ireland.

In terms of lessons learnt from the design, operation and review of various support measures – especially focused on support business-science cooperation, the following need to be highlighted:

- In taking any development forward a good coordination between research and innovation performers as well as policy-makers is needed. Whenever a consultation takes place, communication is critical. The view of the industry is that there are always too many funders but companies need more simplicity to access funding. Some debate on how to cluster some activities and provide information and support to companies is needed.
- An inbuilt trust between academia, industry and the public sector is important. Funders need to find ways to enable trust building and collaboration, first through small opportunities, then gradually growing bigger. One level is to enable individual researchers to work with industry. Another level is through Horizon2020 (and now future Horizon Europe) where small opportunities to work with industries could also be realised.
- Establishing business-science cooperation was a long process in Ireland. First, it was about building trust. Compared to the approach SFI took back in 2012 the amount funding for public research increased elevenfold. SFI applied different support measures to stimulate opportunities. SFI Research Centres started back in 2012 with heavy support from state funding; now companies can engage with direct cash. To enable this, the entire system had to evolve. For example, questions of how to handle the IP had to be developed and support within universities for that issue needed to involve as well. IP policies were implemented, template agreements were prepared, Knowledge Transfer Ireland was set up. Companies did not necessarily like all the aspects but at least the process and all the elements around IP are now clear. And it did streamline the process which many companies (especially MNCs) appreciated.
- The Industrial Fellowship, which ran from 2014, was a successful programme. Companies were happy with it. There was a movement of researchers from academia to the private sector which could have been perceived to be negative

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but when considering the whole national RD&I ecosystem this may have been a loss to academia but it was a gain for industry. According to the SFI data 47% of the researchers who took part in this programme remained in industry (about 25% are still in the same company they started with while 25% are now in a different one). The other half returned to academia.

- Although some of the SFI Research Centres and the EI/IDA Technology Centres were set up to encourage MNCs to engage in R&D or increase their investments in R&D in Ireland, they also strengthened the interest of smaller foreign-owned companies as well as indigenous companies in collaborative work with the science base in Ireland.
- Sectoral specificity is an important point. Many sectoral developments in Ireland were bottom-up due to strong sectoral performers. Support to sectors came from different players.
- A system-wide portfolio approach is necessary. It is not possible to create one dedicated support measure just for business-science collaboration and expect to see results. Interventions need to be done at a scale that will attract companies.
- Such system-wide approach means that various support agencies can engage in fostering research and innovation. For example, IDA although an FDI-oriented agency also provides some funding support to suitable RDI projects and identifies other support available from partner organisations.
- To create a good portfolio of support measures, policy-makers need to have a clear understanding of the companies in various sectors, the supply chain, the investor environment etc. For example, the Technology Centre in the ICT/biosciences field means that the companies are innovative by definition. However, Meat Technology Centre is serving companies in meat processing. This Centre did not appear among the first funded ones because companies from this sector were not ready. It took long time to happen and evolved as a result of working with different companies, supporting them to shift their mindset towards an inclination to work with other companies and the research base.
- Focus is crucial and should take as its starting point existing scientific excellence. To further develop excellence requires both basic and applied research.
- If there is just one policy or plan there is an increased need to build in flexibility. In a similar way, if the plan is for many years, it is also important to ensure flexibility. Actual operational objectives and the instruments may not necessarily endure for the same duration.
- The development was gradual. There has been lots of evolution in building a critical mass across the research base to serve industry rather than creating silos of separate research. Technology Gateways started very much to respond responding to the regional company needs but nowadays they are very much national.
- Support instruments are reviewed during their life time. However, the enhancements are done through some adjustment during the calls periods of the programmes. For example, changing from 2 calls/year to a continuous call.
- All public investments need to bring impact. Consideration of impacts should be part of any support measure. All publicly funded initiatives likes Technology Centres or Research Centres or any other should be focused on their metrics /

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indicators. In case of Technology Centres, Enterprise Ireland, for example, insists on starting each Advisory Board meeting with a discussion of indicators.

- All investments take time. In the case of a Technology Centre, a minimum of 5 years is needed for some results to be visible and 7-10 years for a centre to mature.

1.6 Sources of information

1.6.1 Stakeholders interviewed

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- Enterprise Ireland – Paul Maguire and Lara Bruen, SBIR Team
- Knowledge Transfer Ireland – Alison Campbell, Director
- Science Foundation Ireland – a group interview with Siobhan Roche, Director of Science for Economy, Peter Clifford, Head of Strategy, and Michael Ryan, Head of International
- Technology Centre CeADAR - National Centre for Applied Data Analytics & Machine Intelligence – Edward McDonnell, Director
- Technology Centre Food for Health Ireland – Nessa Noronha, Director
- Procurement Transformation Institute – a group interview with Mary Ryan, Procureti, Kay Duggan-Walls, EU Programmes Officer, Health Research Board. National Contact Point Horizon 2020, Health. Board Member EU JPI AMR, and Gerard Kennedy, Horizon 2020 ICT National Contact Point and National Expert at Enterprise Ireland

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Annex 2 International comparator – Sweden

This summary presents a review of the best practice analysis in Sweden in the topic of business-science cooperation and pre-commercial public procurement and procurement of innovation.

2.1 Macroeconomic and innovation performance context

Sweden is a country of 10 million people and is a small and export-oriented economy with strong political and economic ties to other Nordic countries, to continental Europe, to North America, and several countries and regions in the Third World. Its exposure to globalisation and shifts of balances of global productivity and trade makes the Swedish economy vulnerable. However, its highly educated workforce and generally friendly business climate, gives the country robust means to meet the challenges of the current geopolitical and economic world order (RIO, 2017). After the economic crisis in 2008-2009, the economy of Sweden grew significantly faster than the economy of the OECD members as a whole. It has performed well in recent years and continues to have a favourable environment. In 2018 Sweden's real GDP grew by 2.2%. Total investment as % of GDP was above the EU average over the past decade and both private and public investment have grown faster than GDP and the EU average. Although the country has experienced years of solid growth and its economic growth remains positive, the medium-growth prospects are expected to slow down.

Sweden benefits from an innovation-friendly environment, highly skilled workers, attractive research systems and internationally competitive and innovative large companies. With R&D spending at 3.3% of GDP in 2018, it has the highest R&D spending in the EU; the highest business spending on R&D (2018: 2.35% of GDP) and the second highest public spending on R&D (2018: 0.96% of GDP) in the EU. This means that Sweden is one of the few countries that exceeds the goal of 3% set by the EU in its Europe 2020 strategy and its national ambition was to reach 4% by 2020. Such investments and performance result in the country having strong research and innovation performance in the EU and globally.

In the Global Innovation Index (GII) list Sweden ranks 2nd on a global scale (one position up since 2018) and 1st in Europe (GII, 2019). Its key strengths are **intellectual property**, **innovation linkages** (from **patent families** to **joint ventures/strategies alliance deal** to university/industry research collaboration), **knowledge workers** and knowledge creation (and especially covering firms offering formal training, GERD performed by business and knowledge-intensive employment), gross expenditure on R&D as % of GDP and **number of researchers**, ICTs and either business or organisational models creations, and online creativity. The highlighted strengths are strengths relative to the other top 25-ranked GII economies to which research talent (as % in business enterprises), ICT services imports and exports, and ICT use are added. The country has since 2012 also been the top performer in the European Innovation Scoreboard (European Commission, 2019) and has further increased its performance over time staying on the 1st position as the "Innovation Leader". Its Summary Innovation Index in 2018 was 147.74 (slightly below 148.47 in 2017). Sweden performs especially well in the numbers of public-private co-publications (357.20), broadband penetration (355.56) and international scientific co-publications (342.80).

Sweden is one of the top ten performers (ranking 8th in the EU-28) when it comes to funding from Horizon 2020. In total there were 23,670 applications representing a 15.03% success rate (above the EU average of 12.16%). More than 4,000 organisations were successful in their applications, winning some €1.8bn since 2014 (European

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Commission, 2020). SMEs participate quite actively, representing some 712 or 17.36% of total successful applicants. Particular successes were applications in the climate and health areas.

Adding to that the contribution from the European Structural and Investment Funds (ESIF), the total EU contribution to R&I in Sweden stands at €2.13bn. Looking at the wider EU financial contribution to Sweden, the financial allocation from the EU Cohesion policy funds (ERDF, Cohesion Fund, ESF, Youth Employment Initiate, incl. national co-funding) for Sweden is about to €3.47bn in the current Multiannual Financial Framework, or just 0.1% of annual GDP (European Commission, 2020).

The country also continues to be one of the leaders in the digital economy. Sweden's Digital Economy and Society Index (DESI) although fluctuating, stayed on the top of the EU ranking moving from the 4th rank in 2017 to the 1st in 2018 and the current 2nd (overtaken by Finland) in 2019 (European Commission, 2019a). Its rank remained the same in Connectivity, Human Capital and the Integration of digital technology but decreased in the Use of internet services and Digital public services categories. Sweden has the second highest number of ICT specialists in the EU (6.6% of total employment, 2017 data as reported in DESI, 2019), but still lacks professionals with advanced digital skills.

Although Sweden has been – and still is – experiencing strong performance in many areas some weaknesses exist and are being addressed by various measures. The Global Innovation Index (2019) points to such weaknesses, (among other and strongly linked to the RD&I performance), as growth rate of Purchasing Power Parity GDP/worker, high-tech imports, GERD financed by abroad, and FDI net inflows. Interestingly enough none of these or other weaknesses has been marked by GII as weaknesses relative to the other top 25-ranked GII economies. According to the European Commission, Sweden's GDP growth was set to slow to 1.2% in 2019, private investment to fall in 2019 and 2020, growth of exports (while strong in 2019) to slow down and long-term unemployment to rise (albeit from low levels), and disparities of GDP per capital between urban centres and regions is visible (European Commission, 2020). Despite all, in the long run the potential growth is predicted to remain, the economy to stay competitive, and the country to continue to lead in innovation.

Its full potential will also depend on how fast and well SMEs are participating as their innovation performance has decreased since 2011. So far, innovation has relied on a limited number of large and globally competitive companies. One of the possible solutions mentioned by the European Commission is a stronger collaboration between academia and the business sector. Although there are close links between the business sector and public sector researchers, which result in academic publications, the co-funding of public R&D expenditure has decreased in recent years, with Sweden ranked 8th in the EU (European Commission, 2019). This shows further potential for privately co-funded university and government R&D to support the research needs of the business sector.

Specific sectors of the economy will be crucial for productivity growth in the near future. The Swedish business performance builds on decades of strengths in high- and medium-technology sectors. In the second half of the 20th century, it was dominated by a small number of large, domestically-owned industrial manufacturing companies. From the 1980s with all the structural reforms and globalisation, the country has shifted towards the economy with many innovative and export-oriented firms active in a range of manufacturing sectors, such as automotive, aerospace, telecommunication equipment, pulp and paper, chemicals, pharmaceuticals, electrical goods, and a large and growing

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service sector. The transport vehicles sector has been a key contributor to the Swedish economy in recent years but it is facing technological and global market challenges. Considerable investments are underway in Sweden to improve the competitiveness of the Swedish companies in the automobile supply chain. The "computer programming" sector is highly dynamic and has taken the relay from the computers and electronic equipment sector as a leading contributor to productivity growth. The construction sector is one of the few sectors with labour productivity below the EU average and has been attracting resources due to increasing demand, which has reduced overall productivity growth.

Among the sectors of the Swedish economy which have been of strategic importance for many years are ICT and health and life sciences.

Digitalisation is high on the agenda in Sweden. The country is 2nd in the EU when it comes to ICT specialists (and female ICT specialists) (DII, 2019). Compared to other EU countries, Sweden's number of ICT specialists is 6.6% of total employment. However, 5.4% of Swedish enterprises (EU 4.6%) report that it is hard to fill vacancies with specialist ICT skills. And even in the ICT sector itself, more than 50% of employers report a shortage affecting growth (European Commission, 2019). To address these and other points, the National Digitisation Strategy was adopted in 2017. It focuses on digital skills and competences and highlights the need for all citizens to participate in a digital society; to modernise the education system (especially making sure the students' and the labour market's need for digital skills coincide), and to focus on increasing digital competences in the public sector. SMEs are also encouraged to pay more attention to digitalisation. This is done (amongst other) as a way to address the productivity gap between small and large firms. Every third SME sells online and 10% of their turnover comes from e-commerce, they embrace cloud services as a new technology but lag behind in big data (DESI, 2019). Only 4.4% of large enterprises have very low digital intensity compared to 22.3% of SMEs. The Swedish Smart Industry Strategy supports the digital transformation of SMEs with, for example, vouchers for consultancy services. This is part of a new support measure Robotlyftet launched in 2018 with a budget of €10.5m for 2018-2021. The aim here is to reduce the risk of investing in modern automation technologies and raise awareness of how automation and robotisation can help SMEs to strengthen their competitiveness. The government has also provided €1.46m for digital skills for SMEs' management teams (European Commission, 2019). In 2018, a new Agency for digital government (DIGG) was established. With a proposed budget of €55m for 2019-2021 its remit is to improve the coordination of public sector digitisation and support it at both central and local level. DIGG's priorities are to develop further e-identification, e-invoicing, digital post, web accessibility, data and information exchange.

Artificial intelligence (AI) and robotics are widely expected to have a strong impact. In 2018 the Swedish government adopted a roadmap for artificial intelligence (Regeringen, 2018). It aims to improve welfare and competitiveness and make the country a world leader in the field. The roadmap focuses on education, research, innovation, and frameworks and infrastructure. Vinnova, Sweden's Innovation Agency, will invest €100m over the next 10 years in AI-related projects. This funding is matched by the investment from the Wallenberg Foundation. Linked to the roadmap in June 2019 the government also announced an investment of SEK 40m (c.€3.9m[72]) to seven Swedish universities (with Chalmers University in a lead) to develop an AI knowledge platform and framework for competence development within AI. It will function as a one-stop-shop and help companies and the public sector to get in touch and collaborate more with academic

[72] For ease of calculation a 1 EUR: 10 SEK conversion rate is used.

regarding AI. The universities will also develop AI courses both for professional engineers and professionals from, for example, public sector. The allocated budget for 2018-2019 was €3.9m. The country shows its commitment to new digital technologies also on the EU level. Sweden has signed the Declaration establishing a European Blockchain Partnership and the Declaration on cooperation on Artificial Intelligence.

2.2 Key STI features

The Swedish system overall and the governance and implementation of Research, Development and Innovation policy are decentralised. Historically, national Swedish public administration has been characterised by relatively small government ministries (compared to their international counterparts) and larger governmental agencies with responsibilities for specific policy areas. More so, the RD&I system is characterised by a very large academic sector that is almost entirely publicly owned:

- Vinnova, Sweden's innovation agency (set up in 2000), finances innovation projects and provides support in the form of networks, meetings and analyses
- Swedish Research Council (Vetenskapsrådet) funds public research
- Other thematic agencies, such as the Swedish Defence Research Agency, the Energy Agency, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) and the Swedish Research Council for Health, Working Life and Welfare (Forte), are important RD&I funders and policy actors in their domains.
- There are a number of semi-public non-profit research foundations, such as the Knowledge Foundation (KK-stiftelsen) and the Swedish Foundation for Strategic Research. The former aims to stimulate competitiveness by creating conditions for innovation and creativity, and by strengthening the links between academia and industry. The latter supports research in the natural sciences, engineering and medicine.
- The Swedish Agency for Regional and Economic Growth (Tillväxtverket) is the managing authority for the European Regional Development Fund (ERDF) and as such supports Swedish regions in their work with Smart Specialisation.
- Universities and colleges are technically government agencies and are the biggest public research actors. They consume more than two thirds of the government spending on R&D (RIO, 2017)
- In 2016 the relatively small Swedish research institute sector was re-organised and several industry-specific institutes were merged into the larger RISE – Research Institutes of Sweden, organised as a private enterprise but almost entirely owned by the government.
- The few very large and R&D-intensive companies like Volvo, Ericsson, Sandvik, SCA, Electrolux and AstraZeneca, which cover a very dominant part of Swedish business R&D.

At national level, the research bill and energy research bill (both released every four years, most recently 2016), the national innovation strategy along with the strategy for regional development are key framework documents providing overall guidelines for Swedish innovation policy and regional development up to 2020.

In 2014, the Swedish enterprise and industrial policy was introduced, calling to strengthen the competitiveness and creating good conditions for more jobs in growing

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companies. The area included conditions for entrepreneurship and enterprise, such as developing and strengthening the innovative capacity of Swedish companies. At the same time in 2015, the National Strategy for Sustainable Regional Growth and Attractiveness was adopted focusing on four societal challenges: demographic development; globalisation; climate, environment and energy; and social cohesion. The efforts within these areas are concentrated in innovation and business development; attractive environments and accessibility; competence supply; and international cooperation.

At the same time, the Prime Minister appointed – for the first time – a Minister of Enterprise and Innovation. In 2015 a National Innovation Council with the Prime Minister as the chairman was created clearly indicating an "innovation drive" in politics. The Council is an important reference body for all things concerning national strategies for innovation, including S3, and it has indicated three important areas to target in this work: digitalisation, life sciences and environment, and climate technology. In order to ensure that the conditions for entrepreneurship and innovation in Sweden are efficient and internationally competitive, the same year the government also initiated a review of the regulatory framework regarding innovation and entrepreneurship promotion efforts. The aim of the review was to identify barriers and propose measures for the improvement and development of the innovation and entrepreneurship climate in Sweden.

The period 2008-2016 was characterised by a significant increase in the investment into R&D, totalling SEK 9bn (c.€900m). The increases were mainly through the direct grants to universities and colleges as well as investments in so-called strategic research and innovation areas. However, back in 2012, the OECD criticised the Swedish research funding structure for being too fragmented, with small and partly overlapping efforts. It was thought that increased coordination would allow a more strategic focus on priority areas of strength.

As a result, the Swedish Government's Research and Innovation Bill 2013-2016 launched a more selective, quality-based funding approach, with a significantly increased government budget for R&D. The focus was on continuing to develop good conditions, incentives and framework conditions for entrepreneurship, promote positive attitudes to entrepreneurship and innovation in society. The Bill emphasised academic collaboration with private sector and society, partly in contrast to its predecessor bills whose focus rather laid on strategic specialisation and promoting excellence in research. "Strategic innovation areas" were introduced as a new instrument for meeting societal challenges. Through these efforts, the Government wanted to lay the foundations for new, long-term collaboration projects between universities and colleges, research institutes, business, public sector, civil society and other actors. Part financing from business and public sector was a prerequisite. In its follow-up review of strategic research areas and strategic innovation areas in 2015, the OECD emphasises, firstly, the importance of continued development of the collaboration dimension and partly that the number of areas may not get too numerous (Ministry of Trade and Industry, 2015). The 2016 Research Bill has, as a result, focused a lot on "collaboration". The new Swedish research bill, with priorities and focus for the next four years, is currently being prepared and will be presented in autumn 2020.

Government Bill 2008/09:50	Government Bill 2012/13:30	Government Bill 2016/17:50
• Substantial increases in R&D allocations. Total expenditure increases amount to SEK 5bn (c.€500m), 2012.	• A total expenditure increase of SEK 4bn (c.€400m) (in addition to the expenditure increases that occurred in the previous bill), gradually until 2016.	• Focus is very much on "collaboration" • Move to "strategic cooperation programmes"

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Government Bill 2008/09:50	Government Bill 2012/13:30	Government Bill 2016/17:50
• Overall, broad and relatively general funding has been prioritised, but the biggest increases are in traditionally innovative areas such as medicine and technology. Stronger incentives for higher education institutions to commercialise future innovations. • The creation of RISE Holding, with the aim of bringing together (the majority of) the Swedish industrial research institutes under one roof. • Set up of innovation offices in the higher education institutions. • Investments in "strategic research areas" (strategiska forskningsområden") in medicine, technology and climate. • Competitive exposure when allocating base funding to universities and colleges (10% according to such indicators as citations and external funding)	• Continued general investments in higher education institutions. Continued investments in traditionally innovative areas such as medicine and technology and establishment of another four innovation offices. • Introduction of "strategic innovation areas" ("strategiska innovationsområden") • Increased support for research in the life sciences, gradually until 2016, when the increase is expected to be close to SEK 600m/ year (c.€60m/year). • Further steps have been taken to reward quality research, and to increase the elements of collegial assessment in application process. • Two new major programmes initiated at the Swedish Research Council, with the aim to promote cutting edge research and to make Sweden more attractive for international excellence.	

Source: Utveckling av innovations- och entreprenörsklimatet, 2015

The Swedish Innovation Strategy 2014-2020 explicitly highlighted three needs for this strategy: to meet global societal challenges, to increase competitiveness and create more jobs, and to deliver public services with increased quality and efficiency. Development of this strategy involved all ministries within the Government Offices. Also, the Swedish ERA Roadmap 2019-2020 highlights, among other topics, more effective Research and Innovation system (e.g. internationally attractive country for R&I investments, review of the HEI governance); a joint approach to meeting societal challenges and optimising public investment in research infrastructures; and International cooperation.

SMEs play an increasingly important role in the Swedish economy and policy-making. Since 2008, Swedish economic policy has been dedicated to addressing the economic crisis and the focus has been on the SMEs rather than start-ups. The Swedish government then argued that a well-functioning policy framework for capital supply is crucial for creating new firms and making them expand. The state acknowledged its role as complementary to the market, particularly in areas where the private market is limited, e.g. early stages of development and commercialisation of innovative ideas. Since then policy efforts, such as programmes with support to start-ups and high-tech firms, are in place to reduce the dependence in Sweden on large multi-national companies (MNCs) for innovation. About 20 Swedish MNCs account for the majority of the investments into R&D from the private sector (RIO, 2017). This has been on the political agenda for at least two decades and stayed unchanged through shifts of government (RIO, 2017). A 2014 reform launched a limited tax incentive scheme for small businesses hiring R&D staff. In 2016 the Swedish Agency for Economic and Regional Growth was tasked to make a strong effort at promoting new enterprise among immigrants.

Development of SMEs and their potential is a building block for the regional development, which is also the focus in Sweden's use of smart specialisation (S3). Sweden uses regional smart specialisation (S3) as a tool for regional development that promotes innovation based on the preconditions of a region. The adoption of the S3

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started late in Sweden in comparison to when the topic started on the EU level. A national support to the regions was established in 2016 when Tillväxtverket got the mandate for S3 (Paulsson, 2019). Eighteen strategies are in place, supported by the ERDF. The strategies focus on each region's comparative advantages to foster growth and innovation. Many regions have a form of portfolio selection, with both more established strengths and more growth areas, more technology-focused, but also those that bring in more aspects of innovation, a so-called broad view (e.g. environmentally-friendly, service and social innovation). There is quite a big spread in terms of what a priority is and can be. Some regions have sectoral priorities that closely correspond to a conventional sector. Some have priorities that are cross-sectoral or economic domains that cuts across conventional sectors. Others are better characterised as knowledge domains and some are furthermore issue-driven in that, to a large degree, they are defined by a societal challenge. Every region will need such a strategy to fulfil the enabling conditions for the upcoming ERDF programming period. In addition, the government announced in its 2020 budget bill that it wants to strengthen the innovation capacity of counties. Regional development strategies including innovation or smart specialisation should interact with national and international strategies and actions (European Commission, 2019).

The message that is being conveyed in the research and innovation bills as well as other policy documents is that the Swedish research, development and innovation system is in a relatively healthy shape but nonetheless in need of some trimming. This is dependent on strategic profiling and mobilisation in core areas such as materials science, life science, and climate research, and strengthening the rather weak interaction between businesses and academia.

2.3 Business-science cooperation

Over the years there has been a long-lasting debate in Sweden about the alleged inefficiency in turning huge investments into R&D into innovation and its related growth. Difficulties in attracting business R&D investments have been persistent despite public investments and strong education system; and product-market regulation and business-science collaboration appearing below the EU average. To keep on the positive track of development, for several years the links between research and innovation have been acknowledged in the governmental research bill. As a response a series of supply-side support measures – mostly focused on promoting cross-sectoral collaboration – were launched but without any specific measures targeting just business-science cooperation. The main focus was to move from funding such basic research towards more collaborative models.

Challenge-Driven Innovation (CDI) Programme

The Challenge-Driven Innovation (CDI) programme has been running since 2011. During the years 2011–2017, the CDI announced funding for projects aimed at meeting social challenges identified by Vinnova. Since 2018, the global sustainability goals in Agenda 2030 have been a central starting point for CDI. The projects have to meet the societal challenges in a way that contributes to Sweden achieving one or more of the global sustainability goals. Although the projects that started before 2018 initially did not categorise the societal challenges based on the global sustainability goals, it is possible to categorise the projects based on the global sustainability goals.

Projects receive funding in three stages:

- Stage 1 – Initiation: intended for groups of at least three participants and applicants coming from all sectors and industries are welcome. The focus is on

developing an idea and how it will be realised. Funding to a max of SEK 500,000 (c.€50,000) per project is available.

- Stage 2 – collaboration project: through a collaboration a solution or a partial solution is developed. A max of SEK10m (c.€1m) per project is available.
- Stage 3 – implementation: testing the solutions in a real environment and implementing and disseminating the results. One project can get up to SEK 20m (c.€2m).

The investment model is based on increased competition at each stage. Vinnova's grant, calculated as a proportion of the project's total costs, decreases with each stage, even though the actual monetary figure increases. As the project gets closer to implementing its results (commercialisation for example), the involvement of the project partners must increase, i.e. moving from 80% Vinnova's contribution at Stage 1 to a maximum 50% at Stage 2 and 25-40% at Stage 3.

Up to January 2020 CDI has approved a total of 731 projects. More than 500 projects received funding for Stage 1, and just under 50 projects have been funded for Stage 3. Vinnova's contribution was just under SEK 2bn (c.€200m). More than 2,000 unique organisations participated in the programme. Examples of funded projects include: new technology for carbon dioxide-free asphalt; a project on how to reduce the strain on the fish stock in the seas through sustainable and circular fish feed; smarter school with sensors; FUN digital platform making young people move more during school day; smart tool for sustainable urban planning; digital tools to activate young people with neuropsychiatric disabilities; proteins from plants; full-scale drug treatment facilities, IoT for smart rural development, and others. Project Stadsbruk, for example, focused on cultivation in the city contributing to entrepreneurship, employment, integration and health. Skåne's Food Academy, Sweden's agricultural university, research institutes, several municipalities and companies cooperated to bring a concept for a new type of cultivation in the city being developed and disseminated on commercial grounds. Malmö, Gothenburg and Växjö have developed or started urban farming in their municipalities and several new cultivation companies in the urban environment have started.

Vinnova has defined a number of principles that govern evaluations and are set out in the evaluation criteria. Under these principles, a challenge-driven project must: (1) have identified innovative solutions to a social challenge that requires broad cooperation; (2) can help achieve the Global Goals defined in the UN's 2030 Agenda; (3) combine social benefit and international business potential; (4) result in innovations in a broad sense; (5) involve cooperation among different sectors, such as civil society, industry, academia and the public sector; (6) develop solutions jointly with users, customers and other relevant parties who impose requirements; (7) work to remove obstacles that may impede the introduction of the developed solutions at a later date; (8) are gender-equal.

The indicators/metrics are monitored by collecting data from the projects at various points: during the course of the project, every six months via status reports (for Stages 2 and 3 only); at the conclusion of the project via a final report (standardised template) and questionnaire. After the project has concluded, given that the impacts usually arise in the longer term, all project partners (and in particular the coordinator) have a responsibility to note the results and impacts which arise after the end of the project and report them to Vinnova upon request.

External evaluation of the CDI programme (Ramboll, 2020) concluded that that the programme contributed to the participants participating in strengthening their capacity for innovation, for example through knowledge, networks and methods; this was

something that was also the primary purpose. The funded projects resulted in several innovations in the form of new concepts and solutions that were further introduced or commercialised.

Strategic Innovation Agendas (SIAs) and Strategic Innovation Programmes (SIPs)

The 2012 Research and Innovation Bill gave Vinnova the task to design strategic, challenge-oriented innovation areas that had strong links with the Swedish research base and would lay the foundation for new, long-term and stronger collaborations among the research players, industry, the public sector and society. The Swedish Energy Agency and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) were also expected to contribute funding. The Bill also emphasised that it was not up to the government to decide which areas are important and that bottom-up processes are important. This was a shift as conventional practice has been for government/Vinnova to design priority areas on a much more top-down basis. In addition, the overall R&I policy in Sweden has started to evolve towards tackling societal challenges. In many cases this involved changing how the support measures were designed.

Strategic Innovation Programmes were launched by the 2012 Research Bill and further reinforced in the 2016 Research Bill with the launch of “strategic cooperation programmes” in five fields – next generation travel and transport, smart cities, circular bio-based economy, life science, and connected industry and new materials. The programmes have evolved from the earlier sectoral (branch) research programmes, which were aimed at key sectors of Swedish industry and were intended to promote competitiveness in areas of Swedish strength. The visions of the SIPs is to create preconditions for sustainable solutions to global societal challenges and to increase competitiveness in fields of high relevance to the Swedish economy.

The specific objectives of SIPs are/were to create economic growth and jobs in Sweden; create collaborations between academia and industry; create demand driven projects; contribute to the solution of societal challenges; for the stakeholders (industry, academia and public organisations) in each strategic innovation programme develop a shared vision and to work on common objectives.

Since its setup, Vinnova, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) and the Swedish Energy Agency funded 17 strategic innovation programmes. Vinnova provided seed funding (where it was necessary) to the innovation community to work together to formulate SIAs through consultations involving a large number of relevant stakeholders. Once these were completed, it invited proposals for SIPs within the areas defined by these SIAs. Different configurations of R&I actors generates SIAs in areas of their own choosing and then submitted proposals for SIPs. In each case, these proposals were evaluated by independent experts in processes facilitated by the agencies, which were ultimately responsible for the formal funding decisions. The final decision on the total number of strategic areas also lay with the state agencies, though this was largely determined by the available budget.

Funding for each SIP was provided initially for three years, with a possibility of renewal for a maximum of nine further years. A review every three years was planned into the process. The funds available to the research organisation were matched by the funds from industrial participants (including SMEs, larger Swedish-owned companies, foreign-owned companies and companies owned by municipal/county councils). The bulk was provided by the industrial partners.

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Until 2016, there have been three waves of calls asking for SIAs to be formulated and submitted as part of the process of designating SIPs; a total of 17 SIPs had been selected by October 2015. Beneficiaries in the first wave of five SIPs tended to be communities in areas of traditional Swedish strengths (mining and metal mining, metallic materials, lightweight materials, process industries and automation, and production technology) that had prior experience in formulating roadmaps and innovation agendas of this nature. For example, innovation actors in the process-automation area had formulated a research agenda prior to formulating the SIO. Involvement in Vinnova's VINNVÄXT programme (which aimed to create functional regions united by a common topic beyond county borders) had identified the need to collaborate on a Scandinavian level if Swedish actors were to influence the formulation of relevant policy initiatives at the EU level. This led to the formulation of a research agenda for the industry, which was in place when the SIA was announced and submitted during the first wave of proposals for SIPs. The outcome was the Process Industrial IT and Automation (PiiA) SIP.

Similarly, industrial and academic participants in the Innovair, an initiative focusing on innovation in the aeronautical sector (which formally became a SIP in the second wave), formulated a strategic innovation agenda two years prior to the launch of the SIO. The Swedish Steel Association also benefited from many years of experience in working with the industrial steel community to define topics of mutual interest to its members, and from participation in the European Technology Platform for Steel.

Whereas the first wave of SIPs focused on areas of traditional strength and areas specifically highlighted in the 2012 Research Bill as deserving special treatment (i.e. the mining and steel sectors), the second and third waves of SIPs had a greater focus on some areas more obviously related to societal challenges, in line with the call for SIAs to focus on challenge-oriented areas. The second wave focused on aerospace, bio-based innovation, life sciences, the Internet of Things, smart electronics and graphene; the third wave of five SIPs covered resource and waste management, automated transport systems, medical and health-related technologies, smart built environments, and transport infrastructure.

First wave of SIPs	Second wave of SIPs	Third wave of SIPs
• Mining and Metal Producing Industry (STRIM) (run by Lulea University of Technology; involvement from global companies, SMEs, and research and HEIs) • Metallic Materials (run by Swedish Steel Producers' Association; involvement from large companies and industry associations) • Lightweight (run by Swerea; involvement from global companies, SMEs, and research and HEIs) • Process Industrial IT and Automaton (PiiA) (run by SICS Swedish ICT Västerås AB; involvement from global companies, SMEs, industry associations) • Production2030 (run by Association of Swedish Engineering Industries; involvement from global	• BioInnovation (run by Swedish Foorest Industries Federation; involvement from global companies, SMEs, HEI; regional authority; industry associations) • SWELife (run by Lund Univeristy; involvement from global companies, SMEs, HEIs) • Internet of Things (run by Uppsala University; involvement from global companies, SMEs, research and HEIs; industry associations) • Electronic Components and Systems (run by Acreo Swedish ICT; involvement from global companies, SMEs, and research and HEIs; other organisations) • SIO Graphene (run by Chalmers University of Technology; involvement from global companies, SMEs, and research and HEIs) • Innovair (run by Swedish Air Transport Society; involvement from global companies, SMEs,	• RE:Source (run by SP Technical Research Institute of Sweden; 7-12 members from industry, society, authorities and research organisations) • Drive Sweden (run by Lindholm Science Park; involvement from global companies, public agencies; city council; research organisations) • Medtech4Health (run by KTH Centre for technology in medicine and health) • Smart Built Environment (run by Swedish Centre for Innovation and Quality in the Built Environment; 8-10 representative from companies, public authorities and research organisations) • INFRASweden2030 (run by KTH Road2Science; 8-9 representatives from large companies, research organisations) • Viable Cities (run by KTH)

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First wave of SIPs	Second wave of SIPs	Third wave of SIPs
companies, research and HEIs, industry associations)	research and HEIs; Swedish Armed Forces); industrial societies	

Source: Vinnova website, OECD (2016)

The nature of projects funded by the SIPs varies enormously. The project portfolio contains much that is of interest to academics and industry alike, including examples of work in "breakthrough" technology areas, the production of demonstrators as outputs and plans to include product vendors. Each SIP is managed by an external project co-ordinator and overseen by a board of directors, which is responsible for designing the SIP activities (often assisted by an appointed "agenda council" comprising select members of the community) and implementing them after they have been approved by Vinnova. All the SIPs involve a broad range of actors, including universities, research institutes, large companies, SMEs, and public authorities. This considerable breadth distinguished SIPs from earlier Vinnova sectoral support programmes or parallel initiatives such as the Strategic Vehicle Research and Innovation programme, all of which tended to involve a more limited set of industry players (e.g. Volvo and Saab in the vehicles programme). Other distinguishing features included the actor-led procedures determining the nature and strategic direction of the SIPs, and the strong role played by these actors in SIP governance.

Once initiated, the SIPs are responsible for devising and implementing activities in line with the overall aims of the SIP. They are run as public-private partnerships that define strategic research agendas, involving quite big networks of companies and R&D performers. They organised calls for project proposals (perhaps one or two calls every year for each SIP) and oversee the implementation of the resulting projects. By design, programme governance is dominated by industry rather than researchers or the state, which leads to rather applied projects of common interest to several companies, whose results can be used in the comparatively short term, rather than to longer-term or fundamental research.

The orientation and selection criteria of the calls and distribution of funding among different calls are mostly decided by the programme leadership. The programmes also carry out a small number of "strategic projects" that are usually larger and organised in a more direct process without open calls. In this case, the funding agencies are responsible for decisions on whether to fund proposals for strategic projects, based on their evaluation of whether the process of developing the proposals has been sufficiently open to potentially interested parties.

The evaluation of the first generation concluded that while the SIPs were quite different from each other, they were on the right track in building up collaboration between stakeholders (Piirainen et al., 2019). The first five SIPs **succeeded in establishing actor-driven activities and managed actors to join forces in areas of innovation that are strategically important for Sweden**. In the evaluation of the second-generation programmes, the programmes had reached all the important stakeholders. The second-generation programmes were also very different in nature and some were based on a narrow topic bringing together a small number of already known actors, while others gathered a larger consortium of partners previously unknown to each other. The evaluation found the **programmes to be open and transparent and they were addressing important societal challenges, albeit with different approaches**.

Strategic Cooperation Programmes (Samverkansprogrammen)

At the November meeting in 2019, the National Innovation Council discussed Strategic Cooperation Programmes. The government launched four collaboration programmes for

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the 2019-2022 mandate to further strengthen collaboration between business, academia and government. The Strategic Cooperation Programmes are based on the goal of gathering power to strengthen Sweden's global innovation and competitiveness and meet the major societal challenges.

The themes of the four collaboration programmes for 2019-2022 were part of the January 2019 agreement, the substantive political agreement reached by the government parties with the Center Party and the Liberals, and is based on the strengths and areas of Sweden and Sweden that are deemed to be of great importance for future growth:

- **Business digital transformation and business**: Businesses need to undergo a digital structural transformation on a broad front for a long-term sustainable competitiveness that lays the foundation for sustainable economic growth and welfare. The collaboration programme aims to help digitalisation to a greater extent lead to business benefits, innovations and solutions to societal challenges.
- **Health and life sciences**: Sweden is to be a leading life sciences nation. Life sciences contribute to improving the health and quality of life of the population, ensuring financial prosperity, developing the country as a leading knowledge nation and realising Agenda 2030. The collaboration programme lays a foundation for the implementation of the national life sciences strategy.
- **Climate change**: Sweden is to take the lead in the climate and environment area and become the world's first fossil-free welfare country. By 2045, Sweden will have no net emissions of greenhouse gases into the atmosphere. The business sector accounts for a significant portion of emissions while being a crucial part of the solution. The collaboration programme will contribute to the adaption of businesses to address climate change.
- **Competence supply and lifelong learning**: Climate change, digitalisation and improved health will place higher demands on skills and tasks will change. This, in turn, places demands on lifelong learning. The starting point is based on business demand, the need for new skills and improved conditions for employees to change or further educate themselves with the aim of strengthening and developing competence supply and lifelong learning to increase Swedish competitiveness and people's opportunities for skills development or changeover.

It is expected that these horizontal themes and challenges will be reflected in the programmes currently run by Vinnova and other players in the Swedish RD&I system.

Vision-Driven Innovation (VDI) environments in health area

In 2019 Vinnova started establishing five vision-driven environments to meet important health challenges. The innovation environments are established in areas where Sweden has the greatest potential to make a difference:

- Zero vision for malnutrition in the elderly (coordinated by Skåne's Food Academy)
- An antibiotic smart Sweden (coordinated by Public Health Authority)
- Zero vision cancer (coordinated Sweden's municipalities an country councils)
- Information-driven healthcare through AI application (coordinated by Lindholmen Science Park)
- Sweden's leader in advanced therapies in 2030 (coordinated by RISE Research Institutes of Sweden)

All five have different approaches and a different constellation of partners. The base of these initiatives is to have a goal which is clearly stated. To decide on the visions is

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extremely difficult especially in the public sector. This was achieved through a several-steps approach. Vinnova took the experience from SIPs and Challenge-Driven Innovation programmes where calls aimed at solving a challenge. To start with a very broad dialogue with actors (50-80 organisations, incl. companies, government agencies, civil society, patient organisations) took place. It not only allowed an understanding of the topics pertinent in the community but also what criteria could be set or not. For example, requiring 50% co-funding will in most case discourage small companies from applying. Several discussions took place over about 1.5 years. When the call was opened at the end 90-100 application came through and 15 were selected. At the end five were selected to build their "environments".

Vinnova plans to provide innovation funding with a total of SEK 125m (c.€12.5m) over five years, of which SEK 50m (c.€5m) has now been decided for the first two years. The goal is for these collaborations to continue even after Vinnova's funding ceases.

Vinnova's support to SMEs and other players

Vinnova continues to support the development of the innovative capacity: these focus on innovation capacity in the public sector; innovative SMEs (the largest in terms of annual funding in this block of programmes); enhanced interactions between research, innovation and education in the so-called knowledge triangle; and individuals and innovation milieus. This involves creating strong research and innovation networks, infrastructures and milieus, including establishing the Berzelii Centres (based on excellence in basic research, but aimed at developing co-operation with industry); the VINN Excellence Centres (focusing on more downstream development); and VINNVÄXT (competitive research and innovation funding for regional clusters). While most of the programmes covering innovative SMEs and innovative milieus have their roots in initiatives that began in the early part of the 21st century (or earlier in the case of the VINN Excellence Centres), new programmes have been initiated and funding expanded in the public sector and the knowledge triangle.

Vinnova's programme for innovation driven growth in SMEs includes various forms of support for a total of SEK 400m (c.€40m) per year. Vinnova's programme Innovation projects in companies (former Forska&Väx and VINN NU) is a key policy support measure. Vinnova gave support via innovation vouchers (approx. SEK 100,000 or c.€10,000) per voucher, a total of SEK 30m/c.€3m, per year). Vinnova supports the early development of high-risk companies, and the financing is done through grants. The agency supports companies either through full financing up to SEK 500,000 (c.€50,000). Companies that have been operating for up to five years can apply for 100% financing of a project, or 25-50% financing for up to SEK 5m (c.€500,000). If the project needs more funding than SEK 500,000 (c.€50,000) or if the company has been around for more than five years, Vinnova can finance the project with up to 50%. Another example is the Vinnova programme Open Innovation, that aims to recognise and encourage open and transparent innovation processes in the public sector, the business sector and among consumers or users. The programme provides support for strategic ways to use external expertise, resources and networks to develop innovations.

2.4 Public procurement of innovation

Sweden has a long history of collaboration between business and the public sector in terms of innovation and technological development, where innovations have emerged in so-called **development pairs** between government agencies and innovative companies. But the conditions for this type of collaboration have changed since the launch of a European public procurement framework. At the same time, the public sector in Sweden

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annually purchases goods and services for about SEK 600-800bn (c. €60-80bn), corresponding to between 16-22% of GDP. If 10% of the regular procurements are directed towards innovations, this means an investment of about SEK 70bn (c. €7bn) annually, which is about twice as much as the total Swedish research budget (European Commission, 2017a). And it is not only about procurement itself. The proposed approach would also lead to increased competition, not only among different potential suppliers of similar products, but also among radically different products that solve the same problem. All this will lead to a higher quality of the public services, i.e. to innovations in the public sector.

In the 2018 benchmarking of the national innovation procurement policy frameworks across Europe, Sweden was the 5th in the overall ranking. From the 30 countries analysed, Sweden was among good performing countries in implementing a mix of policy measures for mainstreaming innovation procurement. Among strengths a clear political commitment for innovation procurement, a presence of the national competence centre (i.e. Public Procurement Agency) and financial incentives for public procurers to engage in more innovation procurements are mentioned. However, some weaknesses are present too. These are a lack of an action plan, spending target and a centralised monitoring system to mainstream innovation procurement widely across all sectors, and a lack of IPR policy in public procurement that encourages innovation.

The development of innovation procurement has been a long journey in Sweden. Already back in 2011 Vinnova set up some guidance around innovation procurement. In 2012 together with the Swedish Research Agency it was assigned to work on innovation procurement in environmental technologies, e.g. energy or how to deal with mercury poisoning in the environment. Each agency got SEK15m (c. €1.5m) for three years. (This is the only time that special funding for innovation procurement projects has been allocated to Vinnova from the Government Offices.) There was money from the government but the money was to inform the guidelines and it was not set aside to actually perform innovation procurement. The goal was to get some example projects that could inspire public sector to apply innovation procurement in their work and create knowledge rather than be a broad resource for contracting authorities wishing to try innovation procurement. These example projects were called “Strategic Projects”. Around SEK 5-10m (c. €0.5-1m) was set aside. Among the financed projects are PCPs, PPIs and financial support for coordination activities, pre-studies and procurements in pre-procurement purchasing groups. Apart from Vinnova’s funding, there are some buyer’s networks are financed at the Energy Agency and the Swedish Environmental Protection Agency. Also, some larger contracting authorities such as the Swedish Transport Administration, Region Skåne, Stockholm County Council etc., have internal innovation budgets that at times are used for innovation procurement projects.

On a political level, in 2014 the Prime Minister appointed a Minister for Public Administration for whom the responsibility for public procurement became an important task. In 2015 this new minister created a new separate public agency for “procurement support”. This was done in close collaboration with the Swedish National Innovation Council. The mission of the National Agency for Public Procurement (Upphandlingsmyndigheten) is to promote legal certainty, efficiency and social and environmental sustainability through procurement; to strengthen the strategic importance of public procurement; and to promote innovation in the public sector. The need for such a coordinate approach towards public procurement came due to several challenges in the system. Small contracting authorities led to a fragmented demand and lack of resources; and the public sector in many instances also lacked knowledge and resources when it comes to public procurement of innovation. Vinnova and the National

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Agency for Public Procurement started cooperation: Vinnova works with financing innovation procurement and the Agency provides all the information and guidelines.

From that time Vinnova's approach was to think how to include innovation procurement projects in the agency's general calls. For example, challenge-driven innovation which is a broad programme and focused on addressing a societal problem could give the applicants a freedom on how to apply.

Also in 2015, the Procurement Agency got another governmental mission. It focused on starting an early dialogue with the suppliers, helping them to understand the market, what can be done etc. As a result, in the beginning of 2016 the Agency launched a programme with the aim of developing public procurement with regards to innovation and dialogue with the market. It ran until 2019 and focused mostly on support for the phase before innovation procurement: identifying and analysing needs as well as early dialogue with the market. The Programme had three focus areas: methodological support to specific innovation procurement projects; collection and dissemination of knowledge in a form of guidelines and good examples; facilitation of networking and experience sharing among contracting authorities. Between 20-30 projects were funded, e.g. the electric roads project in the north (funded by the Swedish Traffic Administration), prevention of falls in the hospitals (in region Skåne), innovation procurement models for small communities etc.

Vinnova funded projects via the FRÖN ("For increased innovation in publicly funded activities") programme. The calls were openly published, but contracting authorities first needed to go into a dialogue with Vinnova before being permitted to apply. The calls were permanently open to FRÖN and ran in 2015-2016 with a broad call for public innovation projects in general. Among other things, the calls were open to innovation procurement projects. Two calls were open in 2014 and only one in 2015 and 2016. This was not ideally suited to the demands of innovation procurement. When needed, Vinnova financed a few innovation procurement projects as "strategic investments" to avoid getting stuck in FRÖN's calls.

In late 2016, the National Public Procurement Strategy was adopted. One of the seven parts of that strategy has the title "Public procurement that enhances innovations and alternative solutions". Innovation procurement takes a central role in this strategy. The Strategy clearly states that "there is a large potential in using procurement as an instrument to enhance development and innovation". By putting forward a requirement for functions rather than specific requirements for goods and services will make the supplier (i.e. companies of all sizes) to think creatively and innovate. It was also acknowledged that by requiring functions can increase competition in the procurement, since a larger number of firms and organisations can respond to the tenders, and this is beneficial particularly for SMEs.

In 2017, Vinnova moved towards strategic investments with the innovation procurement grants covering part of the process costs as well as part of the contract costs to the suppliers. Process costs can include both personnel, as well as consultants, test lab time etc. Due to organisational change in 2017, innovation procurement projects were financed using a closed call in 2017, i.e. by invitation only.

Co-funding is always required, since Vinnova argues that co-funding demonstrates commitment and that a true need is involved. Overall Vinnova's projects have been fairly small (e.g. between €50,000-100,000 for pre-study and €200,000-€500,000 for a procurement). A buyers' network cost around €130,000/year to run but there were additional project costs if they wanted to try an innovation procurement. The support levels have shifted during the different waves of funding. They also depended on which

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type of project Vinnova is funding. For example, during FRÖN, Vinnova's funding was 80% for a pre-study and 50% for a procurement. In the first two calls, funding was 100% for process costs and maximum 50% for contract costs. Projects funded by the government special budget for environmental innovation procurement tended to get a higher support level.

Vinnova is currently revamping all the available support towards mission-oriented approach. The challenge-driven innovation programme is still in place but is closed for new applications for stage 1 (i.e. initiation). Stages 2 (development) and 3 (implementation) still have some calls.

In Sweden there is no specific spending target for innovation procurement. There is no structured system to measure innovation procurement expenditure and to evaluate the impacts of completed innovation procurements. This is partly due to the absence of a national procurement register. However, the projects already funded are used as examples to showcase the results, outcomes and impacts of individual innovation procurement initiatives. In 2019 ten projects in innovation procurement that Vinnova and other players funded were evaluated. Among identified success factors behind these projects were: politically decided investment; pre-study done in the form of market and needs analysis; organisation to support innovation procurement; support received from the Procurement Authority, the Swedish Competition Authority or Vinnova; sufficient time and funding; access to structure for implementation; dialogue with the market; and learning in the organisation through education and exchange of experience. Among challenges the following were noted: no experience in innovation procurement; pre-study that does not cover all essential perspectives; too wide or too narrow projects; not realistic time and resource plan; digital solutions require rapid development to cope with competition; innovation procurement as a form is not rooted in the organisation; collaboration projects can be demolished if a partner leaves; structures, processes and guidelines need to support innovation procurement of digital solutions; and non-systematic work with risk analysis.

2.5 Lessons learnt for Lithuania

- In designing any support measures a system approach is crucial. Based on its long-standing experience, Sweden can be viewed as the 'home' for system approach and Vinnova is the agency for innovation systems. This requires involving various stakeholders, preparing and managing the process well and holding numerous discussions, unlimited by time. If a year is needed to reach an understanding and consensus then a year is well spent. At any given time it is important to keep flexibility and be ready to fail. If some things are trialled and they did not work, then it is worth stopping, thinking and re-considering.
- The 'beauty' of Strategic Innovation Programmes and their eventual success lies in their combined top-down (selection of Strategic Research Areas) and open bottom-up calls for consortia and projects.
- Under the SIPs once launched, responsibility for the selection of projects to be funded lied with the panels of independent experts constituted by Vinnova. This was not welcomed by all the SIPs, which argued that they are in a better position to judge whether or not individual projects match the project portfolios they deem necessary to achieve their overall goals. Vinnova has shown some flexibility as the initiative has evolved. In the first instance, the agency took complete control of the selection process once SIPs came to them with a call proposal, with applicants sending their proposals to Vinnova for review by independent expert

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panels responsible for assessing their excellence, potential, structure and management. Nowadays some SIPs proposals go both to Vinnova and the SIP management, with the Vinnova review panel classifying projects through a "traffic-light" system (yes/maybe/no), and the SIP commenting on the relevance of all projects to the overall SIP portfolio and advising on the fate of "marginal" projects. Moreover, it is also now possible to launch individual "strategic projects" without issuing a call if the SIP and Vinnova both agree with this course of action.

- Participants in the large programmes like SIPs need to be able to use supplementary instruments, for example, helping dissemination projects results through workshops and courses for companies; skills development and networking for both senior researchers and doctoral students; support for preparation of proposals to international programmes; etc.
- Having a long-term perspective is crucial for the achievements of ultimate results. The SIP instrument's budget and long-term perspective have meant that programmes have been able to formulate long-term visions and establish activities that otherwise would not have been realised.
- In designing support programmes that are tasked to address societal goals or challenges, it is important to involve a varied group of stakeholders, including societal stakeholders and not only companies and research providers.
- In Sweden there seems to be a weak link between the initiatives/ programmes and smart specialisation. Tillväxtverket also highlighted the difficulty in getting the work on smart specialisation to harmonise with the SIP's, as well as the work of other agencies and governmental strategic initiatives.
- Missions linked to global sustainability goals provide a solid ground for organisations from different sectors to cooperate with each other.

Relate to public procurement of innovation the following lessons have been identified:

- There is no one way of approaching innovation procurement. It is about understanding what an organisation and a national agenda are trying to achieve and what is the best way forward. If there is a challenge to solve or a mission to address, organisations need to think what type of projects best help solving your mission. It is about strategic choices.
- Swedish development pairs ("government agencies-innovation companies") have been very important, particularly for the development of key sectors. Even if they cannot always exist as such, the culture of public sector close collaboration with (large) industry in key development areas is likely to exist.
- Splitting information/guidance provision from a funding function is useful. It was a relief for Vinnova not to have a support / information action. Since Vinnova funds projects, it was perceived that it is better not to be involved too closely with the project, which usually happens when a support and guidance is provided to the applicant how to prepare the project.
- A solid preparatory phase, including market analysis and a dialogue, is essential. Needs must be properly identified (by users and end-users), prioritised and developed. It is also important to have a deeper knowledge of the technology that is available is sufficient for a solution to be developed within the project period. A market analysis is also important in order to gain an understanding of which suppliers are available, if only one supplier should deliver alone or if a

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combination of two suppliers with different competencies need to work together to find a solution. Therefore, a contracting authority needs some basic innovation management skills and strategic thinking in place. Any methods or tools that can help with this are important, such as needs processes (design thinking approaches are usually useful), or supplier dialogue workshop methodology.

- On the buyer's side (i.e. public sector) it is also important to have a mixed group of competences. For example, procurement skills should be available from the beginning of a project, as should people from operations, and from the development functions. Support and involvement from upper management is vital and perhaps even from politicians (if the contracting authorities is e.g. a municipality or a county council.)
- Prior to implementation, the organisation should analyse and secure structures, processes and guidelines that support innovation procurement. This is especially important in innovation procurement of digital solutions, where many organisations have IT security regulations that hinder access to sensitive data
- There must be a proactive interest in the organisation to take the lead in new, innovative solutions to business-related problems and that there are people in the organisation who are able to develop and run this type of project. The project needs to be well-anchored in its own organisation.
- The supplier who obtains a new product with financing support after the end of the public procurement project owns the product developed and can commercialise, develop and sell it. This is important to communicate to potential suppliers so that all the benefits of innovation procurement are understood better and realised in the future. In that sense innovation procurement projects are more interesting than standard R&D projects. Everything which has not been resolved before the project start will show up in innovation procurement project. Implementation stages are really difficult as processes might need to be changed, need to get a buy-in, discussions about business models, who is applying, why. In case of "normal" R&D projects a prototype might be created and look nice but it is difficult to assess if it is going to be used and how.

2.6 Sources of information

2.6.1 Stakeholders interviewed

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- Nina Widmark, Programme Manager, Innovation Management, Vinnova
- Johanna Enberg, Strategist Innovation Procurement, National Agency for Public Procurement
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Annex 3 International comparator – The Netherlands

This summary presents a review of the best practice analysis in The Netherlands in the area of business-science cooperation with a particular focus on the sector of 'Agri-Food' as well as for pre-commercial public procurement and procurement of innovation.

3.1 Macroeconomic and innovation performance context

With a population of 17,134,872 in 2017 the Netherlands is the 7th most populous EU Member State.

According to the 2017 Research and Innovation Observatory Country report (RIO 2017)[73] the Dutch economy has been on a steady economic growth path for many years. The 2016 annual growth rate was 2.2% and this was expected to be maintained. However, more recent figures show the GDP Annual Growth Rate to have dropped in the last 3 years. Annual economic growth was revised higher to 1.6% in the fourth quarter of 2019, from a preliminary estimate of 1.5% and compared to the previous period's 1.9%. That was the weakest pace of expansion since the fourth quarter of 2015. Considering the 2019 full year, the economy expanded 1.8%, the least since 2014[74]. According to a 2018 forecast by the Netherlands Bureau for Economic Policy Analysis (CPB), the Dutch economy is growing at a slower rate than previously anticipated. It was predicted that this trend would continue in 2019. The effect of Brexit and, more recently, the COVID-19 virus, remain significant unknowns that could impact on the economy.

The Netherlands has a prosperous and open economy, which depends heavily on foreign trade. Industrial activity is predominantly in food processing, chemicals, petroleum refining, high-tech, financial services, creative sector and electrical machinery. A highly mechanised agricultural sector employs no more than 2% of the labour force but provides large surpluses for the food-processing industry and for exports.

Multinational companies play a significant role in the economy of the country, making up just 2% of all registered companies but providing nearly two million jobs, or 40% of jobs in the Dutch private sector. In addition, despite being a tiny percentage of all companies, Dutch multinationals generate 25% of turnover in the private sector, and foreign ones produce 40%. Together, they account for nearly two-thirds of all private-sector turnover. In 2013 foreign multinationals were responsible for half of all goods imports and exports in 2013, while those with Dutch roots accounted for around one third of each. Another reason such firms are significant for the Dutch labour market is that they tend to be among the companies willing to hire internationals in the Netherlands.

Labour productivity has been increasing at a slow pace in recent years, but was expected to pick up for 2018[75] (CPB World Trade Monitor, 2017). More recent figure show that, following a peak of close to 106.5 in 2018, productivity has since decreased, dropping down to 104.75 points in the fourth quarter of 2019 from 104.97 points in the third quarter of 2019[76]. Unemployment decreased remarkably swiftly in 2016 to 5.4%, surpassing ex-ante expectations of around 6.1%[77] (Statistics Netherlands, 2017). The overall trend continued positive with employment rates in the third quarter of 2019 at 78.40%, up from 78.10% in the second quarter of 2019[78].

73 RIO Country Report 2017
74 Source: Trading Economics The Netherlands.
75 Source CPB World Trade Monitor, 2017
76 Source: Trading Economics The Netherlands.
77 Statistics Netherlands, 2017
78 Source: Trading Economics The Netherlands.

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Overall, the Netherlands is performing very well on almost all indicators for competitiveness and innovation[79]. On the European Innovation Scoreboard (EIS), the Netherlands improved its performance and in 2019 ranked 4th as Innovation Leader. It has particular strengths in 1.3 Innovation-friendly environment, 1.2 Attractive research systems and 1.1 Human resources. The country was also ranked 4th in the 2019 edition of the Global Innovation Index (GII) after Switzerland, Sweden and the US. Its key strengths are Institutions (sore 90.9, rank 8), followed by Business Sophistication (score 63.7, rank 6), while Knowledge & Technology Outputs and Infrastructure both score 61.8 and are ranked 3rd and 14he respectively.

The Netherlands were 4th in DESI 2017 ranking highest in connectivity; Dutch citizens are very active users of the Internet and have the right skills to do so. The digitisation of Public Services is among the most advanced in the EU while the country's challenge is to improve the take up of technology by business – although already above the EU average.

Public and private R&D spending is relatively low, limiting the growth potential of the economy. Expenditure on research & development (R&D) has been between 1.7% and 2.2% of GDP for more than fifty years. In 2018 the total R&D intensity of 2.16% of GDP was still significantly below the Europe 2020 target of 2.5%. This was down by 0.02 percentage point relative to 2017 but 0.01 percentage point up on previous years and still slightly above the European average of 2.11 percent.

Over the overall 2017 figure for 2017 of 2.18% of GDP the Dutch government invested 0.64% and the private sector 1.23% of GDP (both figures are low compared to other innovation leaders). Foreign investment in R&D came to 0.26% of GDP, provided by foreign firms and, in the public sector, the European Union. Total financial public support for R&D and innovation grew from €6.13b in 2015 to €6.50b in 2016. The total government budget showed, however, a small decrease to €6.38b in 2017. In absolute terms, expenditures of business on R&D are rising. In 2016, R&D expenditure by firms rose remarkably by 6.05%, to €8.132b, compared to 2015.

However, total public R&D support, including both direct and indirect fiscal instruments, was projected to decline from 0.94% of GDP in 2016 to 0.82% of GDP in 2021[80]. Applied research institutes are required to compensate for this decrease in public funding by obtaining more private funding. This change in funding has implications for quality of research.

The large multinationals that together account for about 60% of all industrial R&D in the Netherlands invest more in R&D than their counterparts worldwide do on average. That means that the desire to move towards an R&D intensity of 2.5% of GDP is not a matter of industry and government investing a little more; in actual fact, it is a call to change the economic structure of the Netherlands[81].

The financial return Dutch researchers receive from the different **EU Framework Programmes** exceeds the financial contribution of the Netherlands to the EU budget in each framework programme (through the Multiannual Financial Frameworks). The results of 2014-2018 (revenues), and 2014-2017 (contribution), also reveal a decreasing proportion of the Netherlands to the EU Framework Programme budget. This is mainly due to the growth in the number of EU Member States. The budget share of the Netherlands in the Horizon 2020 programme up to March 2019 was €3bn, making the

[79] Source: European Commission, EIS 2019
[80] Vennekens and van Steen, 2017
[81] Rathenau Instituut

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Netherlands the sixth recipient. It accounts for 7.7% of the total allocations compared to a contribution of the Netherlands of 5.2%. (In the last programme period the top 10 recipient countries accounted for almost 80% of the resources allocated).

The ERC programme (European Research Council) accounted for €700m of the Dutch budget share which makes this programme the largest recipient for the Netherlands. Other programmes receiving over €300m are Health, MSCA (Marie Sklodowska Curie fellowships) and ICT. The Netherlands receives over €100m from the programmes: research infrastructures, food, energy, environment and transport.

Research and Technology Organisations (RTOs) perform particular strongly in the Netherlands. The Netherlands Organisation for applied scientific research (TNO) in particular has spun our hundreds of start-up companies and has demonstrated very strong impact for innovation in the country.

The agri-food complex is an important economic pillar of the Dutch economy. The Netherlands is a European leader in the agri-food sector with many successful and innovative companies and knowledge institutes such as Wageningen UR. The agri-food sector is one of the key sectors in the recent business policy of the Dutch Government. The Netherlands is one of the world's largest exporters of agricultural products. Together with the USA and France, the Netherlands is one of the world's three leading agri-food producers. At the same time, the production poses challenges to the environment. The Dutch Government has stated that food production must become more sustainable. Today, the Dutch agri-food complex has a strong focus on sustainability, producing healthy and safe foods with respect for the landscape and the environment.

The RIO 2017 country report identified a number of challenges for R&I policymaking in the Netherlands[82]:

- **Increasing private RDI expenditure and economic restructuring:** despite a small increase in private R&D expenditure over the last years, the goal of 2.5% of GDP R&D expenditures (public and private) is still out of reach. A new facility, InvestNL, was introduced with the aim to generate more venture capital for start-ups and scale-ups.
- **Finding the right level of public expenditure on applied research organisations**: Lower levels of public funding for applied research may harm the present strong knowledge position of Dutch Research Technology Organisations (RTOs). Substantial investments in both applied and fundamental research are provided for in the most recent coalition agreement. This includes an extra investment in large technological institutes that address market needs.
- **Maintaining and improving the human capital base for R&I**: there is a continuing pressure on the labour market, especially for STEM and ICT related jobs. The Dutch Technology Pact 2020 is implemented to address these needs, but in the short term the challenge remains.
- **Governance of challenge-oriented R&I**: grand societal challenges are becoming increasingly central in R&I policy. This is acknowledged in the 'top sector policy' and new instruments such as City Deals in which several departments of the central government, municipalities, business and other

[82] Evaluation Committee Schaaf. (2017). Evaluatieonderzoek organisaties voor toegepast onderzoek (TO2): Van Excellente Instituten naar Vitale Innovatie Ecosystemen. The Hague: Evaluation Committee Schaaf.

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societal actors jointly make agreements on specific policy initiatives. The identified challenge lies in coordination between government departments and across the various levels of government (local-regional-national).

The country has also independently identified a number of specific challenges for RDI. The two main ones are a shortage of skilled human resources, especially in engineering and technology professions; and high-quality public research output input being sufficiently translated into innovation output. The Netherlands continues to develop effective policies to attract highly-skilled workers from abroad. The knowledge immigration scheme in place since 2014 has become the largest channel of non-EU labour migration to the Netherlands and is popular with employers[83]. Improved translation of research output in to innovation output will continue to be addressed under the top sector policy.

According to the 2025 Vision for Science strategy paper[84], factors which explain the international success of Dutch science include its external orientation, its non-hierarchical, open culture, the long track record of successful research evaluations, and the high degree of autonomy enjoyed by institutes and individual researchers. In addition, the Netherlands has an excellent research infrastructure. The emergence of new strengths in recent years has served to reinforce the sound reputation established by the traditional areas of focus which owe their existence to various historical and geographic factors. There are many disciplines in which Dutch research is unquestionably among the best in the world. Dutch researchers are known for their openness; they are more than willing to cooperate with others, both within and beyond their own disciplines. As a result, “the Netherlands can both ‘deliver’ and ‘collect’ knowledge, a process which relies on two-way traffic”.

3.2 Key STI features

The ambition of the Netherlands is to be among the top 5 most enterprising and competitive economies in the world. Government policy therefore focuses on stimulating innovation, reducing regulatory pressure and administrative burdens, increasing access to capital market financing, good public services for companies and fiscal support for entrepreneurs.

Responsibility for science policy and innovation policy in the Netherlands rests with two ministries: the **Ministry of Education, Culture and Science** (OCW) is responsible for science policy, and the **Ministry of Economic Affairs** (EZ) is responsible for innovation policy. As a result, these policies are set out in two separate policy documents. In practice, however, these two policy areas are increasingly connected and overlapping. The **main R&I policy implementation bodies** are the Netherlands Organisation for Scientific Research (NWO), the Royal Netherlands Academy of Arts and Sciences (KNAW), and the Netherlands Enterprise Agency (RVO). Another very important player in the innovation landscape is TNO, the Netherlands Organisation for applied scientific research. This RTO was founded by law in 1932 to enable business and government to apply knowledge. As an organisation regulated by public law the TNO is fully independent and not part of any government, university or company.

[83] OECD, 2016a
[84] 2025 Vision for Science choices for the future

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Recent R&I developments (RIO 2017) include establishment of a new finance and investment organisation Invest-NL; launch of the National Plan Open Science; and extra impulse for application of scientific knowledge. On the **science policy** in November 2014 the present government published its policy document 'Science Strategy 2025: Choices for the Future'. Three main challenges were identified as growing international competition; the need to connect science more closely with society and industry; and the growing pressure on Dutch scientists. The government set-out three goals with actions designed to achieve them:

- Goal 1: World-class science in the Netherlands
- Goal 2: Dutch science more connected with society and industry and with maximum impact
- Goal 3: Dutch science as a seedbed for talent in 2025

The government plays a role in science policy in three ways: through funding, legislation and dialogue with the field. Government funding for research and science has fluctuated over the last two decades. Over the period 2000-2010, the budget of the Ministry of OCW for research and science increased. A decrease in 2011 was mainly due to a decrease of the earmarked grants following the phasing out of the FES funds. After an increase across the board in 2012, a decline for all budget categories occurred 2013. 2014 showed a further decline in budget for the National Library institutes, other expenses and the KNAW (Royal Netherlands Academy of Arts and Sciences). The institutional budget of NWO increased in 2014 and 2015, both in absolute terms and in percentage of the total budget of the Ministry of OCW for research and science and was largely stable in to 2016.

Total income of the universities has developed positively since 2004, from €4.2bn to €7.3bn in 2018. Direct government funding remains the largest source of funds for the universities, although its share has declined since 2004 from 61% to 57%. Revenues from "Contract activities" in particular have risen faster than direct government funding, so the share of this income has increased in the period 2004-2018, from 22 to 26%. Since 2012, this percentage has been relatively stable. "Other income" grew less constantly and its proportion went down (from 10% to 8%).

Innovation policy, which complements science policy, also has three goals, which are monitored every year:

- Goal 1: The Netherlands intends to be one of the top five knowledge economies in the world by 2020.
- Goal 2: By 2020 the Netherlands will spend 2.5% of its GDP on R&D.
- Goal 3: Public and private parties will contribute at least €800 million to the top consortia for knowledge and innovation (TKIs) by 2020, at least 40% of which will come from industry.

The innovation element of the Ministry of Economic Affairs' enterprise policy consists of generic instruments for all innovative companies and specific instruments that focus on the **top sectors** (see below). Most public instruments are focused on SMEs. This involves, among other things, government funding for SMEs through the SME Top Sectors Innovation Support Scheme (MIT) and the Dutch Good Growth Fund for SME projects in emerging markets and developing countries.

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A tax incentive scheme for R&D, governed by the Research and Development (Promotion) Act (WBSO), has existed since 1994. Under this scheme, the Dutch government compensates companies for a proportion of the wage costs and other costs and expenditure associated with R&D projects. It is intended for Dutch companies engaged in research or development projects, ranging from start-ups, the self-employed and SMEs to multinationals in every economic sector. Companies actually receive these tax benefits when they file their tax return with the tax and customs administration. The Netherlands Enterprise Agency administers the WBSO. €1.163m was available for this scheme in 2018.

The other major generic instruments designed to promote innovation take the form of resources that the Ministry of Economic Affairs uses to reduce the problems companies – particularly innovative SMEs at various stages of development – encounter on the capital market. In 2015 these instruments were merged to form the DVI (**Dutch Venture Initiative**), part of the Future Fund. If an initiative is successful, the company repays the holding or loan to the fund so that the money can be re-invested.

Alongside extended innovation incentives for SMEs and top sectors the government continues to encourage innovation by using the **Small Business Innovation Research arrangement** (SBIR) as a launching customer, for example from the Ministry of Defence and Rijkswaterstaat (Public Works and Water Management).

The Top sector approach

In 2011 the **top sectors approach** came into the play in the Dutch research and innovation system. The underlying basis of current innovation policy is the Coalition agreement of October 2010, in which it was agreed that the theme-based innovation grants for companies would be phased out and replaced by more tax incentives to encourage companies to invest in R&D. Further details of these arrangements were announced in a policy document outlining a new enterprise policy[85] which the then government published in February 2011. Besides tax incentives, it was also proposed that an innovation fund be established for SMEs, which would make more risk capital available to innovative enterprises. Under the new 2011 policy, innovation programmes were replaced by an approach focused on nine 'top sectors' (occasionally also referred to in the literature as 'key sectors'). The aim was to tackle obstacles to growth in these sectors, encourage research and innovation through public-private partnership and realise economic impact. Funding to help valorise knowledge was taken partly from the budget of the 'Top Institutes (TO2)' (created prior to 2011) and the NWO.

The Top Sector approach introduced a strong regime of significant subsidies to stimulate long term, strategic Public Private Partnerships (PPPs) based on a triple helix model and using a bottom up approach to create the associated programmes. This unique form of collaboration (golden triangle/triple helix) is designed to promote innovation, to attract talent (human capital) and to ensure a solid position for the sectors in the international context. This approach has remained rather consistent for a number of years despite changes in the different ruling government coalitions. The programmes are often of significant financial size. For example, €5bn total at 50% subsidy is not unusual for the larger top sectors. They are also designed to last for a significant number of years e.g. 4 to 10 years. This requires long-term programming efforts and is seen to be at the heart of their success along with a clear focus on quality ranking as a criteria for awarding money rather than a 'first come first served' approach.

[85] See https://www.government.nl/documents/parliamentary-documents/2011/02/04/to-the-top-towards-a-new-enterprise-policy

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Initially the public-private partnerships (PPPs), were more targeted towards large companies than SMEs. They are now more inclusive and a boarder range of private sector companies have been encouraged to join, having observed that those who engaged early have prospered from the partnership. Inclusion of SMEs has been driven partly by regional innovation strategy (RIS) and associated EU funding. Regional programmes are now clearly aligned with Smart Specialisation Strategy but based on a PPP model. Some companies continue to struggle with the long term commitment required to be part of a PPP where the scope of a programme may change, but the partners are expected to commit for some 5 for more years to the programme.

The top sectors include **Agriculture & Food** but the agriculture industry overall is also represented in the sectors of **Horticulture and Raw Materials**. The nine key sectors are well represented at the four technical universities in the Netherlands. In the Coalition agreement of October 2017[86] it was agreed to focus the top sector policy more on the economic opportunities offered by three main public themes:

- energy transition/sustainability;
- agriculture/water/food; and
- quantum/hightech/nano/fotonics.

While economic impact and remaining competitive are still important, this mission led 'pivot' towards themes more directly addresses societal challenges such as an ageing population and climate change and is designed to better reflect the long term needs of the Netherlands. It makes the top sectors more 'cross-sector' and interdisciplinary and has created new valuate chains.

A top sector itself has a primarily representative role in the field of research and is not a legal entity. It is made up of a figurehead and a senior team. Aside from that, each top sector has one or more TKIs (Top Sector Consortium for Knowledge and Innovation).

Industry, knowledge institutions and the authorities collaborate in what are known as **'top sector consortia for knowledge and innovation'**, or TKIs. They engage in research initiatives across the board, from fundamental research to market-ready innovations. A TKI is a legal entity and universities are able to enter into contracts with this organisation as well. There are currently a total of fifteen TKIs for the nine top sectors to reflect the fact that in some top sectors there are several sub-sectors with diverse interests (see for example 'Water'). The TKIs serve as an intermediary between, among others, the government and knowledge institutions. TKIs distribute the money and are accountable for it to both parties. The nine top sectors and their TKIs are shown below.

Top Sector	TKI
Agri & Food	TKI Agri & Food
Chemicals	TKI Chemicals
Creative Industries	TKI CLICKNL
Energy	TKI Energy
High Tech Systems and Materials	TKI HTSM
Life Sciences & Health	TKI Life Sciences & Health
Logistics	TKI Logistics

[86] See https://www.kabinetsformatie2017.nl/documenten/publicaties/2017/10/10/regeerakkoord-vertrouwen-in-de-toekomst

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Top Sector	TKI
Horticulture and Propagation Materials	TKI Horticulture & Propagation Materials
Water	TKI Maritime Engineering; TKI Delta Engineering; TKI Hydraulic Engineering
Cross-cutting	TKI Biobased Economy

Source: Rathenau Instituut

To encourage industry to participate in public-private partnerships, the TKIs receive a special allowance from the Netherlands Enterprise Agency (RVO). For every euro that industry invests in R&D with a research organisation, the TKI receives 25 cents. This allows it to fund new public-private research. The budget for the TKI allowance is set to rise to approx. €130m in 2020. The majority of public funding focused on PPP is acquired by aligning individual ministries' programmes and the efforts of NWO, KNAW and TO2 institutes with thematic roadmaps. However, in order to reach the ambition of 2019-2021, a financial impulse for the agri food sector from the government will be necessary.

3.3 Business-science cooperation

The Netherlands boast a world-class science and research base and good cooperation between academia and business allows for knowledge diffusion in the economy. The country currently ranks among the top five in the EU for scientific research and cooperation between universities and the private sector. According to the 2018 report 'The State of Dutch University-Business Cooperation Report' (Business Perspective)[87] the nature of University-Business Cooperation (UBC) activities between Dutch businesses and universities generally follows the European pattern with Dutch businesses engaging mainly in research activities such as collaboration in R&D and consulting. As for UBC in education, Dutch businesses undertake joint activities with universities in mobility of students, even though the development of activities connected with curriculum co-design and life-long learning is very low.

Outside the PPPs there is a noticeable lack of development of other joint activities. Over 50% of Dutch businesses do not undertake any collaboration connected with valorisation and management. Particularly unpopular is business involvement in the governance. Notably, Dutch businesses see themselves as the more proactive actors in the initiation of UBC.

Dutch businesses see the variation in their cultural peculiarities with universities, such as different motivations and time horizons, as the major obstacles to collaboration. Dutch business representatives also note that the lack of government funding and bureaucracy related to UBC in universities hinders the intensity or quality of joint activities. Different professional staff profiles in the business world and academia, and thus the lack of university staff with business knowledge is reported to serve as an important barrier for businesses to follow with UBC. Finally, academics have rarely been engaged or had extensive experiences in the business field due to their homogeneous career path at the university.

[87] The State of Netherlands University-Business Cooperation: the business perspective 2018

While funding to undertake cooperation emerges as the top factor that enables the UBC in the eyes of Dutch business representatives, the factors that are related to the relationships are not less prominent:

- Dutch businesses highlight the importance of a shared goal, mutual commitment and trust, and prior relationship with the university partner.
- Dutch business representatives see UBC as much less beneficial for themselves than for other stakeholders. They see students and universities as the major beneficiaries of UBC, while themselves and the government as receiving the fewest benefits.
- Dutch businesses are primarily driven to collaboration with universities for improving their own innovation capacities, namely obtaining new technologies, knowledge and new discoveries at an early stage.

In general, Dutch business representatives report a low to middle level of the development of all UBC supporting mechanisms within their companies, not exceeding 50%. Mainly, Dutch businesses support their UBC by investing their resources, but also by engaging in presentations and mentoring programmes and student projects with the universities. This is, however, a much less structured system on average for Dutch businesses than for the European ones. Systematic R&D programmes and a well-defined strategy for co-operation are not as well-developed according to Dutch business representatives. In addition, physical infrastructure (Science/Technology Park precincts), employment fairs and life-long learning programmes represent the least developed UBC supporting mechanisms compared to the European average. Lesser involvement and support of UBC in education and life-long learning is co-related with Dutch business representatives' perception on their already strong human resources profile.

Dutch businesses follow an overall European trend in seeing themselves as rather supportive of collaboration with universities. In particular, Dutch businesses are certain of their own capability to absorb knowledge and technology from universities, and they indicate a higher level of UBC support within their businesses than the European average shows. Dutch business representatives report they have sufficient university contacts, skills and knowledge of UBC and what universities want from collaboration.

Notably, Dutch business representatives do not see cooperation with universities in delivering and developing education and training activities as their responsibility. As a result, those joint activities in education are much less widespread in the UBC overall landscape in The Netherlands.

Policy context around business-science cooperation and how it helped addressing challenges and barriers, e.g. public funding, incentives, regulatory reforms, soft measures

The top sector policy was design to address the lack of collaboration between universities and businesses. Top Institutes, (in the fields of polymers, food and materials) preceded top sector, but before the policy was introduced in 2011-2012, universities and business were quite separate from each other. Academics primarily researched topics that they found scientifically relevant but did not take in to account the issues important for the business sector. In a similar way, industry invested relatively little into research at public institutions, preferring to undertake in-house research into the potential for new products. The 'key sector' (or now 'top sector') policy was designed to bring these parties together. As a result, the academic sector is increasingly looking at themes that are

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industrially and socially relevant. At the same time, the business community is now also investing more in university research[88].The key sector policy provides for a better relationship between knowledge institutions and companies. The policy approach has replaced ad hoc collaborations over a single project with strategic discussions between a university's Executive Board and the management of a company whereby both parties are looking at a long-term relationship and a mutually agreed roadmap.

There was early resistance from some academics and universities to top sector, perceiving it as a programme that did not support fundamental research. This has gradually changed. Many academics have seen that **the questions that top sectors seeks to address, particularly in the mission driven research, also feed on and draw from blue-skies research and PPP funding clearly targets fundamental research topics**.

Culture in the universities is shifting, driven in part by the urgency of finding solutions to merging societal challenges and the uncertainty of the future. However, academic culture change has not come rapidly. It has been supported by the overall culture of the Netherlands but is has also been a process spanning some 30 years. Evolution rather than revolution has been the path for change and it is recognised that the 'DNA' of a country will play a strong role. Simply introducing subsidies for PPP will not work unless there is an underlying culture to support the goals.

The success of the top sector approach is due not only to cooperation between industry, science and government in the various sectors. The cross-fertilisation between the top sectors also produces clear added value. For example, the Horticultural sector can work together with the Energy sector to partially meet a city's energy needs. This is important **as policy in the Netherlands increasingly focuses on addressing grand societal issues that call for an overarching, cross-border approach**.

Alongside the top sectors, the government is also structuring cooperation between businesses and educational institutions to better align educational programmes and the job market. The business, education and government sectors have made concrete agreements towards this aim in the Technology Pact. The **Top Sector policy is also seen as key to enabling substantial investments in SMEs** who represent a significant part of the economy. SMEs struggle to obtain the right financing or to make contact with researchers, as their networks often do not include these kinds of contacts. The top sector approach helps to connect them with networks that can result in better access to research programmes and state-of-the-art research facilities.

Implementation of the Top Sector policy

Top Sector Policy is formulated through Missions at Ministry level and strongly implemented by the relevant TKIs. Missions for each top sector are devised by the relevant Ministries working together. This can be complicated as there is not always initial agreement between the Ministries. Once agreed, the Missions are translated in to themes and then programmes by the TKIs.

Each central theme is the responsibility of a small team consisting of a Leader, working with a core team of experts (maximum 5) from the triple helix. Themes and programmes are then presented each 6 months to a wider group (or for some themes, groups), also involving academic and commercial sectors who act as a 'sounding board.

[88] More innovations through joint research between universities and industry, Dutch Topsector policy works September 2019

The primary implementing policy instrument is the Public Private Cooperating Project – PPS. Per PPS, there is a steering group and a project team. The steering group consists of at least the coordinator of the PPS, mostly a private party, and a representative of the knowledge institution involved. In a few PPSs, governmental representatives are also involved. In order to qualify for a PPS grant, a university and a company must enter into a contract stipulating that they will both work together on a structural basis. These represent long-term projects when it comes to mutual accountability and risk. Both parties make money, set goals and share results.

The basis for the PPP grant is that for every private euro spent in cash to a research organisation, a TKI can apply on average for 30 cents cash of public funding. This money must be invested again in R&D. For the TK Agri&Food this is done with the original private spenders, representing a subsidy for the research project.

On projects with a low TRL (1-3) TK Agri&Food works together with the Dutch Science Foundation and different models apply with co-funding from 10-30-50%. The annual subsidy is in the region of €6m. A much more substantial part of the programme is for research in the mid TRL's (4-6) where TK Agri&Food makes PPP's with the applied research centre Wageningen. Here the co-financing has to be 50% of which at least 50% in cash. The public part here can amount to €32m per year. A notable second R&D partner in this TRL range is the TNO which works through two main PPP programmes: Demand-Driven Programmes or the Knowledge Transfer Programme designed specifically for SMEs.

In the high TRL (7-9) TK Agri&Food works together with the different regions with the full spectrum of EU programmes (EFRO Interreg etc), as well as special one MIT (SME In top sectors), where Agri & Food has some €10-12m per year on small studies and full R&D projects, organised by the four (NESW) coupled provinces together. In addition, some regions have extra instruments, that they usually align around the top sector agenda.

The main criterion for selection of projects is quality. Participants in PPSs are numerous: 400 companies (half of these are classed as SME) and 30 knowledge institutions.

The TKI receives the final results of applications for PPP grants from all of the projects of all the universities. The TKI then submits an application to the Netherlands Enterprise Agency (RVO) for the grant. It implements the PPP scheme on behalf of the Ministry of Economic Affairs. Once this has been approved, the RVO pays out the grant to the TKIs. The TKI's have been given the freedom to determine for themselves the process by which they pay the supplement to universities for new PPPs. Some TKIs issue a request whereby the university has to submit a proposal for the PPP grant while other TKIs allocate grants to universities based on the groundwork that they have already contributed. This second approach is frequently the most advantageous for universities. A shorter version has been available since last year. This route is called the PPP project grant. Universities and companies can apply for a PPP project grant for a specific project. They are then able to spend the money directly on that project.

Procedures

The KI Agri & Food organises and supports the development of public-private cooperation projects through the following procedures and instruments.

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1. Appeal for PPS projects co-financed by Wageningen University & Research capacity or TKI allowance.
2. Application and use of TKI allowance
3. Appeal for Seed Money Projects Internationalisation
4. Development of Strategic and Social Innovation Programmes
5. Co-financing of EU projects at Wageningen University & Research
6. Setting up calls for academic research in cooperation with NWO
7. Deployment of innovation brokers
8. Organising network activities
9. Setting the agenda with the EU and regional stakeholders.

KPIs for the programme include the absorption of project funding. This is seen as a measure of commitment to the project by the companies. Each programme also has milestones and a supervisory committee who reports back on milestones. The committee focuses on the monitoring principals and advises on changing the scope of a programme. This **practice has emerged in recent years and was strongly driven by the 'climate' theme** where very clear targets exist ,e.g. for CO2 emissions at EU and Global levels. It is now seem for other themes e.g. circularity and sustainability. For Food and agriculture emerging goals include 'enhanced animal welfare' and some clear quantitative targets exist such as a shift from 40% to 60% plant protein in the diet. The supervisory committee monitors programmes with perspective of the milestones, e.g. will future CO2 conversion realistically be based on the on the use of new catalysts.

After running the top sector approach for some five years, the Ministry of Economic Affairs conducted an evaluation. Specifically for this purpose, a framework was developed for assessing the governance and impact of so-called 'modern industrial policy'. The evaluation, finalised early 2017[89], served to gain insight in the effectiveness of the top sector approach. The top sector approach was **originally set up to strengthen innovation systems, primarily for stimulating cooperation**. In practice, this **has led to different priorities, agendas and increasingly more cross-sector initiatives in each top sector**. The approach has been undeniably effective in the more demand-oriented programming of PPP research at Dutch knowledge institutes, aligning human capital activities and promoting export. These results are underpinned by a number of findings (A to E). In its application, the top sector approach has been valuable especially in engaging various stakeholders for the implementation of innovation directions the market aims to develop, but less so in redefining these directions (not an explicit objective). Despite being part of the enterprise policy, this approach also revolves so much around knowledge development that there is only a limited amount of impetus on promoting innovative entrepreneurship and especially creating a market for innovation. The findings F to H show how the top sector approach could have (had) a greater impact.

A. The top sector approach has contributed to the more demand-oriented research programming at Dutch knowledge institutes, maintaining particularly applied research infrastructures and setting up some long-term PPP programmes for basic research. Thereby it has **supported the transition from a subsidy-based**

[89] See https://www.dialogic.nl/wp-content/uploads/2017/08/Evaluation-Topsector-Approach-Management-Summary.pdf

innovation landscape to an environment in which knowledge institutes and companies meet one another through PPP. Out of the more than €800m that is being invested in PPP-projects receiving TKI allowance, 47% is financed by private parties. Obtaining >40% private funding was a key objective of the top sector approach in the relevant period.

B. The top sector approach has **resulted in collectivity** and an overview, especially in heavily fragmented top sectors. This approach has proven useful in creating mass and jointly generating the momentum to tackle issues in innovation systems.

C. The top sector approach **offers a platform on which parties can jointly organise their development and application of knowledge**. The coordination between companies, knowledge institutes (and governments) has provided insight in the various top sectors' activities, their objectives and who is all involved. Although the approach is strongly sectoral, the current TKIs and Knowledge and Innovation Agendas (KIAs) also offer plenty of opportunities to work on cross-overs.

D. The transition from innovation programmes to top sector approach has indeed **paved the way for a broader specific enterprise policy**, focussing on a wide spectrum of bottlenecks potentially linked to strengthening innovation systems. This focus has also initiated the 'societalisation' of innovation policy. As control is mainly based on the demand from financially strong businesses, the top sector approach is still not a panacea for affirming the core importance of (innovative solutions for) societal challenges.

E. Some top sectors typically achieve a relatively large impact from their efforts in the areas of trade facilitation and human capital, despite limited resources. The top sector approach **has latched onto internationalisation**, in particular involving businesses more intensively with trade missions. The top sector label is applied successfully to enhance the image of the Netherlands for specific themes. Also the positive impact of human capital is related to connecting and fulfilling existing initiatives.

F. The extent of **the focus on developing ground-breaking (innovation) visions is still limited**. Initially, obtaining support and commitment certainly featured more on the top sector approach agenda than making clear-cut decisions. The added value of the approach, in terms of developing innovative visions from the private market, is most apparent in the less established top sectors, where joint participation and alignment were previously less developed.

G. **Market formation based on innovative procurement policy is still a too limited part of the top sector approach**: neither the Dutch Ministry of Economic Affairs nor the top sectors themselves vigorously pursue the government's role as launching customer and 'pioneer' in achieving innovation agendas. By taking ownership of a number of typical societal issues, the government could help to create (market) conditions for testing and marketing innovations.

H. Although the top sector approach is focussing more and more on connecting with the regions and colleges, there are still plenty of opportunities for improvement. Meanwhile, actions have been taken to ensure that promising companies and innovations in the region can grow quicker to (inter)national level. Part of this development is involving colleges and vocational education, however interaction in the region could probably be improved by taking into account the development,

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exchange and application of knowledge other than from the TO2 institutes and the four technical universities.

Future actions related to improving Impact from Scientific Research

In 2014, the Dutch Government published its Vision for Science 2025 [Wetenschaps-visie 2025]. One of its aims was to link Dutch scientific research more effectively with society and to ensure that it has an impact on society and the economy. In 2017 the Royal Netherlands Academy of Arts and Sciences was asked to provide advice on how best to determine the societal and economic impact of science. A number of recommendations for the future were made including to NWO and other research funding bodies[90]. These are outlined below.

1. NWO: Continue along the planned path of **requiring applicants for research funding to consider how their proposed research can have an impact on society**, and what action is needed for that to be achieved. This can involve, for example, asking for impact pathways to be specified. Ensure that impact pathways do not become merely static documents but rather a means for promoting utilisation by society. This will also require enabling researchers to devote time and attention to the necessary activities.
2. NWO and other research funding bodies: When setting the assessment criteria for research projects and programmes in which societal impact is one of the aims, **include the requirement for there to be a potentially productive interactive network**.
3. NWO: **Continue** along the planned path of, for example, **experimenting with mission-driven programmes** within the framework of the National Research Agenda (NRA) and investigate how this approach can lead to a faster and better impact on society.

3.4 Public Procurement of Innovation

The Dutch government procures around €73bn worth of work, services and supplies every year. Much of this is for primary process. On 1 July 2016 the amended Dutch Public Procurement Act entered into force, which implements the latest EU procurement directives (2014/23/EU, 2014/24/EU and 2014/25/EU). The Public Procurement Act applies to both national and European procurement procedures. This recent transposition of EU Directives into the Public Procurement Act led to a number of changes, which include facilitating better access for SMEs, reducing the administrative burden for contracting authorities and economic actors, and granting contracting authorities more flexibility in how they organise their procedures. Furthermore, the Netherlands is increasingly investing in implementing sustainable public procurement mechanisms.

The Netherlands is a highly decentralised unitary state in which power is shared quite diffusely among the central government, 12 provinces and 393 municipalities. In the Dutch system, each contracting authority is responsible for the management of its own public procurement procedure, regardless of its level of authority. Coordination and policy-making are handled at the central level by the Ministry of Economic Affairs and its Public Procurement Expertise Centre, PIANOo[91].

[90] See https://knaw.nl/en/news/publications/maatschappelijke-impact-in-kaart?set_language=en
[91] See Public procurement – Study on administrative capacity in the EU The Netherlands Country Profile

PIANOo (Professioneel en Innovatief Aanbesteden, Netwerk voor Overheidsopdrachtgevers EN: Professional and Innovative Tendering, Network for Government Contracting Authorities) was set up in 2005 to professionalise procurement and tendering in all government departments, with a view to improving efficiency and compliance with the rules. It started out as a knowledge network for government procurement officers and contracting authorities – able to source information for the network, and migrated to become a competency centre able to directly deliver knowledge to te network. As of 1 January 2017 PIANOo is part of the Netherlands Enterprise Agency (RVO.nl), which in its turn is part of the Ministry of Economic Affairs and Climate Policy. The unit is not large, comprising around 15 FTE along with a further 15 focused on the e-procurement platform.

For a full and recent Case study on the set-up and role of the Competency Centre PIANOo within the context of innovation procurement in the Netherlands, the reader is directed to a recent (May 2019) and comprehensive case study[92], prepared for The Portuguese National Innovation Agency (ANI).

Development of PPI

PPI in the Netherlands dates back over a decade to the SBIR[93] (Small Business Innovation Research). This was a procurement programme in which the Dutch Government used the power of procurement for finding innovative solutions to societal issues. SBIR challenged companies to put their entrepreneurship and innovative strength into action to develop solutions within a short time span and enabled the government to be a first client for new innovations.

PIANOo continues to encourages PPI by publishing guiding principles and offering an 'Innovation tool chest'. This provides practical tools that can be used to conduct a targeted search for an innovative solution or to consciously provide scope for companies to deliver innovative solutions. Besides tools, the innovation tool chest offers sample procedures for a PPI process, and case studies showing how these tools are used in practice. The tool chest is widely and frequently used, as demonstrated by monitored 'hits' and 'downloads' to the site. This activity forms part of the KPIs for PPI but overall, indicators are more qualitative than quantitative, relating to the process but not the outcome of innovation procurement. Individual authorities have also been provided with self-evaluation tools and the agencies are ranked as to how 'innovation friendly' their PP is perceived to be.

Understanding the market is also key to innovation procurement and regarded as another strategic goal. To facilitate connections between innovative businesses and contracting authorities, Dutch authorities have created a number of tools, including an Innovation Market platform[94] to allow suppliers to promote their products to governments across the Netherlands and beyond.

[92] See https://www.ani.pt/media/4374/final-report-case-study-nl_julho2019.pdf

[93] https://www.rvo.nl/sites/default/files/bijlagen/SBIR%20brochure%20The%20power%20of%20public%20procurement.pdf

[94] https://www.innovatieplatform.nl/

In terms of SMEs and innovation, recent estimates indicate[95] that 80-90% of public contracts in the Netherlands are awarded to SMEs. However, Dutch authorities still see room for improvement, and are promoting common solutions, such as breaking contracts into lots, eliminating turnover requirements, and using standardised tender documents. The Netherlands are also working to include SME voices in the planning process through greater dialogue and market research.

Alignment between PPI policy and overall top sector policy has never been very strong although there was an attempt in the 1990s to better align public procurement and policy goals and professionalise the service, following significant fraud, detected in public procurement in the construction industry. Lack of wide-spread alignment is partly due to the fact that PPI works better for some sectors than others. For example, in the construction, safety and security sectors, where the main client is 'public sector', policy can lead procurement. In others, such a food, procurement of food is largely a private sector requirement, e.g. schools and hospital canteens are privately run. For the food sector, the exception is in 'Defence' where there is a need to feed many people from the public budget.

The recent top sector evaluation noted that 'market formation based on innovative procurement policy is still a too limited part of the top sector approach: neither the Dutch Ministry of Economic Affairs nor the top sectors themselves vigorously pursue the government's role as launching customer and 'pioneer' in achieving innovation agendas. By taking ownership of a number of typical societal issues, the government could help create (market) conditions for testing and marketing innovations'.

3.5 Lessons learnt for Lithuania

The top sector policy has proved very successful for the Netherlands as indicated by its consistency across a decade of changing government coalitions. Key success factors are seen to be:

- The size and duration of the programmes: €5bn for a programme at 30-50% subsidy is not uncommon and partnerships are established for between 4 and 10 years. This requires significant investment in to flexible programming by all parties to enable activities to change if a programme is not achieving its intended results. Public and private partners need to commit to long term projects and government need to be able to guarantee that funding and programmes will have the necessary longevity, despite changes in the political landscape.
- Creating new programmes – not subsidising old ones. The Netherlands has focused on creating new subsidised programmes rather than simply subsiding existing initiatives. This stimulates change and renewal.
- Significant investment in to a collaborative design process to select quality projects and ensure commitment from the beginning. The Netherlands invest a lot of time in establishing selection criteria to ensure high quality projects. This involves bringing together 30-40 individuals, representing different stakeholders

[95] It should be noted that, due in part to the country's uniquely decentralised political system, and the variety of public and private actors at play, the Netherlands does not collect or publish comprehensive, nationwide data on their public procurement practices or outcomes.

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at national and regional level cross-sectoral workshops as well as considerable investment into community and platform building.

- A clear focus on demonstrating partner commitment by monitoring that each partner is spending their budget. This requires significant monitoring for a large programme.
- A focus on results based on milestones and targets. This activity is undertaken by a supervisory committee who reports back regularly on milestones and advise on changes to the scope of the programme. This approach has developed recently, pushed by the climate change agenda where there are clear EU targets for CO2 emissions that enable well defined milestones for a programme.
- Culture and tradition. The national culture of the Netherlands has played a clear role in the success of the top sector policy and its implementation model of PPPs. This needs to be stated as good practice may not be transferable without a supporting culture. If the desire to see PPPs succeed for the good of the economy, planet and society is not in some way 'hard wired' in to the countries 'DNA' then a programme of subsidies alone will not succeed. Culture change can take several decades.
- With regard specifically to the Agri-food sector this is very different to others in the Netherlands. It is one of the largest and strongly focused on export (80-90%). It is also highly segmented with many different categories of players, (e.g. Horticulture, farmers, food industry, food processors), often with their own lobbying associations and agendas. For a sector like this there is a need to bring them together in a common frame and common agenda. An established history of collaboration between academics and the private sector in the Agri-food industry, started under the extension programmes is seen to have played a significant role in bringing the different groups together in PPS. It has also been helpful to have recognised specialised institutes/ universities with excellent research – in this case the Wageningen University. However, a key success factor has been the KT centre – Top Sector Consortium for Knowledge and Innovation (TKI) Agri&Food.
- Top-sector brings together the three parts of the triple helix in a way that is beneficial for all three. Policy makers in particular, regard the top sector structure and bottom up development of programmes as a way to inform and refine policy and not just to distribute funds. It is also a valuable new way to transfer knowledge to the commercial sector in the absence of a more traditional 'extension service'.

Emerging lessons learned/ potential drawbacks

- One potential draw-back of the Dutch PPI subsidising scheme model is for startups/spinouts. In a "traditional" subsidy scheme, the balance sheet for a startup/ spinoff appears healthier, as it shows money coming in for R&D activity. However, under the Dutch PPI scheme, it only shows money going out as they do not receive the subsidy directly – the money goes to the research organisation. One alternative approach would be to reserve the public money, and spend it according to the list of PPP's selected, as if it were a simple subsidy with the enterprise partner shown in the system.

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Overall, key lessons for Lithuania may be the value of larger programmes with significant duration and the shift towards a top down Mission' implemented through a bottom up approach to project and programme design.

In relation to the **development of the public procurement to innovation** the following key lessons are be noted:

- The Dutch PPI activity has emerged from a robust attempt to professionalise public procurement as a whole. Although the original impetus was from a negative political situation – identification of fraud in the construction sector - this was turned in to a strong positive outcome by moving to 'professionalise' public procurement in general. PPI was then able to emerge strongly from this early basis.
- Establishing a network and consciously migrating to a Competency Centre has proved very valuable. This requires long-term financial commitment to a core team who can both acquire and develop valuable knowledge to be offered to a network. Joining projects to expose a Centre to wider good practice is beneficial but being part of a peer group who are generating new knowledge is even more important and requires a perspective beyond a short project horizon.
- Developing and making available tools is beneficial for encouraging PPI, along with supporting their use.
- Quantitative KPIs to measure PPI are challenging. Qualitative KPIs may be easier to apply but overall, PPI is hard to measure because of the very different definitions and interpretations of innovation.

Overall, key lessons for Lithuania may be seeking to professionalise PP as a whole and providing good tools to support uptake.

Particular lessons related to **encouraging/ facilitating industry/ academic partnerships in the Agri-food sector** include:

- For certain sectors, including Agri-food, it takes several years and sometimes more than a decade to translate a new discovery or scientific finding into a marketable product.
- The longer the scientific results can remain under an embargo the better it is for the companies involved because it gives them time to start with their breeding programmes ahead of the competition.
- The precompetitive topics that benefit the sector as a whole are important. This will encourage different companies to work together and the more fundamental nature of the research provides more academic freedom and room for failure.
- The likelihood of international companies participating in research projects that are at the core of their business is low. This is because the really essential innovations must be kept secret as to provide an opportunity to file a patent. Also innovations that rely on patented products or methods from third parties can restrict the possibilities for the company to sell the product in the future.
- It is best for academic researchers to work with organisms and varieties that come close to those used by the companies themselves. If the company can provide material to work on this is ideal. Everything that helps a company to understand how a certain innovation behaves in the materials or setups that they

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use themselves is more useful than the same results in an unrelated species or environment etc.

- Some of the Dutch companies have huge R&D facilities in-house and they spend a large percentage of their profit on research. This also means that they have strong academic in-house infrastructures with highly educated people. The sooner the research possibilities and experience at the involved companies is determined and acknowledged the better the cooperation with the academic partners will turn out to be.
- Many of the Dutch companies have their own links and existing collaborations with academic partners in the Netherlands and with researchers at high level universities worldwide. New partnerships should therefore complement these existing collaborations, or excel in a certain field.

Sector specific pre-requisites in terms of framework conditions, e.g. those related to the public research organisations/ enterprises/ supporting instruments/ ecosystem including finance?

- This depends a lot on the specific sector and on what they can provide in co-financing and hence what they can subsequently demand in IP rights. It also depends a lot on the way certain sectors are organised and whether or not they operate locally or on international markets. The demands on framework conditions will depend on all these factors. With this in mind, one generalisation may be that all companies would probably like the possibility to obtain the IP-rights for new discoveries. However, they understand very well that publishing is a central and essential part of the academic work and academic training of PhD students.

3.6 Sources of information

3.6.1 Stakeholders interviewed

- Professor Emmo Meijer, Council member AWTI
- Dr. Ir. C.D. (Kees) de Gooijer, Director TKI-bureau Agri-Food
- Dr. Jan de Wit, Ministry of Agriculture, Nature and Food Quality
- Floris den Boer, Senior Adviser, PIANOo
- Leon Gielgens, Head Strategic Partnerships, Dutch Research Council (NWO) | Domain Applied and Engineering Sciences (AES).

3.6.2 Documents analysed

Netherlands - Country analysis from JRC

- RIO Country Report The Netherlands 2017
- Challenges for R&I policy-making in the Netherlands
- Smart Specialisation Strategies: The Netherlands
- Netherlands - Key indicators
- Netherlands - European Semester
- Smart Specialisation
- Netherlands Library

All available from: https://rio.jrc.ec.europa.eu/en/country-analysis/Netherlands

Regional Policy, https://ec.europa.eu/regional_policy/index.cfm/en/atlas/netherlands

Mutual Learning Exercise MLE on Innovation-related Procurement, European Commission June 2018.

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Public procurement – Study on administrative capacity in the EU The Netherlands Country Profile (Undated)

SBIR The power of public procurement: innovative solutions to societal challenges, NL Agency

NL Innovation, Ministry of Economic Affairs Agriculture and Innovation, January 2011

Mapping social impact, Royal Dutch Academy of Sciences, 2018 ISBN 978-90-6984-728-3 With a summary in English

Annex 4 Background information used for the review of the Lithuanian context

The work on preparing a review of the Lithuanian context in identifying barriers and rivers for business-science cooperation was based on the analysis of relevant background reports produced between 2017-2019 and provided by the Ministry of Economy and Innovation, with a specific focus on the interim evaluation of the Smart Specialisation priorities; the background analysis was validated via 14 stakeholder interviews, and a workshop with key stakeholders, organised on the 5th of March 2020.

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4.2 List of interviewees

No.	Sector	Name	Organisation
1	ICT	Paulius Nezabitauskas	Director of the Kaunas Science & Technology Park / Coordinator of the Digital Rocket LT Cluster
2		Andrius Plečkaitis	Project manager, INFOBALT
3		Linas Bukauskas	Vice-Dean of the Faculty of Mathematics and Informatics, Vilnius University
4	Photonics and laser technologies	Petras Balkevičius	Executive Director of the Lithuanian Laser Association
5		Gediminas Račiukaitis	Head of the Department of Laser Technology, Center for Physical Sciences and Technology (FTMC)
6		Gintautas Tamulaitis	Professor at the Institute of Photonics and Nanotechnology, Faculty of Physics, Vilnius University
7	Life Sciences	Gintaras Valinčius	Director of the Life Sciences Center, Vilnius University
8		Vaidotas Marozas	Director of the Biomedical Engineering Institute, Kaunas University of Technology
9		Inga Matijošytė	President of Lithuanian Biotechnology Association
10	Agro-innovation and food technologies	Giedrius Bagušinskas	Coordinator of SMART Food Cluster
11		Kristina Šermukšnytė-Alešiūnienė	Head of AgriFood Lithuania Digital Innovation Hub
12		Česlovas Bobinas	Director of National Food Cluster (Association)
13		Petras Rimantas Venskutonis	Professor at the Department of Food Science and Technology, Kaunas University of Technology
14		Elvyra Jarienė	Director of Agriculture and Food Sciences Institute, Vytautas Magnus University, Academy of Agriculture

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4.3 Workshops with key stakeholders

4.3.1 Initial stakeholder workshop

Business-science cooperation in Lithuania: What can be changed in the next programming period?

5 March 2020
Venue: Ministry of Economy and Innovation, Gedimino ave. 38, room: 213 (2nd floor)

08:00-08:15 Registration of the participants

08:15-08:45 Welcome and introduction to the discussion
- welcome from DG REFORM / MoEI
- introduction to the project and objectives for the day

Speakers: *Enrico Pesaresi, DG REFORM*
Jelena Angelis, EFIS Centre

08:45-09:00 Understanding barriers and drivers for science-business cooperation in Lithuania
Speaker: *Agnė Paliokaitė, Visionary Analytics*

09:00-10:30 Group discussion on **drivers** for science-business cooperation
- Which drivers worked better in the past (and why) for joint R&D projects; contract research; and commercialisation?
- Are drivers different in four thematic areas of engineering (incl. laser technologies), life sciences, food industry and ICT? What are the reasons behind these differences?
- Which drivers worked to stimulate / increase Pre-Commercial Procurement and Public Procurement of Innovative Solutions?

Moderator: *A representative from the EFIS Centre / Visionary Analytics consortium*

10:30-10:45 Coffee break

10:45-12:15 Group discussion on **barriers** for science-business cooperation
- Which barriers were the largest in the past and why?
- Are barriers different in four thematic areas of engineering (incl. laser technologies), life sciences, food industry and ICT? What are the reasons behind these differences?
- What were the barriers for Pre-Commercial Procurement and Public Procurement of Innovative Solutions?

Moderator: *A representative from the EFIS Centre / Visionary Analytics consortium*

12:15-12:30 Next steps and close

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4.3.2 Co-design workshops with four thematic areas

Business-science cooperation in Lithuania: Co-designing support instruments with life sciences sector

7 October 2020
13:00-16:00 EET
Venue: Zoom platform

13:00-13:15 Welcome and update about the project – What happened since our discussion on 5th March
Jelena Angelis, EFIS Centre

13:15-13:30 Bridging the gap: Mission- or vision-driven approach to science, technology and innovation
Philippe Larrue , OECD

13:30-14:00 Vision-Driven Innovation "environments" in health and life sciences: How this was built in Sweden
Laurent Saunier, Vinnova (Sweden's Innovation Agency)

14:00-14:30 Discussion

14:30-15:00 Possible instruments to support business-science cooperation through a mission-driven approach

15:00-15:45 Discussion

15:45-16:00 Next steps and close

Project team experts:
Jelena Angelis, Lisa Cowey, Agnė Paliokaitė, Alasdair Reid, Kiimmo Halme

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Business-science cooperation in Lithuania: Co-designing support instruments with engineering, ICT and agro-food sectors

14 October 2020
10:00-13:00 EET
Venue: Zoom platform

13:00-13:15	Welcome and update about the project – What happened since our discussion on 5th March *Agne Paliokaite, Visionary Analytics*
13:15-13:30	Bridging the gap: Mission- or vision-driven approach to science, technology and innovation *Philippe Larrue , OECD*
13:30-14:00	Examples of mission- and challenge-based programmes and instruments from Sweden, Ireland and the Netherlands
14:00-14:30	Discussion
14:30-15:00	Possible instruments to support business-science cooperation through a mission-driven approach
15:00-15:45	Discussion
15:45-16:00	Next steps and close

Project team experts:
Jelena Angelis, Lisa Cowey, Agnė Paliokaitė, Alasdair Reid, Kimmo Halme

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