Multi-annual plan for the use of research and development funding

Final report of the Parliamentary RDI Working Group 2022

Parliamentary RDI Working Group 2022

PUBLICATIONS OF THE FINNISH GOVERNMENT
2023:56

FINNISH GOVERNMENT

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Parliamentary RDI Working Group 2022

Finnish Government Helsinki 2023

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Final report of the Parliamentary RDI Working Group 2022

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Abstract

The Parliamentary Working Group on Research, Development and Innovation 2022 was appointed by the Government on 7 April 2022 to continue the work of the previous working group, which operated in 2021. The task of the 2022 working group was to draw up a pian for R&D funding that extends beyond the spending limits period, to serve as a monitoring group for the preparation of the Act on Research and Development Funding and to monitor the implementation of the decisions and policy outlines made by the 2021 working group. The Act on Research and Development Funding, which entered into force on 1 January 2023, will lead to a very significant increase in the State's R&D investments. These additional investments will require comprehensive development of the RDI system and effective allocation of funding.

The Parliamentary Working Group on Research, Development and Innovation identified key areas for development in the Finnish RDI system and assessed the state of research and development funding and how it is targeted. In the course of its work, the working group consulted with a broad range of interest groups and RDI experts. In addition to R&D funding, the policy outlines of the Parliamentary RDI Working Group are related to strengthening the management of the RDI system, increasing the availability of R&D expertise and labour force, advancing cooperation, making strategic choices at the national level, assessing the effectiveness of R&D funding and developing a favourable operating environment for research and innovation. In the 2022 working group's view, the development of the RDI system should continue to be based on the ten principles for developing the RDI system drawn up by the previous working group.

Keywords	research and development, research funding, research policy, innovation policy, innovation		
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Tutkimus- ja kehittämistoiminnan rahoituksen käyttöä koskeva monivuotinen suunnitelma

Parlamentaarisen TKI-työryhmän 2022 loppuraportti

Valtioneuvoston julkaisuja 2023:56

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Tiivistelmä

Valtioneuvosto asetti 7.4.2022 parlamentaarisen TKI-työryhmän 2022 jatkamaan vuonna 2021 toimineen parlamentaarisen TKI-työryhmän työtä. Työryhmän tehtävänä oli laatia kehyskautta pidempi T&K-rahoituksen suunnitelma, toimia T&K-rahoituslain valmistelun seurantaryhmänä sekä seurata kokonaisuudessaan vuonna 2021 toimineen työryhmän linjausten toimeenpanoa. 1.1.2023 voimaan tullut T&K-rahoituslaki tarkoittaa erittäin merkittävää valtion lisäpanostusta T&K-toimintaan. Lisäpanostukset T&K-toimintaan edellyttävät TKI-järjestelmän kokonaisvaltaista kehittämistä ja rahoituksen vaikuttavaa kohdentamista.

Parlamentaarinen TKI-työryhmä tunnisti suomalaisen TKI-järjestelmän keskeisiä kehittämiskohteita ja tarkasteli tutkimus- ja kehittämisrahoitusta ja sen suuntaamista. Työnsä aikana työryhmä kuuli laajasti sidosryhmiä ja TKI-toiminnan asiantuntijoita. Parlamentaarisen TKI-työryhmän linjaukset liittyvät T&K-rahoituksen ohella TKI-järjestelmän johtamisen vahvistamiseen, osaamisen ja T&K-työvoiman saatavuuden lisäämiseen, yhteistyön vahvistamiseen, kansallisiin strategisiin valintoihin, T&K-rahoituksen vaikuttavuuden arviointiin sekä tutkimus- ja innovaatiomyönteisen toimintaympäristön kehittämiseen. Parlamentaarinen TKI-työryhmä katsoo, että TKI-järjestelmän kehittämisen tulee jatkossakin perustua edellisen työryhmän laatimiin kymmeneen TKI-järjestelmän kehittämisen periaatteeseen.

Asiasanat tutkimus- ja kehittämistoiminta, tutkimusrahoitus, tutkimuspolitiikka, innovaatiopolitiikka, innovaatiotoiminta

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Flerårig plan för användning av finansieringen av forsknings- och utvecklingsverksamhet
Slutraporten av den parlamentariska FoUI-arbetsgruppen 2022

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Utarbetad av	Den parlamentariska FoUI-arbetsgruppen 2022		
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Referat

Statsrådet tillsatte den 7 april 2022 en parlamentarisk FoUI-arbetsgrupp med avsikten att denna arbetsgrupp under 2022 skulle fortsätta det arbete som den parlamentariska tidigare FoUI-arbetsgruppen hade utfört 2021. Arbetsgruppen hade till uppgift att utarbeta en plan för FoU-finansiering som sträcker sig längre än en ramperiod, agera uppföljningsgrupp som stöd för beredningen av lagen om FoU-finansiering och följa genomförandet av de riktlinjer som den arbetsgrupp som var verksam 2021 dragit upp. Lagen om finansiering av FoU trädde i kraft den 1 januari 2023 och den innebär mycket betydande ytterligare statliga satsningar på FoU-verksamhet. Ytterligare satsningar på forskning och utveckling kräver att FoUI-systemet utvecklas på ett övergripande sätt och att finansieringen riktas på ett verkningsfullt sätt.

Den parlamentariska FoUI-arbetsgruppen identifierade de viktigaste utvecklingsbehoven inom det finländska FoUI-systemet och granskade FoU-finansieringen och hur den riktas. Under arbetets gång har arbetsgruppen hört ett stort antal intressegrupper och experter på FoUI-verksamhet. Utöver FoU-finansieringen hänför sig riktlinjerna från den parlamentariska FoUI-arbetsgruppen till olika sätt att stärka samarbetet och ledandet av FoUI-systemet samt öka kunnandet och FoU-arbetskraften. Dessutom hänför sig riktlinjerna till nationella strategiska val, utvärderingen av hur effektiv FoU-finansieringen är samt utvecklandet av en forsknings- och innovationsvänlig verksamhet. Den parlamentariska FoUI-arbetsgruppen anser att FoUI-systemet även i fortsättningen bör utvecklas baserat på de 10 principer som den tidigare arbetsgruppen utarbetat.

Nyckelord	forsknings- och utvecklingsverksamhet, forskningsfinansiering, forskningspolitik, innovationspolitik, innovationsverksamhet

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After completing its work, the Parliamentary RDI Working Group 2022 respectfully submits its final report to Prime Minister Sanna Marin.

Matias Mäkynen, Chair

Ville Vähämäki, Deputy Chair

Kai Mykkänen

Arto Pirttilahti

Saara Hyrkkö

Pia Lohikoski

Joakim Strand

Sari Essayah

Harry Harkimo

Riitta Mäkinen

Lulu Ranne

Mari-Leena Talvitie

Hanna Kosonen

Atte Harjanne

Johannes Yrttiaho

Sandra Bergqvist

Antero Laukkanen

1 Introduction

Finland's success now and in the future is based on skills, research and innovation. Research and innovation play a crucial role in increasing productivity, renewing business and industry, and creating wellbeing. Research and innovation contribute to solving the biggest challenges of our societies both globally and on a local level. The impact of science and new innovations in society is highly diverse and wide-ranging.

In December 2021, in the final report of the Parliamentary RDI Working Group, all parliamentary groups committed to increase research and development expenditure to 4% of GDP by 2030 and also to increase state R&D funding in ways necessary to achieve the 4% GDP target. In the report, the Parliamentary RDI Working Group proposed that state R&D funding be increased by passing an Act on Research and Development Funding, which would determine the annual level of state R&D expenditure to ensure that the target is achieved. In addition, the working group proposed that, alongside the Act, a statutory R&D funding plan that extends beyond the spending limits period be drawn up. The plan defines the basic lines of funding orientation, and it strengthens the commitment to the long-term development of R&D funding and activities. The working group also proposed the introduction of a permanent and more extensive tax incentive for R&D activities.

Raising the R&D funding to 4% of the GDP is a very significant policy to secure Finland's future success and is, at the same time, a considerable financial investment for both the public and private sectors. Currently, only Israel and Korea exceed the 4% GDP target among the countries of the world. The substantial additional investments in R&D require effective allocation of funding and continuous development of the RDI system.

On 7 April 2022, the Government appointed the Parliamentary Working Group on Research, Development and Innovation 2022 to continue the work of the previous parliamentary working group, which operated in 2021.

Mandate and term of the working group

By Government decision, the task of the Parliamentary RDI working group 2022 was to draw up a plan for R&D funding that extends beyond the spending limits period, to serve as a monitoring group for the preparation of the Act on Research and Development Funding and to monitor the implementation of the policy outlines of the working group that operated in 2021 (including the R&D tax incentive, ensuring the availability of experts and possible fund-based solutions as part of raising and allocating R&D funding).

The term of the working group was 11 April 2022 to 31 March 2023.

Composition of the working group

The members of the working group were two representatives from each of the parliamentary groups formed on the basis of the 2019 parliamentary elections. The chair of working group was Matias Mäkynen MP from the Social Democratic Parliamentary Group and the deputy chair was Ville Vähämäki MP from the Finns Parliamentary Group. The following members of parliament were members of the working group: Riitta Mäkinen (Social Democratic Parliamentary Group), Lulu Ranne (Finns Parliamentary Group), Kai Mykkänen and Mari-Leena Talvitie (National Coalition Parliamentary Group), Arto Pirttilahti and Hanna Kosonen (Centre Parliamentary Group), Saara Hyrkkö and Atte Harjanne (Green Parliamentary Group), Pia Lohikoski and Johannes Yrttiaho (Left Alliance Parliamentary Group), Joakim Strand and Sandra Bergqvist (Swedish Parliamentary Group), Sari Essayah and Antero Laukkanen (Christian Democratic Parliamentary Group) and Harry Harkimo (Liike Nyt Movement Parliamentary Group).

The working group's permanent experts were (deputy member in parentheses): Permanent State Under-Secretary Timo Lankinen, Prime Minister's Office (Director General Seppo Määttä); Permanent State Secretary Juha Majanen, Ministry of Finance (Director General Terhi Järvikare); Permanent Secretary Anita Lehikoinen, Ministry of Education and Culture (Director General Atte Jääskeläinen); and Permanent Secretary Raimo Luoma, Ministry of Economic Affairs and Employment (Director General Ilona Lundström).

Science Specialist Antti Pelkonen, Prime Minister's Office, served as Secretary-General of the working group, and Ministerial Advisor Taina Eckstein, Ministry of Finance, Director Erja Heikkinen, Ministry of Education and Culture, and Senior Ministerial Adviser Maija Lönnqvist, Ministry of Economic Affairs and Employment, served as members of the secretariat. In addition, several other officials from the Prime Minister's Office, the Ministry of Finance, the Ministry of Education and Culture, and the Ministry of Economic Affairs and Employment contributed to the work of the working group.

Work of the working group

The working group met 10 times during its term.

At the start of its work, the working group drew up a work plan, as part of which the working group had a joint discussion on the interpretation of its mandate. At an early stage of its work, the working group outlined that it would examine both the RDI system as a whole and its development needs, as well as R&D funding and its allocation. In addition, the working group outlined that it would consider R&D funding mainly on a strategic and general level.

In its meetings, the working group extensively reviewed various subareas of the RDI system and R&D funding within the available time frame through consultation with RDI system actors and experts as well as thematic reviews.

Regarding progress on the implementation of the policy outlines of the previous parliamentary RDI working group, the working group received in its meetings reviews of the preparation of the Act on Research and Development Funding and the R&D tax incentive. The Government presented a proposal for an Act on Research and Development Funding on 13 October 2022 (Government proposal to Parliament for an Act on Research and Development Funding in 2024-2030 [HE 211/2022 vp], Finance Committee report on 2 December 2022 [VaVM 34/2022 vp]). The Act entered into force on 1 January 2023 (1092/2022). The legislative proposal on a tax incentive for research and development activities was prepared during autumn 2022, led by the Ministry of Finance. The Government did not, however, submit the proposal to Parliament. At its meeting on 23 November 2022, the parliamentary working group decided to make a legislative initiative regarding the tax incentive. The legislative initiative (LA 69/2022 vp) was signed by 142 members of parliament. The President of the Republic ratified the Act based on the legislative initiative on 29 December 2022, and the Act entered into force on 1 January 2023 (1298/2022). In addition to these two items, the working group discussed in more detail certain other items outlined by the previous working group, such as the availability of experts and attracting foreign talent to Finland.

The progress of the working group's work was communicated on the working group's website[1] and in press releases of the Prime Minister's Office. Social media were also utilised in communications. The working group's meeting materials are publicly available via the working group's website in the Government Project Window. Two series of articles were published (in Finnish) on the working group's website. In the series "From the pen of the

1 https://vnk.fi/en/parliamentary-working-group-on-research-development-and-innovation

working group members", members of the working group wrote about the work of the RDI working group and its priorities from their own perspectives. In the series "Long-term R&D funding", experts wrote about the situation of research and development funding in countries of interest to Finland.

The working group participated in a joint statement (in Finnish) of four working groups (Technology Advisory Board, Working Group on Sustainable Growth, Parliamentary RDI Working Group and Artificial Intelligence 4.0 Programme) "Finland can only succeed in the future with skills and innovation – reforms are needed now". It was published on 14 November 2022.

Consultation of stakeholders and specialists

RDI system actors and experts were widely consulted at working group meetings. In addition, ministry officials were consulted as external experts at working group meetings. Written statements were requested from nine parties. A list of the experts consulted at the meetings and the parties from which a written statement was received is presented in Appendix 1.

On 22 June 2022, the working group organised an open seminar at which the development of the Finnish RDI system was examined. The seminar was addressed by Tarmo Lemola M.Soc.Sc on the history of RDI policy, Professor Heikki Mannila on the development of the higher education field and Director Mari Hjelt on the development of research institutes. Professor Yrjö Neuvo and Marjo Miettinen, member of the Research and Innovation Council and Chair of the Board of Ensto, contributed comments from a business perspective. Over 200 people attended the event.

Through an open stakeholder survey, the working group mapped the views of the RDI actors on the current state of the RDI system and particularly on key areas for development. The survey was conducted in the otakantaa.fi service from 30 August to 18 September 2022, and 77 responses were received. A summary of the responses to the survey is available on the working group's website.

The working group held a stakeholder meeting on 18 January 2023 at which a draft of the working group's final report was discussed. At the event, speeches, requested in advance, were given by the following parties: Universities Finland UNIFI, the Finnish Research Institute Partnership Tulanet, the Rectors' Conference of Finnish Universities of Applied Sciences Arene, the Confederation of Finnish Industries, Technology Industries of Finland, Wärtsilä Plc, the Federation of Finnish Enterprises, Finnish Startup Community, the Finnish Union of University Professors and the Finnish Union of University Researchers and Teachers (joint speech), Young Academy Finland and the BIOS Research Unit. Around 250

people attended the event. In the period 11–22 January 2023, it was possible to comment in writing on the draft of the working group's final report in the otakantaa.fi service. Written comments were received from 88 parties.

The work of the working group was discussed twice at the meetings of the Research and Innovation Council, where the chair of the working group outlined and discussed the progress and content of the work (22 June 2022 and 7 February 2023).

This report of the Parliamentary RDI Working Group is the first multi-annual plan for the use of R&D funding. Under the Act on Research and Development Funding (R&D Funding Act), the Government will in the future approve, once a parliamentary term, a plan for the use of R&D funding for the next eight years. The Ministry of Economic Affairs and Employment and the Ministry of Education and Culture are responsible for the preparation of the plan in cooperation with ministries and authorities.

Chapter 2 of the report examines the current state of Finland's RDI system and R&D funding as well as recent international developments in RDI policy. Chapter 3 describes the volume and importance of the increase in R&D funding under the R&D Funding Act and the role of state R&D funding. Chapter 4 presents the policy outlines and statements of the working group regarding areas for development in the RDI system and R&D funding.

2 RDI system and R&D funding

2.1 Current situation of Finland's RDI system and R&D funding

In international comparisons of innovation activity, Finland often ranks at or near the top. For example, Finland ranks second in the latest European Innovation Scoreboard (European Commission 2022). In this comparison, Finland has long ranked among the top three. Finland ranks 11th in the World Economic Forum's Competitiveness Index (World Economic Forum 2019) and 9th in WIPO's Global Innovation Index (World Intellectual Property Organisation 2022).

Finland's strengths continue to be a well-functioning RDI system, the general cost level of RDI activities, a strong knowledge base in a few sectors and areas of expertise, and a strong and developing startup culture (e.g. OECD 2022a). The lack of a long-term approach to funding, the growing skills shortage, slow productivity growth and the narrow base of the economic structure are among Finland's challenges. At the same time, the quality of RDI operations must be raised and the RDI operating environment developed as international competition intensifies.

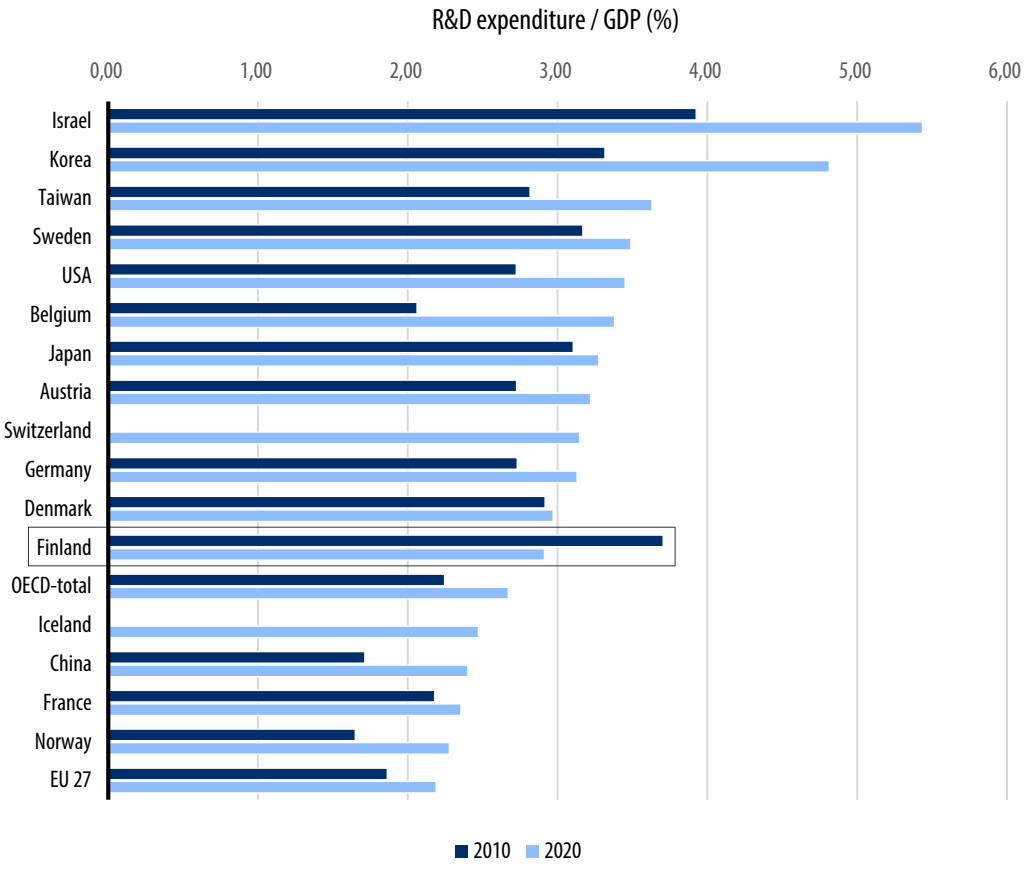
In the 2010s, several significant structural reforms concerning Finland's RDI system entered into effect (Figure 1).

Figure 1. Most significant reforms of the RDI system in 2010–2021.

Development of R&D expenditure

While Finland's R&D expenditure (as a share of GDP) has remained at an internationally good level, it declined significantly in the 2010s (Figure 2). Labour productivity in Finland has grown slowly since the 2008 financial crisis, largely due to a reduction in R&D investments and other intangible investments. Over the past ten years, Finland's GDP has also lagged behind the development of the other Nordic countries (Pohjola 2020). The commitment achieved by the Parliamentary RDI Working Group will increase R&D expenditure to 4% of GDP, promote productivity growth and strengthen Finland's international competitiveness in the future.

Figure 2. Development of Finland's R&D expenditure in a comparison of EU and OECD countries in 2010 and 2020. Source: OECD Main Science and Technology Indicators (OECD 2022b).[2]



2 At the time of writing the report, there were no 2020 data on R&D expenditure in Switzerland and Israel in the OECD statistics. Data from 2019 has been used for them in the figure.

In 2021, R&D expenditure in Finland grew exceptionally strongly, by more than 8% from the previous year (see Figure 3). Business enterprise R&D expenditure grew relatively the most, by around 11%. The strongest growth was in service industries (18%). Growth in the higher education sector was just under 2%. The rest of the public sector increased R&D expenditure by just under 4%. As a whole, the public sector accounted for around one third of Finland's R&D expenditure, and the private sector for around two-thirds (Figure 4). The R&D expenditure of universities and research institutes account for the major part of public sector R&D expenditure.

Figure 3. Development of R&D expenditure by sector in 2010–2021. In this figure, most of the public sector's R&D expenditure is research institutes' R&D expenditure. (Source: Statistics Finland 2021)

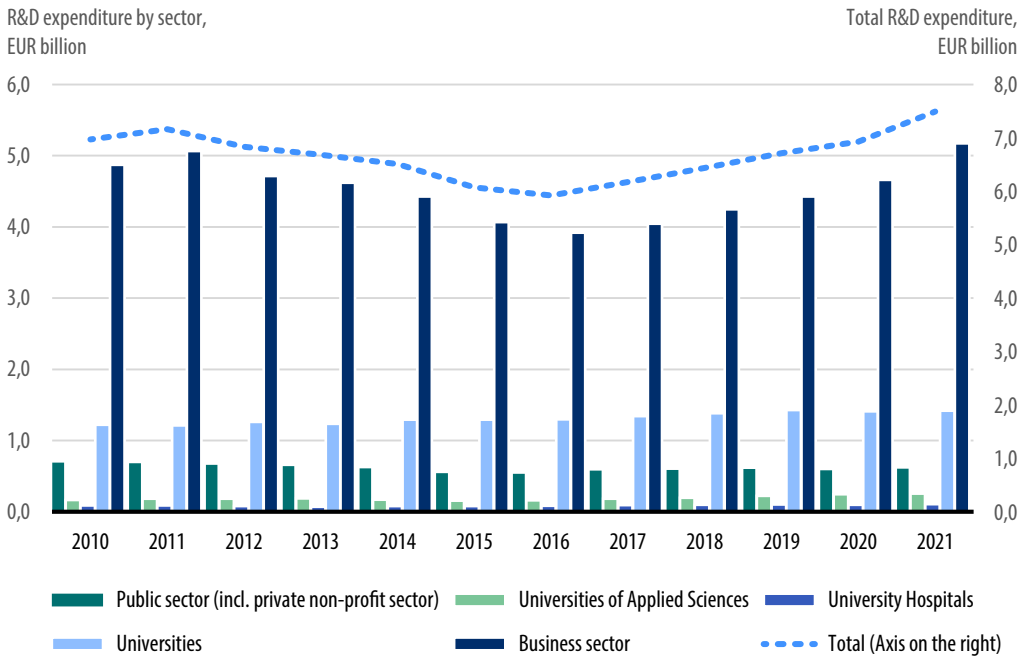
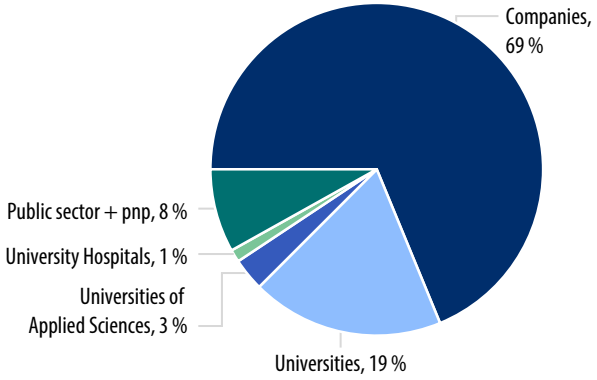
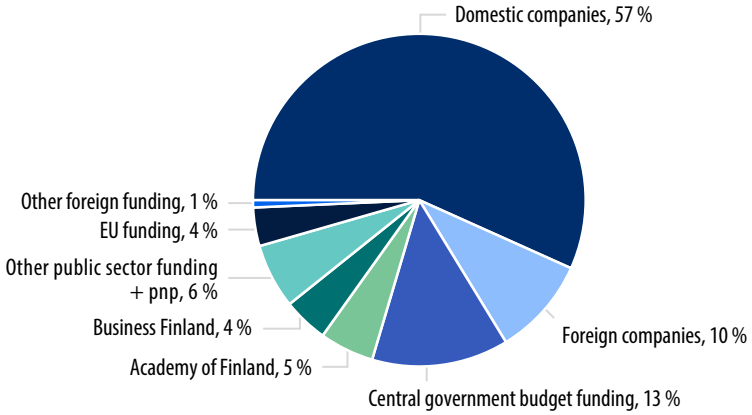


Figure 4. Distribution of R&D expenditure by performing sector in 2021 (Statistics Finland 2021). Pnp means private non-profit activity.



Companies fund around 67% of Finland's R&D expenditure. Of foreign companies' 10% share, most is funding provided by foreign-owned companies operating in Finland (Figure 5). Almost half of public sector funding is central government budget funding for universities, universities of applied sciences and research institutes. Around one third of national public funding is channelled through Business Finland and the Academy of Finland.

Figure 5. Source of funding for R&D expenditure in 2021 (Statistics Finland 2021).

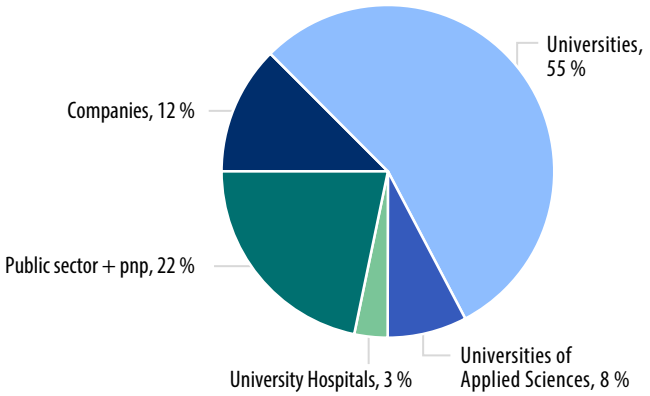


State R&D funding

In 2022, state R&D funding was estimated to be EUR 2,488.5 million, and its share of the GDP is projected to be 0.93%.[3] In state R&D funding for 2021–2023, there were significant European and national one-off R&D funding items related to COVID-19 recovery.

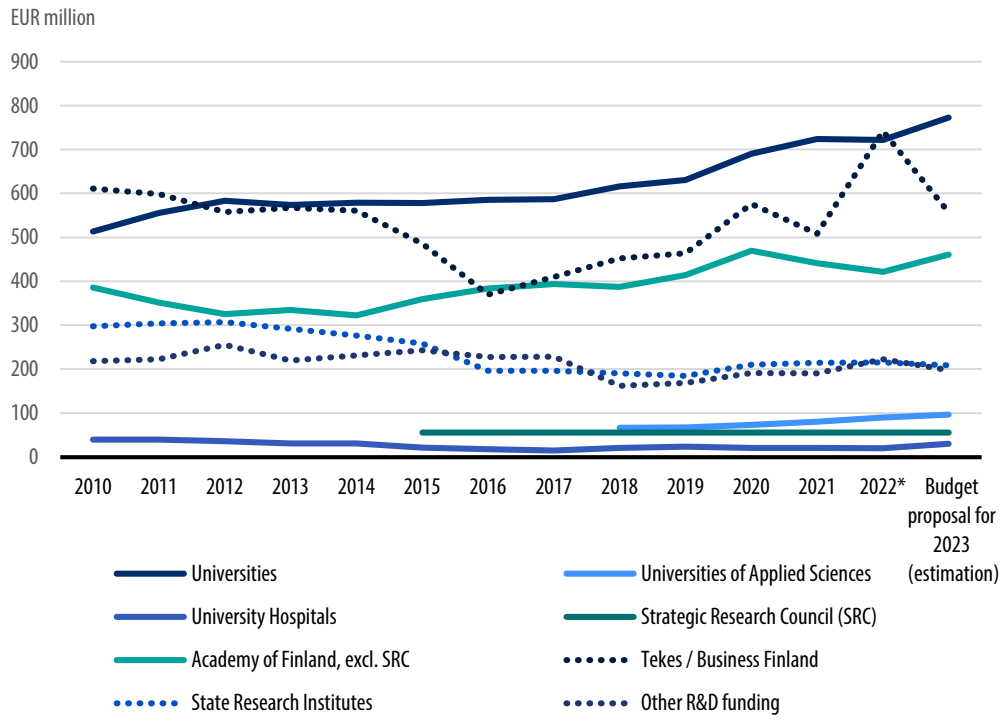
Slightly more than half of public sector R&D funding is spent in universities, 22% is allocated to the public sector (of which most goes to research institutes) and 13% to companies (Figures 6 and 7).

Figure 6. Distribution of public sector funding to sectors' R&D in 2022 (Statistics Finland 2022).



3 The final statistical data on R&D funding for 2022 will be published on 24 August 2023.

Figure 7. Breakdown of state R&D funding by organisation in 2010–2023



Business Finland's funding for 2022 includes an exceptionally large item of authorisations carried over from the previous year, and most of the EU Recovery and Resilience Facility (RRF) funding channelled through Business Finland in 2021–2023. Source: Government proposal for the 2023 State budget; Statistics Finland Research and development funding in the State budget. *) SRC decision-making is independent of the Academy of Finland, but Statistics Finland maintains statistics on SRC funding as part of the Academy of Finland's funding until 2022.

In 2021, 56% of Business Finland's R&D funding for companies went to service sectors and 38% to industrial sectors. The sectors receiving most of Business Finland's R&D funding are information and communications (29%), electronics, computers and electrical equipment (11%), research and development (10%), other machinery and equipment (9%), and architectural and other services (7%). Of Business Finland's funding, 19% went to higher education institutions and 7% to research institutes.

Based on applications and their international review, 78% of the Academy of Finland's competitive funding in 2021 was allocated to universities, 12% to research institutes and 10% to other organisations (Academy of Finland 2021). Of the Academy of Finland's funding for universities in 2020, around 37% was allocated to natural sciences, 20% to social sciences and 17% to medical and health sciences (Vipunen). The Academy of Finland's support for applied research was mainly allocated to flagship sectors where companies are involved in pre-competitive research, for example in artificial intelligence and cancer research, development of next-generation wireless networks, and research into new ways of utilising wood fibres. Of the sources of funding for universities and

universities of applied sciences, Business Finland's funding has decreased significantly, while the Academy of Finland's has increased (Finnish National Board of Education's statistics service Vipunen).

The Strategic Research Council (SRC) finances research aimed at finding concrete solutions, in cooperation with knowledge users, to major challenges demanding a multidisciplinary approach. Of the SRC's funding, 69% is allocated to universities, 23% to government research institutes, around 2% to universities of applied sciences, around 2% to companies and 4% to other organisations, such as associations, foundations and public actors.

Of the universities' research funding, 48% is central government funding for the universities' activities, and of universities of applied sciences' research funding, 49% is central government funding for the universities of applied sciences' activities. Of the research funding of sectoral research institutes, 44% is core funding allocated by the central government. In the universities, most R&D funding is used in the fields of technology (22.8%), natural sciences (22.6%) and medical sciences (17%). The relative proportions of the fields have remained quite stable. Technology and natural sciences have alternated as the largest recipients of R&D funding. In the universities of applied sciences, three fields take up most of the R&D funding: technology (33.2%), health and wellness fields (20.4%) and business, administration and law (12.3%). (Finnish National Board of Education's statistics service Vipunen)

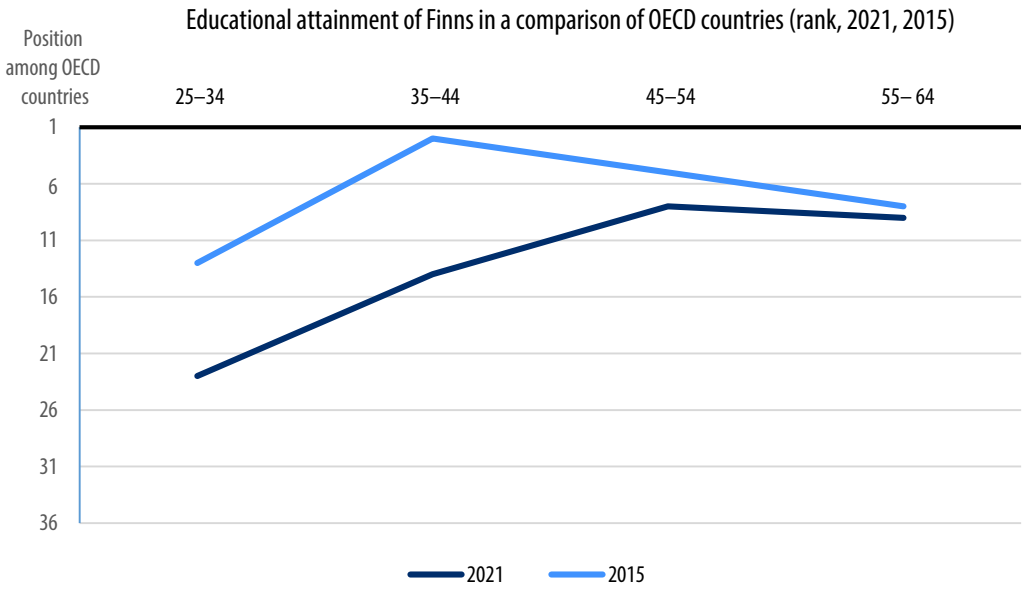
The regional councils and the Centres for Economic Development, Transport and the Environment (ELY Centres) fund RDI development projects of both SMEs and the public sector. The funding is mainly European Regional and Structural Policy funding, co-financed by the EU, of which the most significant elements from the perspective of the development of RDI are the ERDF (European Regional Development Fund) and the JTF (Just Transition Fund). The funds' projects will be implemented under the Innovation and Skills in Finland (2021–2027) programme. Of the funding for the programme, around EUR 1.38 billion of public funding will be allocated to RDI activities in the coming period and of that around EUR 900 million to R&D activities.

Education, competence and research

Productivity does not increase and innovations do not arise unless talented people are in the right positions. A shortage of talent is already a factor limiting growth in the public sector and in companies. An increase in the level of R&D funding also requires a rapid increase in the number of the most highly educated R&D experts, which presents a challenge for the entire education system. The learning outcomes of basic education have deteriorated and there is also concern about educational equality. People may complete a number of upper secondary qualifications before entering working life or

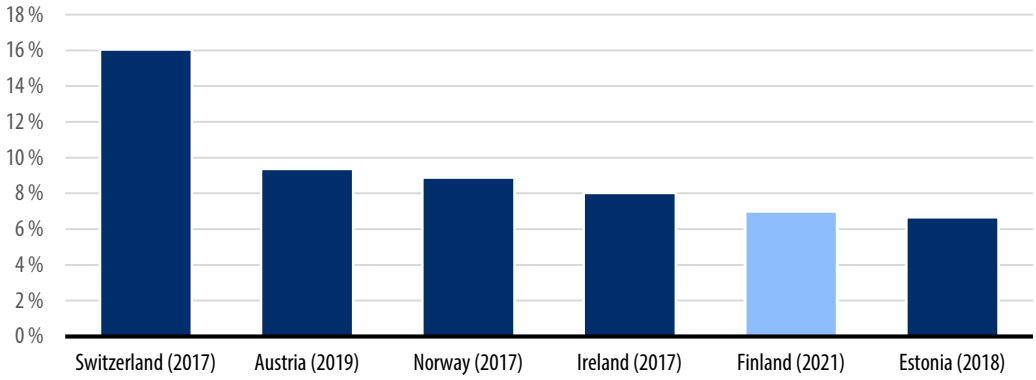
higher education. The proportion of highly educated young adults (aged 25–34) in Finland is clearly below the average of OECD countries. The age cohorts reaching retirement are the 9th most educated of the OECD countries, but young adults are ranked 23rd in a corresponding comparison (Figure 8). Finland has, however, the largest shortage of highly educated workers in the OECD countries. As age cohorts shrink, it will be necessary to increase education-based immigration and to encourage graduates to remain and work in Finland significantly more often than at present in order to better meet the demand for skilled workers in the labour market. R&D-based economic growth is only possible if a greater proportion of talented people become interested in research careers and if clear research career opportunities are available in research-performing organisations, including companies. (Ministry of Education and Culture 2017; also Finnish Government 2019).

Figure 8. Education level of Finns aged 25–64 years in a comparison of OECD countries by age group (by education level, 2015 and 2021). Source: OECD: Education at a Glance 2022.



Only 20% of Finland's R&D personnel have completed researcher training (doctorate, licentiate). In the corporate sector, only 7% of those doing R&D work have completed researcher training (Statistics Finland). The level of education and competence of companies' personnel affects the ability to innovate and overcome economically difficult periods. The most productive companies have more highly educated employees than other companies (Criscuolo et al. 2021). Finland's largest export companies do not employ highly educated people as much as the export companies of other Nordic countries (Ahtonen et al. 2019). In Finland, there is a smaller proportion of corporate sector R&D personnel who have completed researcher training than in many peer countries (Figure 9).

Figure 9. Proportion of R&D personnel with doctoral degrees in the private sector in different countries. Source: Statistics Finland, OECD.



Finland's research community ranks well in the production of publications in a European comparison. The level of publications in several fields is somewhat above the average of peer countries and in a few fields is world-leading. Most publications are produced in the ICT, electrical engineering and clinical medicine sectors. Nevertheless, in the clinical medical sciences, Finland publishes relatively fewer research papers than its peer countries. In addition to the fields of ICT and electrical engineering, the relative share of publications is high in the fields of ecology, environmental sciences and plant biology, and in economics. (Academy of Finland 2022.)

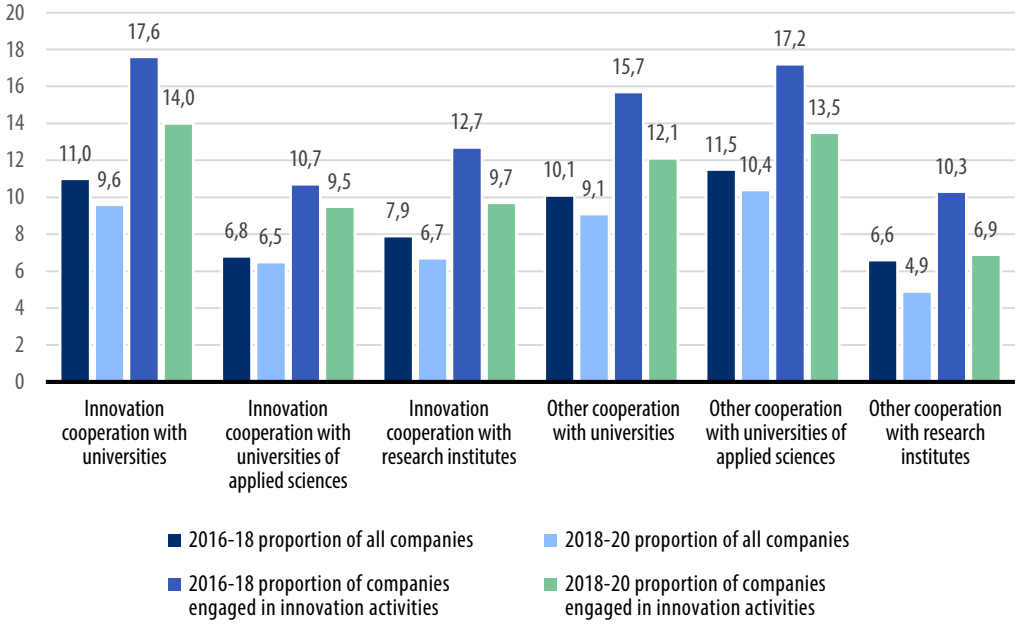
Cooperation between business enterprises and public research organisations

Cooperation between business enterprises and other research organisations has traditionally been strong in Finland and it remains so compared with many European countries (European Commission 2022). However, according to evaluations (OECD 2017; Halme et al. 2021) and innovation statistics, companies' cooperation with higher education institutions and research institutes has declined and, according to R&D statistics, public funding for this decreased in Finland in the 2010s.

For example, as a result of the cuts in the mid-2010s, Business Finland's funding has been more strongly focused on supporting fast-growing and internationalising companies in line with industrial policy objectives, while Business Finland's funding for research carried out by higher education institutions and research institutes in collaboration with business enterprises to renew business and industry has decreased. Cuts in the funding directed at large enterprises have reduced pre-competitive joint projects between companies and other research organisations as well as companies' research subcontracts from other organisations.

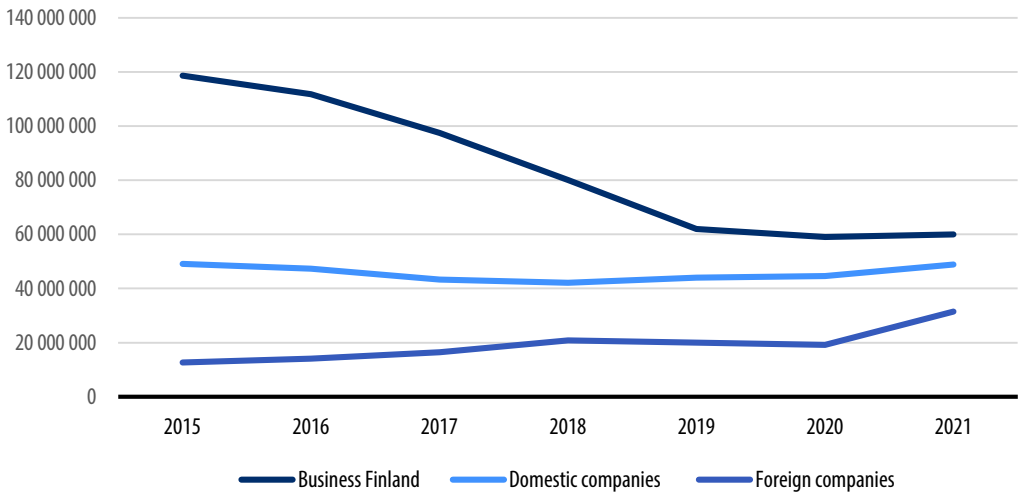
According to Statistics Finland's innovation survey, the number of companies cooperating with higher education institutions and research institutes has also been decreasing for a number of years (Figure 10).

Figure 10. According to Statistics Finland's innovation survey, the proportion of companies cooperating with higher education institutions and research institutes has decreased. Cooperation has decreased in all companies, but more so in companies engaged in innovation activities. (Source: Statistics Finland, Innovation, https://stat.fi/en/statistics/inn).



Domestic companies' funding for higher education institutions has been fairly stable, and foreign companies' funding, in particular, has increased . The level of corporate funding is very low, however (Figure 11). According to the OECD's recent country report, corporate funding for universities is lower in Finland than in OECD countries on average (OECD 2022a). On the other hand, cooperation between companies and public research organisations is more diverse than before, and it is also takes place in ways where funding is not transferred from one organisation to another (for example, Academy of Finland Flagships). There needs to be more investment in cooperation between the public and private sectors.

Figure 11. Development of companies' and Business Finland's funding to higher education institutions 2015–2021 (EUR) Source: Vipunen.



Most corporate funding has been directed to the University of Tampere's vaccine research. After it becomes part of the national vaccine research centre, funding and competence will follow, at least partially, which will also have a downward impact on the total amount of corporate funding (Kajaste et al. 2022). In cross-sectoral analysis, corporate funding has traditionally been high in technological fields, where universities' research funding from companies fell significantly during the 2010s. In most other main disciplines, corporate funding of university research has remained fairly stable over the past 20 years. The total level of corporate funding has been around 3.5% of the universities' total R&D funding (2020; Finnish National Board of Education's statistics service Vipunen).

The total external funding received by universities of applied sciences from Business Finland and companies increased by around a quarter (24%) in 2018–2021, but this increase in funding was dualistic. On the one hand, funding from companies increased while, on the other hand, funding from Business Finland decreased during the review period concerned. Corporate funding to universities of applied sciences increased steadily, growing by 51 percentage points, but as with the universities, this accounts for only 3.5% of their total R&D funding. In contrast, Business Finland's funding for universities of applied sciences decreased by one-sixth during the same period. In the universities of applied sciences, corporate funding is directed predominantly to technological fields, which have received more funding than the other fields of research combined (Vasikainen & Parkkari 2022).

In Finland, the business community also continues to cooperate to an exceptional extent with research organisations in scientific publishing compared with other EU countries but, according to a Finnish Research Impact Foundation report (Koski et al. 2021), cooperation

in publishing has decreased in the 2010s. Of the scientific publications of higher education institutions and government research institutes, typically around 5–6% or less are joint publications with companies. In the European Innovation Scoreboard comparison, Finland was ranked 7th in joint publications (European Commission 2022). In universities, publishing cooperation with companies is most common in technology and agricultural and forestry sciences (depending on the source of data), while in universities of applied sciences and government research institutes it is in technology. (Academy of Finland 2022).

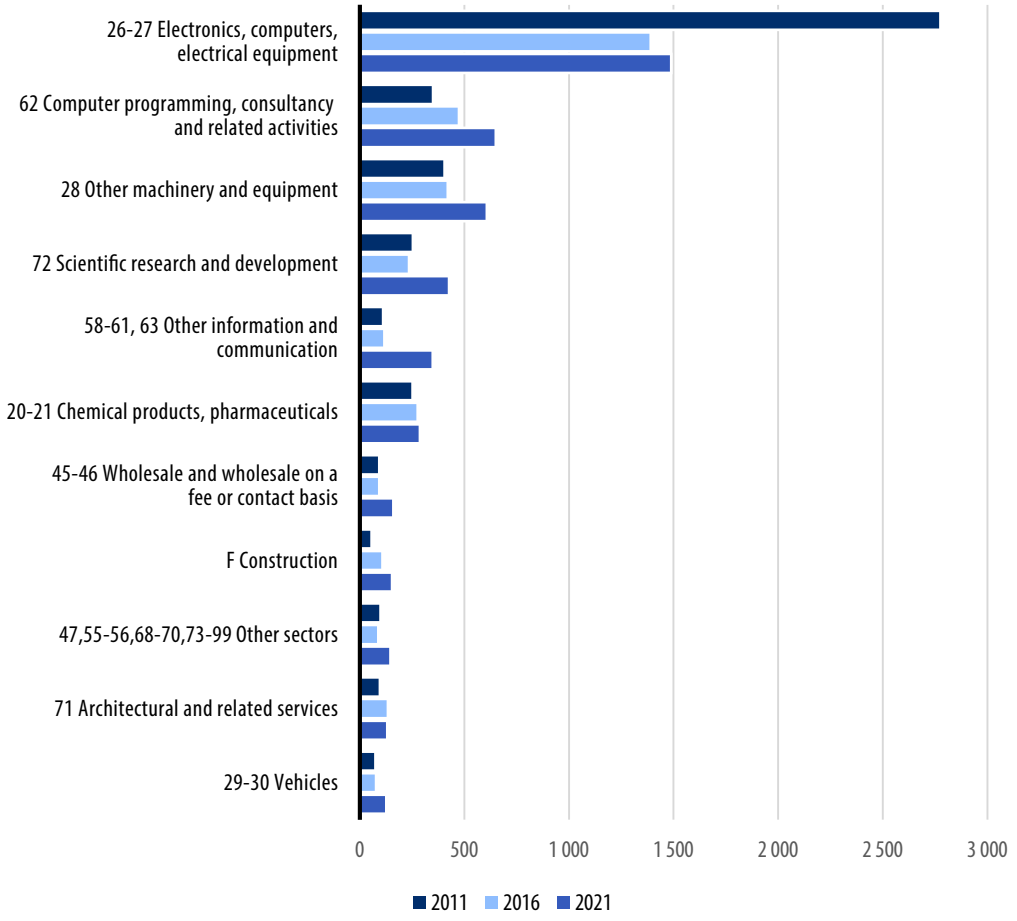
The Academy of Finland Flagships and Business Finland's funding for leading companies (business drivers), launched in recent years, focus on longer-term, high-risk R&D activities and serve as a platform for cooperation. The Flagships and funding for leading companies promote diverse, broad-based cooperation and the development of ecosystems. Based on the mid-term review of the first six Academy of Finland Flagships, business cooperation in the Flagships is close and diverse. The proportion of corporate funding has more than doubled compared with the Academy's direct Flagship funding. The Flagships have led to the founding of 160 new startup companies and have generated nearly 200 patents. Business Finland has encouraged leading companies to increase their R&D investments in the long term. Business Finland's funding leverages leading companies' investments threefold, and fivefold when the entire business-driver ecosystem is counted, including companies of various sizes, research institutes and universities (Business Finland 2022).

Business enterprise R&D activities

Approximately two-thirds of Finland's R&D expenditure arises in business enterprises. Large business enterprises act as drivers of the business community's R&D activities. Business enterprises with more than 500 employees account for more than half of business enterprise R&D expenditure (53% in 2021), but medium-sized enterprises (50–249 employees) have seen the strongest growth in relative terms in 2016–2021 (55%). In 2021, large business enterprises' R&D expenditure turned to stronger growth, accounting for most of the increase in business enterprise R&D expenditure. However, only a small proportion of large business enterprises carrying out R&D activities spend a significant part of their turnover on R&D (Tekniikka ja talous 2021).

Most business enterprise R&D expenditure is concentrated in a few industries, such as electronics, computers, and electrical equipment; information and communication; other machinery and equipment (Figure 12). In these sectors, the growth of R&D activities has also been strongest in 2016–2021. After a decline of just under ten years, business enterprise R&D expenditure turned upwards and grew by 32% in 2016–2021 (at current prices). In the service sectors, growth has been higher (61% in 2016–2021) than in industry on average (17%).

Figure 12. Business enterprise R&D expenditure in the ten largest industrial sectors in 2011, 2016 and 2021 (EUR million) (Statistics Finland 2021).



The business operations, value chains and RDI activities of companies have internationalised strongly in recent decades. Even if the R&D expenditure of Finnish-origin companies increases, the growth and impact will not necessarily be in Finland. Companies' decisions about the location of their R&D activities are particularly influenced by the availability and cost of R&D personnel and R&D subsidies as well as the proximity of the company's other units and customers. In the technology industry, public R&D subsidies were the third most important criterion when companies decided on the target country for R&D investments. Sweden, the Baltic countries and Germany are Finland's strongest competitors as locations for R&D activities. Part of the R&D activities carried out abroad is explained by the fact that companies modify their products to better meet the needs of the target country's market.

2.2 Changing research and innovation policy

Finland has long invested in research, development and innovation activities. The 1960s and 1970s saw the expansion of higher education and the development of a research culture and science policy, while the 1980s saw the rise of technology policy. In the 1990s, Finland was the first country to start using the concept of a national innovation system. Finland's rapid rise to the forefront of productivity and technology in the second half of the 1990s was based on sustained and purposeful investment in people, skills and technological development. By the 2000s, a high-quality education system and innovativeness became key elements of the Finnish landscape both at home and abroad (see e.g. Koski et al. 2019).

In the 2020s, research and innovation policy is being reoriented in many countries. Addressing urgent and complex societal challenges that need solving requires effective allocation of RDI investments and new approaches to accelerate sustainability transitions. At the same time, intensifying geopolitics and the growing importance of technologies in achieving national and strategic goals form an increasingly complex international operating environment for research and innovation policy. The impact and competitiveness of the national RDI system are also challenged by a shrinking of the younger age cohorts, declining educational attainment levels and a shortage of skilled labour.

Internationally, research and innovation policy aims to respond even more clearly to complex global and national development challenges that require system transformation in order to be succeed. Sustainability goals have become increasingly important. Solving challenges innovatively will also create significant new international markets and business opportunities. This trend is called transformative innovation policy (see e.g. Lemola 2021). The aim is to mobilise RDI activities and policies to reform the economy and society in line with sustainable development and in an environmentally sustainable and equitable way. In practice, this means updating policy goals, structures and instruments, and developing ways to measure impact in a more comprehensive way.

Integrating sustainability into research and innovation policy can deliver wider social and economic benefits (Esposito et al. 2017). Such benefits include, for example, better conditions for people's health, preserving resources for sustainable growth, avoiding high transition costs in the future, and reducing direct costs through resource-efficient production.

In addition to new perspectives and ways of working, the transformative policy trend also involves much continuity. The basic elements of research and innovation policy and the RDI system remain central, such as the creation and application of new knowledge, support of high-quality basic research and applied research, a broad knowledge base and

researcher training, and the promotion of enterprises' innovation activities. Furthermore, strengthening the interaction, networks and cooperation of actors in the RDI system and the circulation of knowledge, among other things, remain equally important.

Most countries are still considering how to implement transformative innovation policy. Finland has not been among the first to adopt this trend. The OECD's country review of research and innovation policy stated that Finland needs a new RDI vision that connects economic needs and societal challenges (OECD 2017; also OECD 2022a). A recent evaluation of the Academy of Finland (Arnold et al. 2022) states that Finland should decide how to approach social challenges comprehensively in research and innovation policy. Although Finland's innovation policy has elements of transformative innovation policy (see e.g. Schwaag Serger & Palmberg 2022), a national debate on the approach and the opportunities it offers has yet to take place.

Developing new solutions for economic and societal needs requires a good understanding of the challenge at hand as well as multidisciplinary and multi-level cooperation. Individual policy areas, companies or agencies cannot respond effectively to major societal challenges. What is needed is the ability to define strategic priorities as well as cooperation between different policy areas and between national and regional policy actors. The crossing of scientific and research boundaries and also the role of the humanities, social sciences and creative fields in the development and deployment of technologies and innovations are commonplace, particularly when tackling major societal challenges, but also when addressing simpler problems.

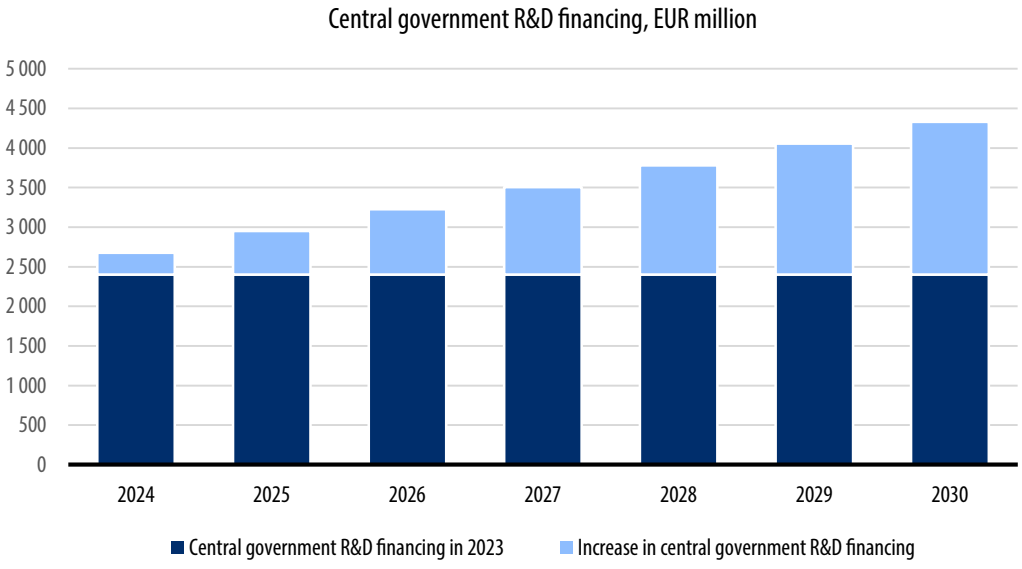
As societal challenges cannot be solved without significant private investment, a better way must be found for policy measures to promote the cross-sectoral solutions needed to address systemic challenges. There is also a need to make wider use of measures and instruments that influence the demand for and diffusion of innovations as part of the adopted package. These include, for example, innovative public procurement, innovation-friendly regulation, and development and experimentation environments.

National R&D and innovation investments play an important role in the knowledge-based economy and systemic changes, but they alone will not lead to renewal, new operating models and new business. Understanding global market developments and disruptions and analysing their impact are an essential part of a transformative research and innovation policy.

3 Increasing state R&D funding

The Act on Research and Development Funding (R&D Funding Act), which regulates state R&D funding, entered into force at the beginning of 2023. The implementation of the Act will increase state R&D funding on a long-term basis, from 2024 until 2030. State R&D funding will rise to 1.2% of GDP by 2030. According to current estimates, funding will increase from the EUR 2.4 billion budgeted for 2023 to EUR 4.3 billion in 2030, for a total increase of EUR 1.9 billion over 7 years (Figure 13). State R&D funding will increase by 40%. From the 2024 budget onwards, each year's budget will include an estimated increase of around EUR 280 million compared with the previous year.

Figure 13. Development of state R&D funding in 2024–2030 according to the R&D Funding Act by current estimates (EUR million)



These increases will have a very significant impact on appropriations and will lead to a substantial increase in State Budget expenditure. Strengthening central government finances and general government finances as a whole in the longer term will require a significant parallel increase in private R&D investment, which will support long-term productivity growth in the economy as a whole. If the private sector also invests in R&D

in such a way that the 4% R&D target is achieved, this will have a significant positive impact on the sustainability of general government finances in the longer term through accelerated economic growth. An increase in state R&D funding alone will not increase economic growth and tax revenue growth to such an extent that increasing state R&D funding would finance itself.

Role of state R&D funding

State funding can promote and accelerate the creation of new knowledge and its utilisation in society. Increased R&D funding should be allocated in ways which maximise the total benefit to society from investment and which result in private sector investment growing the most. Public innovation policy should actively direct R&D subsidies to those activities and sectors where there are significant societal benefits, such as increased knowledge, sustainable economic growth, accelerated sustainability transitions, increased productivity or improved social wellbeing. Innovation policy can address not only global challenges but also critical problems at a national and regional level. It is not worthwhile for the state to support innovation activities that companies would do without public support (Einiö 2014). It may be worthwhile to target public support at projects that would otherwise not be undertaken by private parties due to high costs or risks, but where the expected externalities are significant. Finland needs investments both in knowledge-generating research and in the promotion of business enterprise R&D investment.

Research data show that public funding has its greatest impact when it is directed towards basic research and the higher education based on it. Domestic research that generates new knowledge (basic research) is a necessary condition for the ability to utilise new knowledge generated elsewhere and for high-level applied research. The success of today's R&D-intensive industries is often based on decades of public investment in basic research (e.g. quantum technology, cancer biology, artificial intelligence). Investing state R&D funding in knowledge-generating research ensures that knowledge exists and is accumulated before a commercial or social application is in sight. Basic scientific research is the cornerstone of the Finnish education system: all teachers are trained in higher education institutions and higher education is based on research and RDI work.

On the other hand, without public sector participation, private investments in research, development and innovation would be smaller in the market economy than would be profitable at the level of society as a whole (Arrow 1962). For an individual company, the risk of failure of an R&D project as well as the long time span for generating returns may reduce the company's motivation to invest. Problems with the availability of financing, for example due to asymmetric information (the provider of financing does not have sufficient information or the ability to assess the future returns of the investment), may also result in companies' innovation activities not being on an optimal level. With its

funding, central government can help to share a company's risk and reduce the return on investment requirements when the company's product or service is not yet close to the market. Public R&D funding targeted at companies benefits society and the national economy through business renewal, increased business, exports and employment. In the economic research literature, the societal returns of private R&D investments are generally thought to be greater than private returns due to positive spillover effects, as the generated knowledge spreads and benefits society more broadly (Bloom et al. 2013).

R&D investments have an impact with a long delay

Public R&D funding affects overall productivity and production with a delay. The US Congressional Budget Office (CBO) has estimated that the macroeconomic impact of basic research can be seen with a delay of around 20 years, and for applied research after around 10 years; the impact is gradual and the full effect on production may only be observed much later, for example in the case of basic research after 40 years (CBO, 2005; CBO 2016; Campbell & Shirley 2018).

In the research literature, there is a large variation in terms of the delay of the impact of R&D activities, depending on whether, for example, companies' own productivity growth is examined or also the spillover effects more broadly (Hall et al. 2010). There may also be differences between countries in how quickly R&D activities are reflected in total production (Verbeek & Lykogianni 2008). Private sector R&D can generate returns for companies after a delay of only a few years (Ravenscraft & Scherer 1982; Pakes & Schankerman 1984). Differences in private R&D delay periods differ between industries due to the different nature of R&D (Frontier Economics 2014). The transformation of applied research into commercial products can be rapid, but in the pharmaceutical industry, for example, it can take two decades from the start of research to the commercialisation of a new drug (Campbell & Shirley 2018). In Finland, R&D investments have been found to have an impact on the productivity of companies around 3–5 years after investment (Ali-Yrkkö & Maliranta 2006; Rouvinen 2002).

4 Key development needs of RDI system and R&D funding

This chapter presents the policy outlines of the working group regarding the key development needs of the RDI system and R&D funding.

Objectives of Finland's RDI system

High-level competence and RDI activities are the foundation of Finland's competitiveness, productivity and wellbeing. The goal for Finland's RDI environment is to be among the best in the OECD countries and to better support productivity growth, sustainable economic growth and the wellbeing of society. Socially, economically and ecologically sustainable economic growth also strengthens public finances and enables the funding of the functions of the welfare society. Research shows that a comprehensive societal safety net, democratic and well-functioning institutions, societal trust and the freedom to make life choices are also prerequisites for sustainable development and growth in wellbeing.

The utilisation of new knowledge and innovations in developing solutions to societal challenges, such as climate change, biodiversity loss and social problems, will enhance the wellbeing of society. A high-quality and ambitious RDI policy also enables ecologically, socially and economically sustainable development and broadly shared wellbeing, and promotes the reconciliation of nature and climate constraints and economic development.

The level of ambition, quality and impact of RDI activities must be raised as R&D funding is significantly increased. Growth of RDI activities requires a supportive operating environment, highly educated professionals, strong public-private partnerships and internationally high-quality RDI environments in both the public and private sectors. R&D funding will be allocated efficiently and effectively so that it also leverages private R&D activity and promotes companies' ability to transform R&D into innovations, international business, value-added and production in Finland.

The increase in R&D funding will require the development of the RDI system, emphasising the impact of R&D funding. The Parliamentary RDI Working Group has identified development needs of the RDI system that, in the working group's view, are necessary to address. With regard to the development needs of the RDI system, the working group

has not aimed for an exhaustive presentation; the purpose has been to identify the most important and strategically significant thematic areas. With regard to R&D funding, the working group presents policy outlines for the direction of funding.

The working group is committed to the principles for the development of the RDI system outlined by the previous parliamentary RDI working group in its December 2021 report, which are (content descriptions of the principles in Appendix 2):

1. Predictability and long-term vision
2. Leverage
3. Comprehensiveness
4. Scientific freedom and the quality of research and education
5. Impact
6. Competition
7. Cooperation
8. Internationalisation
9. Recognition of global challenges
10. Technology and industry neutrality

The principles for the development of the RDI system are in line with European and international principles and have been well received by the Finnish research, development and innovation community.

The working group considers that the development and orientation of the RDI system and R&D funding should continue to be based on these parliamentarily agreed principles.

4.1 Management and steering of the RDI system

Finland needs stronger high-level management and coordination of research and innovation policy to enable comprehensive development of the RDI system. This requires a national strategic vision on the direction, priorities and resource allocation of research and innovation policy. The promotion of RDI is a matter for all administrative branches and levels of government. Research and innovation policy must be closely linked to other policy sectors and societal development as well as to international cooperation objectives. Achieving these policy objectives requires a shared vision and commitment to common goals among different parties: administrative branches, the business community, public research organisations and other RDI actors.

The geopolitical situation as well as the maintenance of security of supply and crisis preparedness also require that management of RDI system develops shared viewpoints in relation to competencies and capabilities needed in society. These shared viewpoints need to transcend administrative boundaries. For example, defence administration's and other sectors' research and competence objectives in terms of basic research and education are convergent and cover a wide range of scientific and educational disciplines. The needs of the defence administration and security of supply are increasingly being met by commercial innovations from other sectors, creating new business opportunities for companies, also in international markets.

By strengthening and complementing its tasks, diversifying its activities and reinforcing its structures and resources, the Research and Innovation Council (RIC) can respond to these needs.

Policy outline: *Strengthen the role of the RIC in the management and coordination of research and innovation policy. Reform the RIC's structures and modes of operation, and assign a full-time secretariat to it. Strengthen the position of the inter-ministerial network of officials responsible for RDI tasks. Enhance communication on RDI policy.*

1. Tasks of the Council. The Council's tasks will be strengthened so that it supports the Government in developing and coordinating long-term research and innovation policy, makes national strategic choices (see section 4.4.) and monitors changes in the national and international environment. The Council coordinates and monitors the implementation of the Act on Research and Development Funding and the long-term R&D funding plan. The Council makes initiatives and decisions regarding these. The Council can make proposals to the Government regarding the allocation of RDI investments.

2. Members of the Council. The Council is chaired by the Prime Minister. The ministerial members of the Council are the ministers responsible for research and innovation policies and higher education as well as the ministers responsible for the largest research institutes and other policy sectors central to RDI activities. The Council has three vice-chairs, one of whom is a minister, one a representative of the research community, and one a representative of the business community.

   The Council members have wide-ranging expertise in the RDI system. The Government appoints distinguished researchers and business representatives, among others, as members of the Council.

   The Permanent Secretaries of the Ministry of Education and Culture, the Prime Minister's Office, the Ministry of Economic Affairs and Employment and the Ministry of Finance as well as the President of the Academy of Finland and the Director General of Business Finland serve as the Council's permanent experts.

3. Activities of the Council. The Council convenes at least four times a year in its full composition under the leadership of the Prime Minister to make initiatives and decisions. The Council convenes with the secretariat monthly, without ministerial members, to prepare the Council's initiatives and decisions.

   To support broad preparation, the Council may have substructures, such as an advisory panel of international experts, working in English.

4. Preparation and resources of the Council. Adequate resources are allocated to the activities of the Council. A secretariat is established for the Council, with five full-time employees: a secretary general, three experts and an administrative assistant. The secretariat is responsible for preparing the work of the Council. The secretariat compiles and maintains a knowledge base for strategic choices in cooperation with stakeholders, taking into account, among other things, major societal challenges, sustainability transition requirements and national strengths in order to steer RDI policy.

The secretariat has expertise in, among other things, business and R&D activities.

5. Cross-ministerial collaboration linked to the Council's activities. The RDI policy coordination network will be reformed to support the preparatory work of the Council. The coordination network consists of representatives of the ministries and is chaired by the Council's secretariat. The coordination network is responsible for the coordination of the RDI policy goals and measures of the various administrative branches.

6. Communication of RDI policy measures and country image work. The secretariat of the Council coordinates the communication of government ministries' RDI policy activities and is responsible for the monthly compilation and communication of current topics, and prepares the country image with regard to competence and RDI activities.

7. Parliamentary monitoring of RDI activities is organised in conjunction with the Council.

4.2 Competence and availability of R&D workforce

The targeted increase in the volume and ambition of RDI activities require a significant rise in the level of competence and education. RDI is built on competence and talented individuals. Finland must invest more strongly in the highest education and strive for excellence in more fields than at present. Finland needs an increasing number of strong, internationally attractive, multidisciplinary competence centres with a knowledge base so strong that it inspires the world's best to collaborate. Knowledge produced elsewhere can only be applied in Finland if the country has its own RDI and training activities in the fields of application. Creative industries and creative competence in RDI are also playing an increasingly significant role in economic renewal and value creation. In addition, to ensure security of supply and crisis preparedness, Finland must be able to carry out R&D work in all fields of science and research and in the sectors most important to the economy.

Science barometers year after year show Finns' appreciative attitude towards science and research. The research data shows that raising the level of education-based competence of Finns secures their experience of social justice and inclusion, supports crisis management, increases their commitment to national defence and strengthens democracy in society. For example, in solving global challenges and introducing new products or services, individuals' and communities' experience of inclusion and level of competence are significant.

Finland has the largest shortage of tertiary-educated labour among OECD countries (OECD 2022a). For example, more than nine out of ten jobs suffering from a labour shortage in Finland were in high-skilled occupations, while on average in OECD countries five out of ten such jobs were high-skilled jobs. Productivity growth is based on innovations, and it is people who make and deploy innovations.

A shortage of skilled labour reduces opportunities for R&D. Lack of qualified personnel prevents innovative companies from expanding R&D activities and collaborating with higher education institutions and research institutes. It also makes it difficult for innovative companies to expand their operations, for example through exports, thus limiting the value added/return on innovation. A shortage of talent also undermines the ability of higher education institutions and research institutes to conduct high-quality research.

In addition to increasing the number of tertiary education graduates, faster ways to update and renew skills, i.e. continuous learning, are needed. Ways of implementing continuous learning in higher education institutions are being planned for both individuals and communities. The ongoing reform of continuous learning will introduce RDI-based development in the workplace, which will increase, for example, the opportunities for SMEs to build their capabilities for R&D work.

R&D personnel and doctoral education

Successful R&D work requires from those who do it an education that provides the skills necessary for research. New creative R&D professionals are the most highly educated individuals, i.e. holders of doctoral and master's degrees. The proportion of R&D personnel in Finland is high relative to the size of the population (OECD), but only one in five of R&D personnel is trained as a researcher (doctorate or licentiate). Only 7% of R&D personnel in the private sector have a doctoral degree. R&D personnel also includes people with bachelor-level qualifications and vocational qualifications.

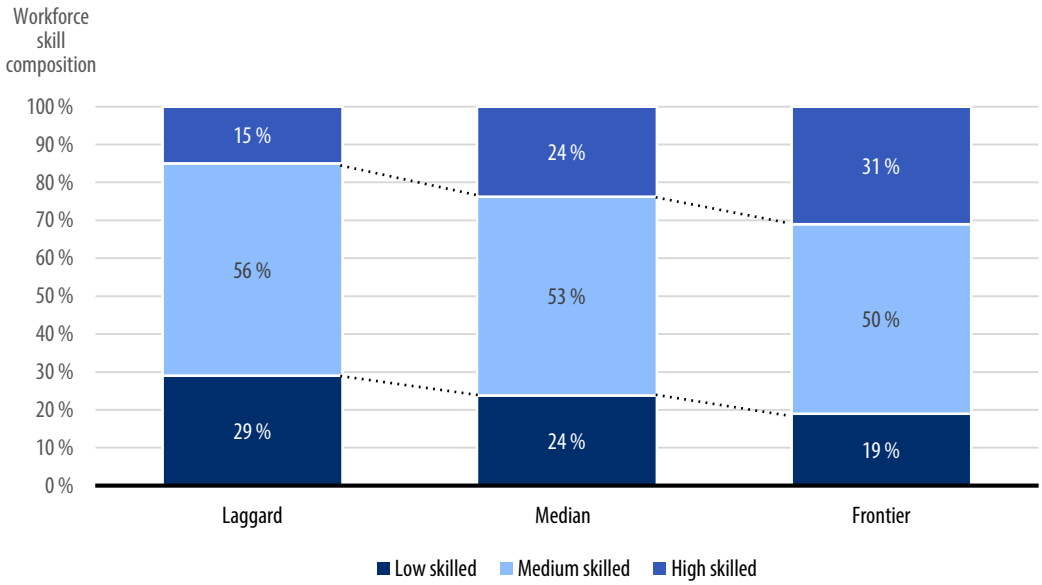
The increase in funding levels in accordance with the R&D Funding Act requires a significant increase in the number of R&D personnel. Based on the current cost structure, it is estimated that the R&D system would need nearly 9,000 additional personnel each year from 2024 to 2030. Given the different cost structures in the public and private sectors, the annual increase in R&D personnel required by the increase in R&D funding levels would imply that nearly 5,000 would be in the private sector (R&D expenditure target 2/3) and more than 4,000 in the public sector (R&D expenditure target 1/3).

The proportion of doctoral graduates in R&D personnel must be increased, as the expanding R&D effort is expected to raise the level of ambition. In that case, based on the current cost structure, it is estimated that more than 2,000 new doctoral graduates transferring to R&D work would be needed each year between 2024 and 2030. Those training to become researchers must have a clear view of research career paths in different sectors and in all research organisations, which will require not only funding, but also active development measures.

Doctoral degrees are awarded in Finland by universities and, in addition to universities, doctoral researchers can also do their work in, for example, a research institute, company, hospital, university of applied sciences or on a research vessel. According to OECD statistics, the employment rate of doctoral graduates in Finland is higher than that of other higher education graduates, but the average age at which doctoral studies are started and finished is older than in most OECD countries. Researcher training also takes a long time in Finland by international standards. Independent research careers start later than in competitor countries and, for example, a Finnish researcher who has just completed a full-time degree may not be eligible to apply for EU funding for young researchers because of their age. Flexible solutions for full-time doctoral research must be piloted, which, by improving the efficiency of doctoral education, would allow doctoral studies to be completed in a much shorter time on average than at present and would secure funding for the duration of a full-time doctoral studies. In order to improve the attractiveness of a research career and to secure the number of R&D personnel, the duration of researcher training must be shortened, without compromising quality, to match European 3-4-year doctoral education, and new types of researcher training and funding models for it must be piloted. The content of researcher training must be modified to take into account the research careers offered by working life that are broader than the academic work environment. Considerations about security of supply must also be taken into account in researcher training.

In addition to R&D work, many peer countries have more doctoral graduates and also more master's level graduates than Finland in large exporting companies and in all kinds of positions. According to the OECD, the most productive companies use significantly more highly educated labour than other companies (see Figure 14). In Finland, a researcher's career path is easily considered to be academic and teaching work. Research careers are also to be found in public administration, universities of applied sciences, other levels of education, companies, public services, the third sector, namely in all areas of working life. A researcher's skills are also useful in jobs where there is no actual research work.

Figure 14. Composition of companies' workforce according to skill levels (Source: Criscuolo et al. 2021). Companies at the forefront of productivity rely more strongly on high competence. There is a vital link between education, research and business, which is why the R&D system must be developed and funded in a balanced way as a systemic whole.



A significant proportion of R&D personnel also consists of graduates of universities of applied sciences (bachelor level degree) and of upper secondary vocational education graduates. In education programmes leading to university of applied sciences degrees, there are R&D-related periods carried out in working life. In vocational upper secondary education, the link with R&D may be intensified and expanded. It is possible to develop cooperation between higher education institutions, research institutes and upper secondary vocational education actors in many ways while taking into account sector-specific needs, for example by providing joint RDI services for companies and public sector organisations so that participation in activities is part of education and training.

Policy outline: *Make science education and multi-literacy support a permanent part of the education system. Raising the competence and education level of the population is a necessary condition for achieving the R&D objectives. Support talented people throughout the education system to pursue research careers. During researcher training, increase links to non-academic working life. Clarify research careers in the public and private sectors.*

Increasing skills-based immigration

Immigration and the mobility of international experts are of growing importance for Finland's wellbeing, economic dependency ratio and competitiveness. In order to develop strong internationally networked competence centres, highly skilled experts from abroad are needed. Moreover, international talent already present in Finland must be better utilised in RDI activities, boosting growth and internationalisation, and creating new jobs as well as export and investment opportunities. At the same time, while those educated and working in Finland must be prepared to operate more internationally, there is a need to increase skills-based immigration and to improve immigration services for those moving to Finland from abroad.

Attracting highly skilled foreign workers, investors and inventors is crucial for strengthening the global connectivity and competitiveness of Finland's innovation system (OECD 2017). Highly educated foreign workers not only alleviate skills gaps, but also contribute to the spread of advanced technologies and new knowledge. In an OECD indicator analysis, however, Finland ranks in the middle of OECD countries in terms of attractiveness for foreign highly educated workers, far behind the Scandinavian countries (OECD 2022a).

A significant challenge for Finland is the low employment rate of highly educated immigrants compared with many other OECD countries. According to the OECD country report, the difference in employment rates of native and foreign workers is relatively large, although smaller than in some large European economies (OECD 2022a).

The Roadmap for Education-based and Work-based Immigration 2035 includes measures to improve the availability of labour, including the development of residence permit procedures as well as establishing and strengthening service provision for attracting talent and international recruitment.

Policy outline*: Increasing skills-based immigration and developing immigration services to support this are necessary in order to attain the intended increase in the volume and level of ambition of RDI activities. Particular attention must be paid to the smooth entry of specialists and their families, the availability of school and early childhood education services and other services that are critical for families of international talent, the attraction of international students from selected target regions through joint actions of the government and universities, and support for the attachment of international students to Finland during their studies and for their remaining in Finland to work. Continue to support international students studying in Finland to remain in Finland.*

4.3 Strengthened RDI cooperation

Balanced development of the R&D system requires that the R&D system and its management as well as R&D funding be developed in such a way that cooperation between companies, universities, research institutes, universities of applied sciences and other actors engaged in R&D activities is strengthened. The Parliamentary RDI Working Group's stakeholder survey also identified increasing cooperation as a key development need. Strong national cooperation models and ecosystems also facilitate access to the highest level international cooperation.

Cooperation between companies and research organisations supports wide-ranging utilisation of new knowledge and competence produced by high-quality basic research, and enables the development of disruptive and radical innovations. New knowledge is utilised in companies' R&D activities and broadly in society. In addition, global challenges, such as the digital-green transition and mission-driven innovation policies require strong cooperation between actors in order to be realised.

Cooperation between companies and universities, universities of applied sciences and research institutes, when done well, generates new openings for basic and applied research, while providing businesses with new competence to develop business, products, services and operating models. The importance of cooperation has grown in recent years, particularly in the recruitment of new talent, piloting and product testing as well as in the joint development of innovations in industry. In service sectors, cooperation in education, in particular, has grown.

Innovations typically arise at interfaces and in ecosystems where different actors collaborate. The RDI system and its funding must be developed to enable research-driven co-creation, business-driven RDI by companies, and development of social and service innovations in collaboration with universities, universities of applied sciences, research institutes and other public actors, such as towns, cities and organisations. Cooperation between different fields, such as technological and creative fields or bio and social sciences, combines different perspectives into new solutions to complex challenges. Internationalisation is an essential part of cooperation.

The development of cooperation, partnerships and ecosystems requires a long-term commitment to common goals. Public support for cooperation must also be predictable and long-term. Making better use of EU and other international cooperation as well as the funding supporting it is of key significance.

Business Finland and the Academy of Finland, as the largest providers of funding for RDI, play a key role in encouraging cross-sectoral cooperation. An evaluation of the Academy of Finland (Arnold et al. 2022) and an OECD country report (OECD 2022a) both

considered it important to increase cooperation between the Academy of Finland and Business Finland, as this could more effectively promote the cooperation between funding recipients and transfer of knowledge and expertise between research organisations and companies.

Linking national strategies to regional and local strengths and development efforts through closer cooperation than at present is recommended in the OECD's (2017) review of Finland's innovation policy. Alignment of policy actions of public sector administrative branches and levels of government (municipalities, towns, cities, regions and central government) to promote research, development and innovation will improve the impact of R&D measures. Various public sector partnerships and close cooperation will enhance the efficiency of resource use while facilitating joint strategic investments to develop innovation. Examples of this include the four-year strategic agreements between the Ministry of Education and Culture and each higher education institution as well as the ecosystem agreements between the Ministry of Economic Affairs and Employment and university towns and cities. By strategically concentrating national and regional resources and ensuring that goals and priorities complement each other, unnecessary dispersal of resources can be avoided. In addition, synergies between different measures and the necessary critical mass of knowledge can be increased.

The different systems of merit recognition for public and private sector researchers have traditionally been considered to be a constraint on cross-sectoral cooperation. In academic career development, scientific publications have been the main indicator of advancement. The CoARA initiative for the responsible assessment of researchers, research and research organisations aims to break away from publication-focused assessment by introducing more qualitative elements and non-publication-based metrics into assessment. The CoARA initiative has been signed by all Finnish universities, except the National Defence University, and a small number of universities of applied sciences. So far, no Finnish research institutes are involved.

Policy outline: *Restore cooperation between RDI system actors as a key strength of Finland's RDI activities. Increase and strengthen cooperation throughout Finland's RDI system. Strengthen the alignment and complementarity of national and regional development activities and promote regional specialisation to increase impact and efficiency. Tighten cooperation between providers of funding, particularly Business Finland and the Academy of Finland, and use national and international funding instruments to enable different types of public-private partnerships to support long-term RDI cooperation. In this way, internationally high-quality and attractive research environments, networks and ecosystems are strengthened.*

4.4 National priorities and strategic choices for R&D activities

The key global transformations are related to the transition to a more ecologically and socially sustainable society and economy. A more skilled workforce as well as research and innovation will play a central role in them. Utilising the opportunities arising from global transformations is not, however, just about knowledge, skills or companies' actions; national, regional and other development efforts are also essential. These efforts must enable anticipation and utilisation of global changes and market demand as well as the systematic construction of the different phases of the innovation cycle.

The significance of new technologies for sustainable growth and competitiveness has increased in recent years. Technologies and related competence also have an important role in solving major societal challenges and in ensuring safety and security of supply. Geopolitical tensions and intensifying competition in critical technologies mean that strategic perspectives on new and emerging technologies are becoming more important. These trends challenge not only research and innovation policy but also industrial policy.

It is important to strengthen competitiveness as well as the state's strategic capital and position by investing on a long-term basis and diversely in research and competence in new and emerging technologies. Finland needs more internationally high-quality and effective competence centres, whose development and creation require not only broad-based expertise but also choices. International cooperation with strategically significant partners will be increasingly important. For example, the EU's funding programmes and partnerships are significant entities that determine the direction of European technology development and Finnish actors must be actively involved in them.

The role of the public sector is to support the wellbeing of citizens, economic growth and renewal, and to address sustainability challenges in a diverse and goal-oriented way. New ways of tackling sustainability challenges and identifying and exploiting growth opportunities must be developed. It is important to identify national competence strengths as well as the capabilities, strengths, needs and expertise of society and enterprises in taking advantage of global transformations. This can be used as a basis to formulate the common national strategic choices that will define national development efforts and direct and pool resources.

National strategic choices create the conditions for proactive, long-term and goal-oriented national development efforts as well as cooperation between companies and the public sector. Strategic choices are an important basis for the effective allocation of limited public

RDI funding. They also strengthen the capability to accelerate sustainability transitions and to develop internationally competitive clusters of competence as well as innovation and business ecosystems in selected regions.

The main task of strategic choices is to form a common national vision of growth areas that are worth considering for Finland in terms of strategic competence, global demand, competitive factors or relevance. This involves creating a common knowledge base and understanding to underpin decisions promoting sustainable growth in both the public and private sectors. In terms of commitment and impact, it is essential that the vision and the strategic choices supporting it are prepared on a broad basis. Cooperation with non-RDI actors is also important, including those whose lives and activities are significantly affected by sustainability transformations.

Solving social challenges in an innovative way requires a deep understanding of the phenomena in question, expertise and new forms of cooperation and action. Companies have a significant role to play and must invest in managing global value chains and networks, ensuring a knowledge base, developing intangible assets, identifying customer needs and creating their own competitive advantages.

Policy outline*: Make choices of strategic priorities and the preparations leading to them under the leadership of the reformed Research and Innovation Council (see also section 4.1). Carry out the process in a transparent manner. It is necessary to involve all RDI actors, such as the business community, higher education institutions, research institutes, national providers of RDI funding, towns, cities and regions, and other RDI actors in the joint discussion. In the selection process, identify global trends, the requirements of the green transition, the conditions for and constraints on growth, and define strategic choices and research and innovation policy development needs such that RDI policy can be steered in a manner that promotes the green transition. Choices for priorities must be based on research data and a systematically and extensively compiled current knowledge base, updated as necessary. Commitment to the choices is vital.*

4.5 R&D funding

In line with the development principles of the RDI system outlined by the Parliamentary RDI Working Group in December 2021, the development and allocation of state R&D funding must take place in a comprehensive manner. The RDI system and public R&D funding as a part of it form an entity, and it is important that all of the components of this system are functioning well and have good operating conditions. R&D funding should be developed with the guiding objective of strengthening the RDI system and its overall impact.

It is important for R&D funding to be predictable and long-term. Long-term and predictable funding enables high-quality and effective research and development activities and encourages commitment and investment by all actors in the system.

In allocating R&D funding, its leverage must be ensured: for Finland's RDI policy to succeed, the growth in business enterprise R&D investment must be at least twice as high monetarily as the growth in public investment. The conditions for leverage must be ensured, particularly when allocating government RDI investments to the private sector. R&D funding must promote innovation in a wide range of sectors, from technological fields and the natural sciences to the creative industries, humanities and social sciences. National funding must strongly support internationalisation in its various forms, such as the acquisition of international investments, talent and funding for Finland.

State R&D funding must be allocated to achieve the desired positive effects on competence, productivity and competitiveness, and thereby on long-term economic growth and the strengthening of the financial base of the welfare society. Allocation must be done in such a way that the Finnish RDI system is more effective, efficient and internationally attractive than at present. In allocating funding increases, the absorptive capacity of the system must be taken into account. Funding must be increased for actors gradually and insofar as they can use it appropriately. For example, a shortage of experts may limit the growth in the number and the quality of cutting-edge R&D projects in the short term. In addition, a large proportion of SMEs, for example, are not currently engaged in R&D activities, so funding specifically targeted at them needs to be complemented by measures to enhance their absorptive capacity and innovation capabilities. At the same time, efforts must be made to allocate funding in such a way that the capacity of the RDI system to produce innovations increases.

During its work, the Parliamentary RDI working group has identified development needs in R&D funding. An examination of the observed development needs and the working group's policy outlines in relation to them are presented below.

1. **Central government funding for universities**
   There is a shortage of the most highly educated professionals in the workforce. Master's and doctoral students are educated in research-based education at universities in accordance with the Universities Act. As the amount of education is increased to create a sufficient and well-targeted workforce, central government funding for universities must ensure research activities that support education. To this end, central government funding for universities will be increased and funding earmarked to increase the number of experts supporting R&D activities, including researcher training.

   Policy outline: *Increase central government funding for universities and earmark funding, in line with the needs of working life, to increase the number of research-trained experts, while maintaining the high quality of researcher training. At the same time, strengthen the link between education and research, enabling long-term R&D work, utilisation of competitive funding and broad-based reinforcement of the knowledge base to also ensure security of supply of competencies. Conditions for basic research must be ensured.*

2. **Academy of Finland funding**
   The Academy of Finland finances high-quality Finnish research that generates new knowledge and contributes to the internationalisation of the Finland's scientific community. An international evaluation of the Academy of Finland (Arnold et al. 2022) raised the concern that the proportion of best-ranked projects funded by the Academy of Finland is so low that this is considered problematic internationally because some of the most ambitious research goes unfunded. In the evaluation, a similar observation was also made about the operating expenditure appropriations of the Academy of Finland's Administration Office, whose share of the Academy's total funding is lower than that of international peers.

   Policy outline: *To further strengthen the quality of research and raise the level of ambition, increase, in line with the recommendations of the international evaluation of the Academy of Finland, the Academy's grant authorisations and appropriations so that more projects that have been evaluated as excellent in international peer reviews can be funded. At the same time, adjust the operating expenditure appropriations of the Academy of Finland's Administration Office to match the workload as well as the resources of international peers.*

3. **Central government funding for universities of applied sciences**
   There is a shortage of the most highly educated professionals in the workforce. R&D professionals who have completed a university of applied sciences degree work in all of the key sectors for Finland's future. As the amount of education is increased to create a sufficient and properly targeted workforce, central government funding for universities of applied sciences must, to support the education of professionals in accordance with the Act on the Universities of Applied Sciences, safeguard applied research, development and innovation activities that promote working life and regional development and renew the industrial structure of regions. Universities of applied sciences particularly support the R&D activities of SMEs. In order to increase the number of companies engaged in R&D activities and to increase the volume of R&D in the SME sector, the role of universities of applied sciences in the RDI system can and should be strengthened compared with the current situation.

   Policy outline: *Increase central government funding for universities of applied sciences and allocate funding to, among other things, the implementation of RDI-based continuous learning. At the same time, strengthen the R&D capabilities and RDI activities of universities of applied sciences on a long-term basis and particularly in cooperation with SMEs, promote the link between education and research, facilitate the strengthening of long-term R&D work, utilise competitive funding, and broadly reinforce the knowledge base to also ensure security of supply of knowledge.*

4. **Applied research and funding for cooperation between companies and public research organisations**
   Applied research widely supports the utilisation, in companies and in society, of new knowledge generated by high-quality basic research (for definitions of basic research, applied research and development work, see box below). Applied research may emerge from public research as pre-competitive or from companies closer to the development of a product or service. Applied research may also be entirely public research. Applied research also promotes innovations that are completely new to the market or disruptive, which are estimated to account for a small proportion of innovations in Finland (OECD 2017). Applied research is also needed to address societal challenges and support large societal transitions (e.g. green transition and digitalisation, economic renewal and diversification).

   Cooperation between companies and public research organisations is central in order to strengthen applied research. This cooperation supports the broad utilisation - in business enterprise R&D and in society - of new knowledge and competence generated by high-quality basic research and facilitates the development of disruptive innovations.

The decline in R&D cooperation between public research organisations and companies has been discussed in section 2.1. In section 4.3, the working group presented its position that cooperation should be restored as a strength of Finnish RDI activities.

Policy outline: *Increase Business Finland and the Academy of Finland funding to encourage long-term R&D cooperation (partnerships) between higher education institutions, research institutes, companies and public bodies. Target funding at cooperation that supports the resolution of societal challenges and societal transitions (such as green transition, digitalisation) and at the development of transformative technologies in cooperation between research organisations and companies.*

Research and development activities cover

Basic research, characterised by the pursuit of new knowledge without immediate practical application. Examples of basic research include the analysis of properties, structures and cause-and-effect relationships with the aim of generating, proving and explaining new hypotheses, theories and regularities.

Applied research, where the aim is to make a practical application realised with the aid of new knowledge. The goal may be, for example, to find applications for the results of basic research or to create new methods and tools to solve a particular problem.

Development work, which is the use of knowledge gained through research and/or practical experience to create new products, processes or methods or to substantially improve existing ones.

All research and development activities share the following characteristics: R&D activities are new-knowledge-seeking, creative, uncertain of success, systematic and transferable and/or replicable in terms of results.[4]

4 Source: Statistics Finland https://www.stat.fi/til/tkker/kas_en.html

5. **Funding of research institutes**

The research of government research institutes has become more short-term and the strategic planning of research has become more difficult, as the institutes are more dependent on external project funding following the research institute reform launched in 2013. Reduced resources and prioritisation of activities have contributed to a deterioration in conditions for RDI cooperation and have led institutes to focus on their official activities. Research institutes produce solution-oriented, long-term research to support decision-making and in cooperation with companies, higher education institutions and public authorities. Some research institutes have a statutory duty to promote conditions for business activity. The steering of research institutes enables them to direct research to finding solutions to societally relevant challenges across sectoral borders. Like universities and universities of applied sciences, research institutes have a significant role in transferring new knowledge from high-quality basic research to broader use by companies and society. Alongside higher education institutions, research institutes maintain important research infrastructures such as long time series data repositories. These are utilised in official activities and long-term research.

Policy outline: *To ensure the long-term development and utilisation of research institutes' expertise, allocate to research institutes funding that improves their capacity to succeed in the international competition for research funding. This will enable research institutes to participate more widely in developing solutions to societal challenges and in supporting, for example, the sustainability transition. Ministries steering research institutes will set clear impact targets for R&D activities.*

6. **Encouraging companies to engage in R&D**

In Finland, companies invest relatively little in developing, commercialising and scaling up radically new and market-changing innovations. A relatively small proportion of companies engage in R&D, and the proportion of SMEs that engage in R&D is particularly small. There is also a clear concentration by sector.

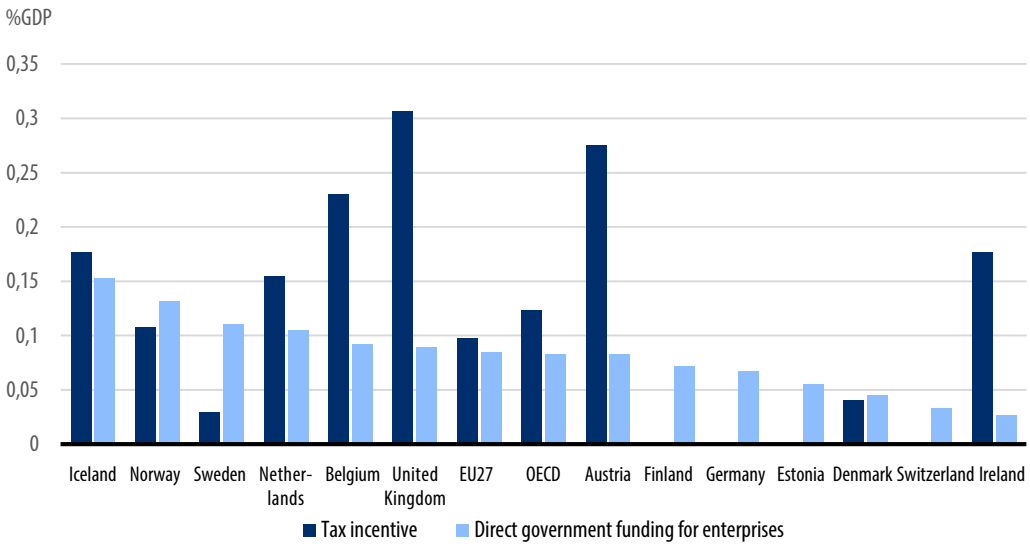
In line with the recommendation of the OECD country report, the development of radical innovations should be encouraged through public funding programmes and stronger cooperation between different sectors and different organisations (OECD 2017; OECD 2022a). There are significant sectoral differences in R&D timeframes, cycles and investment needs, which are also influenced by the maturity of industries and markets. In addition, market area- and sector-specific regulatory approvals often have a comprehensive impact on R&D and market access. In the pursuit of radical innovations and sufficiently rapid market entry and scaling up, these aspects and needs must be taken into account in a holistic way when determining the long-term perspectives, forms and sizes of R&D funding.

Advancing the green transition and digitalisation requires significant additional investments in R&D activities in several sectors in order that new, sustainable solutions can be developed and introduced in business and society. From the perspective of the renewal of industries and the growth of productivity, it is important to encourage more SMEs in various sectors to engage in R&D activities, and to encourage companies already engaged in R&D activities to increase their R&D investments. It is also important to encourage R&D activities and innovations in companies from sectors where R&D activities are not as common in Finland, such as the creative industries or trade.

Government support for business enterprise R&D activities is lower in Finland than in several OECD and EU countries (see Figure 15). In Finland, the state finances just under 3% of business enterprise R&D expenditure (2021), while in EU countries the proportion directly financed by the state is more than 5% (2019) on average, and taking tax incentives into account, more than 12%. The lower level of R&D support allocated to Finnish companies reduces Finland's attractiveness for international RDI investments and adversely affects the competitiveness of Finnish companies in international markets. R&D support to companies must be comprehensively developed, taking into account direct and indirect support (tax incentives). According to research, R&D tax incentives are the most effective incentives for the R&D activities of SMEs.

Indirect government funding through tax deductions is monitored statistically. Government tax revenues not received due to R&D tax incentives are not counted in state R&D funding, and therefore not in the state R&D funding target of 1.2% of GDP. When comparing the international competitiveness of the RDI environment in different countries, both direct and indirect subsidies should be taken into account, even though indirect subsidies are not directly comparable between countries. In the case of indirect subsidies, the level of corporate taxation is also highly significant.

Figure 15. Direct and indirect government funding (tax incentive) for business enterprise R&D activities in peer countries 2020.



Policy outline: *Increase direct support for business enterprise R&D in an effective and efficient way, such that its share of GDP increases, provided that business investment increases in same proportion. Increase Business Finland's funding for business enterprise R&D to support the green and digital transition, the renewal and diversification of enterprises and industries aimed at resolving societal challenges and promoting the wellbeing of society, the creation of new enterprises, and the sustainable growth of high value-added business. Allocate additional funding to the enterprises most capable in RDI, risk-taking, investment in intangible assets and the utilisation of RDI in business. In addition, direct funding to ambitious R&D activities that are further away from the market, whose export potential cannot yet be assessed. Encourage through funding close collaboration with other enterprises and research organisations to support the development of growing ecosystems. At the same time, increase funding to expand and develop the R&D activities of the most innovation-capable SMEs. Allocate increases to Business Finland's operating expenditure such that the resources available for administering funding and activating RDI actors are in line with international peers.*

7. **Utilisation of EU RDI programmes**

The volume of EU RDI funding has grown in recent years and, at the current level of uptake, Finland can be expected to receive around EUR 400 million per year. Finnish research organisations are actively participating in EU programmes, but the success rate of applications has not been at the level of peer countries. Increasing the uptake of EU funding requires raising the quality of applications.

Organisations' application activity is constrained by the self-financing required for projects that go ahead. Self-financing of EU programmes refers to the research organisation's share of a project's costs, because according to EU's financial regulation, EU funding cannot cover 100% of a project's total costs. Research organisations use their core funding for self-financing contributions to EU projects, and some organisations have had funds intended for self-financing allocated separately from the State Budget. Funding for the preparation of EU projects has also been available from different sources, but the conditions for such funding have varied.

Some fields of research are funded by EU programmes through co-funded partnership programmes, where EU funding share is usually 50% and national funding share (ministries, Business Finland and Academy of Finland) correspondingly 50%. The limited availability of national funding also limits participation in partnerships, as the funding available for partnerships is currently insufficient to enable full participation in all strategically important partnerships.

Evaluations of both Business Finland and the Academy of Finland show that the organisations' operating expenditure is lower than in the comparator countries. The human resources of the funding providers for promoting participation in EU programmes are therefore also very limited.

Policy outline: *Support the ability of different research organisations to apply for and receive international R&D funding by increasing their core funding. Ensure the ability of funding organisations to participate in co-financed programmes. In funding for domestic projects, take into account their potential to build capacity to succeed in EU funding applications on similar themes. Opportunities to receive funding will be improved if support is also available for participation in applications and for planning and putting together projects. Also investigate non-research organisations' needs for national matching funding. Create a well-functioning model for securing national matching funding for the different RDI actors.*

8. **More effective utilisation of international R&D funding**
   In addition to the EU's RDI programmes, there are numerous other opportunities for international cooperation. Membership of NATO will bring within the reach of Finns NATO's Innovation Fund and networks as well as, more clearly than before, US federal funding in the defence and energy industries. At the same time, interest in bilateral cooperation with Finland will grow, particularly in the future allied countries, and access to their financial instruments will become easier. Other European collaborative organisations also offer Finnish companies opportunities to participate in cutting edge international cooperation and R&D procurement, including the European Space Agency (ESA), the European Organisation for Nuclear Research (CERN), the European Southern Observatory (ESO) and the nuclear fusion energy megaproject ITER.

   Policy outline: *Set qualitative and quantitative targets for participation in EU programmes and funding uptake to promote ambitious R&D cooperation and cutting-edge competence clusters. Provide additional knowledge and understanding of existing international cooperation and funding opportunities for Finnish RDI actors in all administrative branches.*

9. **Conditions for research that generates new knowledge in the health and social services reform**
   The wellbeing services counties constitute a new RDI system actor. Research, development and innovation activities and strengthening competencies are prerequisites for increasing the effectiveness of health and social services. The effective development of the service system is based on research knowledge and proven effectiveness.

   RDI activities to be carried out in the wellbeing services counties will be funded by their core funding, university funding, Ministry of Social Affairs and Health funding for healthcare and social work research as well as competitive funding (including Academy of Finland and EU funding). There is close cooperation between university hospitals and universities in the field of RDI. Legislative changes concerning the duties of university hospitals and supplementing the funding model of the wellbeing services counties (the so-called university hospital supplement) will enter into force at the beginning of 2024. These legislative changes are aimed at, among other things, strengthening the resourcing of tasks related to education and R&D, particularly in wellbeing services counties that operate university hospitals and in Helsinki.

The level of clinical research in Finland has long been high, as measured by scientific indicators (see the Academy of Finland's State of Scientific Research reports). The level has been declining, however, and relatively fewer peer-reviewed results from fields of clinical medicine are published in Finland than in peer countries. In addition, the years of clinical research work of research-educated RDI personnel (i.e. number of research staff work years) in university hospitals have decreased in recent years (Education Administration's statistical service Vipunen). The results of clinical research are utilised in healthcare and medical processes, diagnostics and treatments. Based on the research knowledge, commercial products and services are also created. Health technology exports are increasing but, according to Finnish Customs' statistics, still account for less than 3% of the total value of exports.

In addition to the wellbeing services counties, clinical research is funded by universities and the Academy of Finland. The pooling of funding would strengthen opportunities to conduct clinical research and generate knowledge for health and social services as well as commercial activities.

Policy outline: *Ensure that the wellbeing services counties participate in a goal-oriented way in research and development activities in line with national strategic goals and in the healthcare and social welfare operational structures that support them. Securing, reinforcing and pooling the basic structures and funding for R&D are essential in order to strengthen RDI in the sector. Support RDI in the field also through innovative public procurement.*

10. **Research infrastructures**

High-level RDI activities require up-to-date research infrastructures that enable research in wide range of fields. They serve as a basis for clusters of competence, attract talent and facilitate participation in international research cooperation.

The construction, development, maintenance, use and dismantling of research infrastructures require adequate resources throughout the entire life cycle. It is important to allocate resources to the construction and operation of the highest quality and most effective research infrastructures, which requires planning and long-term commitment.

The development of research infrastructures involves significant choices and investments. The mission of the Finnish Research Infrastructure Committee (FIRI), established by the Academy of Finland, is to monitor and develop national and

international research infrastructure activities in Finland. Its tasks include evaluating Finnish research infrastructures, selecting the best, and contributing to their funding.

The research infrastructures selected for the Roadmap for Research Infrastructures 2021–2024 are estimated to have received a total of EUR 1 billion in funding from various sources from 2015 to 2019, with research organisations accounting for more than 60% of total funding. The total estimated funding needs for the research infrastructures included in the roadmap is approximately EUR 2.7 billion in 2020–2030.

Advances in science and technology are enabling the construction and use of new types of research infrastructures. Increasing data intensity and the opportunities it creates require better strategic planning, cross-sectoral dialogue and holistic management, as researchers and companies need more efficient data processing capacity and high-quality data management. There is a need to consider in what kind of entities research infrastructures and the management of the data they produce will be governed and developed in the future. The digitalisation of research also calls for a stronger culture of transparency and new accountable procedures for research and researcher evaluation.

The Research Infrastructure Committee currently provides EUR 20 million annually to support the construction and upgrading of research infrastructures. In addition, the Academy of Finland funds the membership fees of international research infrastructures with around EUR 20 million per year. In addition, one-off funding has supported, for example, Finland's participation in the European High-Performance Computing Joint Undertaking (EuroHPC) and RRF funding has supported the construction and development of national and local research infrastructures.

Policy outline: *Increase and target funding for national research infrastructures to support not only the needs of high-level science, but also competence development and cooperation between different sectors (such as universities, universities of applied sciences, university hospitals, research institutes, businesses, private sector, third sector).*

11. **Prioritisation of business subsidies for innovation**
The key objective of the business subsidy system is to encourage companies to invest in renewal, long-term productivity and growth. The goal is to promote sustainable public finances and make the business environment more competitively neutral, as well as internationally competitive in the long term.

Currently, the focus of aid is not on long-term productivity, and only a very small proportion of subsidies is targeted fully at subsidies promoting renewal, the green transition and digitalisation.

In 2021, direct subsidies totalled EUR 2 969 million, of which EUR 1 220 million was for primary agricultural production and forestry. Some tax subsidies can also be considered to business subsidies, but they are not commensurate and the total amount cannot be given. Around 40% of direct subsidies promote long-term productivity as their main or partial objective, but most of the subsidies have no impact on long-term productivity. The focus of direct, including compensatory, subsidies is not on financial goals. The focus of direct subsidies is on subsidies for agriculture and forestry as well as energy subsidies, rather than subsidies that promote long-term productivity development.

Policy outline: *Shift the focus of business subsidies from maintenance subsidies to subsidies promoting renewal.*

4.6 Monitoring of R&D funding and assessment of impact

The impact and effectiveness of RDI activities are reflected in society, the environment and the economy in many different ways. Impact refers to long-term objectives and have not only different routes but also different time spans, depending on whether basic research or the impact of development activities are being discussed. For example, the spillover effects of basic research are often underestimated (Akcigit et al. 2021). Impact is often evident after a long time and is difficult to verify. Impact is about changes, added value and societal benefit produced by activities and actors (Vataja & Hyytinen 2020). Long-term impact cannot be achieved without concrete results and effects. Impact is also one of the ten principles for the development of the RDI system as outlined by the Parliamentary RDI Working Group.

The benefits of public R&D funding for companies, research, education, the economy and society are identified by assessing and measuring the impacts of RDI activities. In an increasingly complex society and when solving severe societal problems, impact assessment must become more sophisticated. Input-output analysis alone does not answer the question of how effective an activity is. To understand impact, approaches are required that also uncover complex and diverse impact pathways and the short- and long-term effects that can be achieved by different actors working together. Impact and effectiveness therefore need to be assessed using a wide range of methodologies.

Impact assessment has become increasingly important as the efficiency requirements for public funding have grown. The significant increase in public R&D funding in the coming years and the needs of research and innovation policy require sufficient focus on monitoring and measuring the impact and effectiveness of public R&D activities and funding.

R&D funding and activities are currently assessed rather extensively in Finland. Business Finland and the Academy of Finland have played a significant role in the development of assessment activities in Finland. Under the direction of the ministries, mainly the shorter-term impacts of activities are monitored. Impact is assessed through separate qualitative studies. The Ministry of Education and Culture monitors the diverse societal impacts of universities and universities of applied sciences as part of their objectives, although there is no separate indicator for this in the funding models of higher education institutions. Universities and universities of applied sciences must also regularly assess their education and research activities as well as their artistic activities and their impact. Research assessments carried out by universities generally examine aspects related to quality of science, transparency, sustainability, impact, interdisciplinarity, funding and internationalisation. The Finnish Education Evaluation Centre (Karvi) also carries out assessments of higher education institutions, which examine, among other things, the societal impacts of higher education institutions.

One of the long-term objectives of public R&D funding is to support the production of a highly educated workforce and create new innovations that resolve sustainability challenges and increase societal resilience and the economy's long-term production potential by accelerating productivity growth. The most substantive way to assess the economic impact would therefore be to examine the impact of R&D funding on sustainable productivity growth in the economy. The main challenge for impact assessment is the lack of reliable estimates of how productivity would have evolved in the absence of public R&D investments. These challenges can be generalised to the measuring of other effects of RDI activities, such as societal and environmental benefits.

The impact that government R&D funding has on the advancement of objectives cannot always be measured directly nor immediately. The challenges in assessing the impact of R&D activities are related to externalities and long delays. On the other hand, it is possible to obtain more reliable estimates of, for example, the impact of some R&D subsidies granted to companies. A key challenge in analysing the impact of R&D subsidies received by companies is selection-related problems, which means that the impact analysis often cannot cover a representative sample of all companies. The impacts could most reliably be examined using a randomised trial arrangement. According to Einiö and Hyytinen (2019), a systematic, regularly conducted randomised evaluation study specific to each business subsidy programme is a reliable way of monitoring the impact of a business subsidy system. Reliable assessment of impacts could also be furthered by policy measures that

include features that can overcome selection problems (Einiö 2022). The possibility of reliably assessing the impacts of policy measures should be part of the preparation of policy measures (Ylhäinen et al. 2016).

Compared with other countries, Finland has a considerable amount of high quality research on the impact of public R&D funding. A reliable assessment of the effects of government R&D funding and its long-term impact requires the use of current, and the development of new, scientific methods. These should be part of the preparation of policy measures and financial instruments. Evaluation results should also be used more systematically in the planning and development of research and innovation policy.

The following indicators may be useful in assessing impact and effectiveness. In the indictors, both input and output metrics should be taken into account in a balanced way.

Monitoring indicators for the National Roadmap for RDI, prepared in 2020:

- R&D expenditure/GDP, % (broken down by companies' and the public sector's expenditure), (Statistics Finland)
- Business enterprise R&D expenditure by size class (Statistics Finland)
- Government funding for R&D/GDP, % (Statistics Finland)
- Foreign direct investment/GDP (Statistics Finland)
- EU R&D funding to be repatriated through the Horizon programme (Business Finland EUTI), as well as other foreign RDI funding
- Business funding for research organisations (cooperation between companies and research organisations) (Statistics Finland)
- Internationalisation of RDI activities (residence permits issued by Finnish Immigration Service Migri for experts and researchers) (Migri)
- Number of foreign students and researchers (Statistics Finland)
- Number of doctoral degree graduates (increased) and proportion of doctoral degree graduates (change) among R&D employees (Statistics Finland, Vipunen)

Other possible indictors:

- Exports, employability, value added of knowledge-intensive (including high-tech) industries
- Patents
- Cost structure of RDI activities
- Number of R&D personnel, research work years, and education level by sector
- Development of education level of company personnel
- Selected OECD indicators, including international comparison
- RDI activities as well as sustainability and other societal goals, e.g. green transition, biodiversity, perceived wellbeing, healthcare.
- Growth of labour productivity
- Impact of RDI activities on exports

Under the provisions of the Government proposal to Parliament for an Act on Research and Development Funding in 2024-2030, the Government is required to monitor the development of public and private research and development expenditure. The monitoring would be done on the basis of Statistics Finland's annual statistics on research and development activities. In addition, the provision-specific justifications require that it would be important to include in the long-term R&D funding plan a proposal for monitoring the plan.

Policy outline: *Coordinated by the Ministry of Finance, the ministries will develop monitoring and analysis of funding allocated to R&D activities in the preparation of the General Government Fiscal Plan and the State Budget proposal in cooperation with Statistics Finland.*

The Government will systematically monitor and assess the impact and effectiveness of the growing R&D funding. A monitoring and evaluation framework will be prepared, which will include measurement and monitoring objectives, the launching of data collection and the securing of the knowledge base, methods and indicators, and which takes into account in a comprehensive and balanced way the impacts on companies, education, research, the national economy and society. When planning subsidies, the needs of evaluation research based on scientific, reliable research design will be taken into account whenever possible.

4.7 Research- and innovation-friendly operating environment

A research- and innovation-friendly operating environment that encourages investment is a prerequisite for increasing R&D investments that will lead to growth in Finland's innovation activities, productivity, employment and tax revenues. Adopting new technologies and operating practices will enable the achievement of ambitious environmental and other sustainable development goals. In a supportive operating environment, both startups and established companies are able to generate new international business effectively.

A well-functioning and inspiring research- and innovation-friendly operating environment is a complex, predictable and long-term entity, where cutting-edge knowledge and competence can be widely and effectively utilised to develop, deploy and scale up solutions. There is a sufficient supply of relevant international expertise and talent to meet needs, and excellent collaboration across the RDI chain.

It is important that the broad utilisation potential of the results generated in the research work of higher education institutions and research institutes is diversely recognised and systematically developed, and that the resulting research results and related materials are widely utilised in society and business, both commercially and systemically.

The broad utilisation of research results, materials and knowledge includes, in addition to the publication of the results, other uses, for example, in the areas of education and continuous learning, new research, societal utilisation and commercialisation.

To support development and innovation activities closer to the market, measures are needed to ensure the rapid and extensive spread of the knowledge, skills, technologies and solutions arising from RDI activities. In addition, there is a need for the continuous acceleration of commercialisation, scaling up and internationalisation. Risk-tolerant and creative research and innovation policy approaches must be developed that take into account the needs of the market, society and demand development as well as sustainability transitions, and ensure rapid scaling up of business models and companies' entry into international markets. Only in this way can the full economic and societal benefit be obtained from growing R&D investments.

The operating environment also has to include factors that make Finland an excellent environment for developing and implementing innovations and create a springboard for enthusiastic visionary entrepreneurs and business activity. There are many individual factors, such as experimentation and development environments, innovation-friendly regulation, innovative public procurement, identification and management of immaterial rights, a functioning financial framework supported by private capital, and an advanced startup-friendly environment. In addition, it is necessary to take into consideration the growing importance of social innovations, standardisation as an instrument for the diffusion of solutions, competition policy, and the overall importance of digitalisation, data and intangible investments for RDI activities.

Due to rapid technological development and the increasing importance of digitalisation, data and artificial intelligence, the significance of regulation as part of a stimulating innovation environment has grown. Through innovation-friendly regulation, it is possible, on the one hand, to secure conditions for research and, on the other hand, promote the roll-out of innovations. Through consultation practices and impact assessment in the legislative process, the views of different stakeholders, such as researchers, new business developers and innovation users, and the impact of regulation will be fully taken into account.

Policy outline: *Ensure that the operating environment promotes the transformation of R&D results and competence into innovations. An attractive operating environment includes, among other things, available experimentation and development environments, innovation-friendly regulation that facilitates RDI activities and encourages the roll-out of innovations, innovative public procurement that promotes innovation uptake and market demand, a high-quality system for the protection of immaterial rights, efficient channels for the exploitation of research results and knowledge, a competent funding system supported by private capital, and a start-up-friendly environment. Explore fund-based models to promote the uptake and scaling up of innovations, combining private and public capital to enable greater risk-taking and promote more radical innovations.*

Appendices

Appendix 1. Experts consulted at working group meetings and requested written statements

External experts consulted at working group meetings

Meeting 9 June 2022

- Vesa Vihriälä, Professor of Practice, University of Helsinki

Meeting 13 June 2022

- Paula Eerola, President, Academy of Finland
- Riitta Maijala, Vice President for Research, Academy of Finland
- Nina Kopola, Director General, Business Finland
- Hannu Kemppainen, Executive Director, Business Finland

Meeting 29 September 2022

- Ilkka Niemelä, President, Aalto University; Member of the Board, Universities Finland UNIFI
- Leif Schulman, Director General, Finnish Environment Institute; Chair, Finnish Research Institute Partnership Tulanet
- Vesa Taatila, Rector, Turku University of Applied Sciences; Member of the Board, Rectors' Conference of Finnish Universities of Applied Sciences Arene
- Liisa Suvikumpu, Managing Director, Association of Finnish Foundations

Meeting 27 October 2022

- Riikka Heikinheimo, Director, Confederation of Finnish Industries
- Juha Leppävuori, Head of Partnerships & Ecosystems, Neste
- Matti Mannonen, Executive Director, Technology Industries of Finland
- Karol Mattila, Head of Government Relations, Nokia
- Marjaana Suorsa, Manager, Innovation Policy, Finnish Forest Industries
- Heikki Ilvespää, Vice President of R&D, UPM
- Nadia Tamminen, Director, Research and Innovations, Pharma Industry Finland
- Matthew Iles, General Manager, AbbVie Finland; Chair of the Board, Pharma Industry Finland
- Joonas Mikkilä, Head of Digital and Educational Affairs, Federation of Finnish Enterprises
- Jarmo Hyökyvaara, Entrepreneur, Chair of the Board, The Orange Company

Meeting 23 November 2022

- Samuel Kaski, Professor, Aalto University; Director, Finnish Centre for Artificial Intelligence

Meeting 20 December 2022

- Elias Einiö, Chief Researcher, VATT Institute for Economic Research

Requested written statements

- Climate Fund
- Finnish Research Impact Foundation
- Finnish Industry Investment Ltd Tesi
- South Savo Centre for Economic Development, Transport and the Environment
- Council of Tampere Region
- City of Oulu
- VTT Technical Research Centre of Finland

Appendix 2. Principles for the development of the RDI system

In its final report, the Parliamentary RDI Working Group that operated in 2021 outlined principles for the development of the RDI system, which are as follows:

1. **Predictability and long-term vision:** R&D funding and policy is predictable and long-term. Initiating high-quality research and innovation activities takes time and cannot be interrupted or put on hold without major damage. Long-term, predictable policies and funding create the conditions for and encourage all actors to commit and invest in the system. Funding solutions must respect the principles of sustainable and fair budgeting and provide more long-term certainty about the development of funding levels.

2. **Leverage:** For Finland's RDI policy to succeed, the growth in business enterprise R&D investment must be at least twice as high monetarily as the growth in public investment. The conditions for leverage must be ensured, particularly when allocating government RDI investments to the private sector. As part of the overall package, an effective R&D tax incentive that also meets the needs of SMEs is required. However, it is important to ensure that the tax incentive does not weaken public finances in the long term. In planning tax support, opportunities for tax avoidance or disguising other costs as R&D costs must be minimised. The incentive should be targeted as far as possible at activities that would not be realised without tax support. The key issue is to ensure the conditions for innovation-based entrepreneurship and business in Finland.

3. **Comprehensiveness:** The RDI system will be developed as a whole, identifying and taking into account the needs and roles of different actors, ensuring that diverse and the most effective public funding and support mechanisms are in place, while avoiding silo effect. High-quality research provides people with versatile capacity to seize new opportunities and benefit from research done elsewhere. High quality research also forms the basis of education. Innovation creates successful companies, renews business and industry, and provides an opportunity for sustainable growth. The RDI system takes into account the different and complementary roles of basic research and applied research. On the other hand, it must be recognised that the distinction between the two is partly artificial and that it is possible to speak of inventive research involving both basic and applied research, or of curiosity-driven research without dividing lines.

Research activities primarily aimed at societal returns and benefits will be strengthened, but the needs of business-driven RDI activities will also be taken into account. From the business perspective, the RDI funding system will be developed to be more business-oriented, in line with the 'one-stop-shop' principle. High-quality and diverse basic research and applied research and innovation activities support each other in many ways.

4. **Scientific freedom and high quality research and education:** Scientific freedom and university autonomy are deep values of a free, trust-based society. The RDI system is developed by respecting these values and by serving society. At the heart of the RDI system are high-quality research, development and innovation activities, education and talented people as well as the maintenance of our universities of learning. From the perspective of the RDI goals, Finland must also raise its level of education to the top of OECD countries. Basic funding for science, universities and universities of applied sciences is an important part of the RDI chain and policy predictability, and its adequate level must be ensured. Improving the long-term sustainability and predictability of funding must also be accompanied by the capacity to improve the attractiveness and reduce the uncertainty of research careers.

   Funding decisions will emphasise high quality, impact, renewability and the opportunity to grasp new challenges. Talented people and a good environment for them are the most important factors for RDI: without talented people, no RDI system will deliver the desired results. High-quality education, an adequate level of funding for basic research and international research environments attract motivated researchers and students from Finland and abroad. Alleviating the shortage of talent is the most important way to increase effective RDI activities in Finland.

5. **Impact:** Research and innovation policy promotes effective RDI activities. Funding processes are carried out in a transparent and accountable manner. In research, we need, in particular, sufficiently strong units focused on their field. The impact of RDI activities is diverse and varies between different actors and different forms of RDI activity. The key routes to research impact are impact via research results, impact via research-society interactions and impact via talented people. The performance and impact of RDI investments is ensured through continuous and high-quality monitoring and evaluation. Impact is based on the quality of research activities. Efforts must be made to avoid supporting RDI activities that would be carried out regardless of the support provided for them.

6. **Competition:** Research competition and market competition are key features of the RDI system, and competition is an important principle and quality factor in research funding. Funding is allocated to business enterprise RDI activities and to the core funding of universities, universities of applied sciences, research institutes and university hospitals. A significant proportion of funding is channelled through the Academy of Finland and Business Finland, which ensures the quality of activities and enables the coordination of different funding instruments. Funding must form a balanced whole.

7. **Cooperation:** High-quality and effective research and innovation activities are increasingly carried out in competence clusters and innovation ecosystems, where universities, universities of applied sciences, research institutes and companies of different sizes cooperate in diverse combinations. The RDI system and subsidies will be developed to strengthen cooperation between businesses, universities, research institutes, universities of applied sciences and other actors engaged in RDI activities. Over the last 10 years, the biggest decline in RDI investments has been in joint projects between companies, universities and research institutes.

8. **Internationalisation:** Internationalisation is fundamental characteristic of the RDI system. The system strongly supports international research collaboration, utilises international research funding and attracts international talent and investment. Particular attention should be paid to the funding challenges surrounding the national share of EU research funding. Smoother entry into the country for specialists and researchers as well as high quality of life are key prerequisites for the expansion of RDI activities in Finland. Companies will locate their R&D activities where the conditions are good. Talented researchers seek high-quality research environments. A goal of the RDI system is to strengthen the capacity of the regionally extensive SME sector to participate in development and innovation funding mechanisms that support internationalisation.

9. **Recognition of global challenges:** In RDI activities and their orientation, global challenges and the opportunities they present are anticipated, identified and addressed. Finland must strive in a goal-oriented manner to become a leading player in a sustainable future by developing system-level planning, development, research and business competence in key technology and competence areas, such as energy and environmental technology.

10. **Technology and industry neutrality:** The public RDI system does not micromanage or select winning companies, technologies or industries at a detailed level. However, existing strengths as well as the strategic goals of society can be taken into account when allocating subsidies. The system works on a bottom-up principle, whereby public RDI funding is channelled in ways that facilitate the emergence of new and unexpected actors and industries.

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FINNISH
GOVERNMENT

SNELLMANINKATU 1, HELSINKI
PO BOX 23, 00023 GOVERNMENT, FINLAND
valtioneuvosto.fi/en/
julkaisut.valtioneuvosto.fi

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