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Austrian Research and Technology Report 2020

Report under Section 8(1) of the Research Organisation Act on federally subsidised research, technology, and innovation in Austria

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Preface

The outbreak of the COVID-19 pandemic has a far-reaching impact on our social and economic lives. Forecasts of future economic development are fraught with uncertainty at present and will depend on how long the crisis lasts, what restrictions are imposed and how effective the measures taken prove to be. Due to the situation, therefore, no GDP forecast has been produced for 2020 – merely a scenario calculation for future economic development. This also means that there is no global estimate of research intensity from Statistics Austria for 2020 and thus no illustration of annual estimated R&D expenditure or R&D intensity for the current year in this Austrian Research and Technology Report. If the pandemic has shown us anything, it is just how important basic, application-oriented research is in overcoming a crisis. In 2020, the federal government provided short-term funding for research into combating COVID-19 and made an extra €28 million available on short notice for studies into the effectiveness of existing drugs. As an accompanying measure, the medical universities are being supported with €2 million to enable them to take part in clinical trials together with companies.

However, the pandemic is also making it clear that the federal government has chosen the right path with the planned Research Funding Act and how important this path actually is. This law will induce fundamental changes to the framework conditions. As well as providing planning and funding security for three years, it is also designed to increase flexibility in day-to-day activities to allow a faster and more effective response to relevant challenges. To enable a complete and systemic view of government-funded research and its performance in the future, annual monitoring of the ten central research and research funding institutions listed in detail in the legislation is also envisaged as part of the Austrian Research and Technology Report. For the first time, the present report attempts to facilitate this view of the system as a whole using standardised key indicators and a reporting structure that also tries to take account of the various differences between these ten stakeholders. This significantly enhances and expands the Austrian Research and Technology Report.

At national level, work is under way to prepare a new RTI strategy valid until 2030, which will give us a framework for the research agendas of the next few years. It is focusing on output as well as impact, excellence and openness. These broad objectives are being reinforced by analyses of Austria's strengths and weaknesses in international rankings, which put the country in a good upper midfield position in a global comparison – but not right at the top. At international level, and with Horizon 2020 drawing to a close, the negotiations over Horizon Europe – the EU's new Framework Programme for Research and Innovation for 2021–2027 – are playing a major role. This Austrian Research and Technology Report thus looks back over the long and successful history of Austrian involvement in the EU Framework Programme for Research and forward to current developments in the programme's new incarnation.

The focus topic for this year's report is artificial intelligence (AI). The rapid progress of global technological development and the use of AI in all manner of different areas will bring radical, disruptive change to our society. AI is also given broad coverage in the current government programme for 2020–2024, and developing an AI strategy is a stated objective. This is reason enough to explore the topic in greater depth and provide an extensive overview of its definitions, potential uses, ethics guidelines and legal situation.

With its analyses of recent national and international research data, sections on measures, initiatives and continuing development in research, developments in certain institutions and sections on selected evaluations, the Austrian Research and Technology Report 2020 once again presents an exciting and diverse picture of research and technology in the country.

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Executive Summary

The Austrian Research and Technology Report is the status report on the country's federally funded research, technology, and innovation. It is commissioned by the Federal Ministry of Education, Science and Research (BMBWF), the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), and the Federal Ministry for Digital and Economic Affairs (BMDW).

The Austrian Research and Technology Report 2020 presents a **revised global estimate of R&D expenditure in the country for 2019** and analyses the **performance of the Austrian innovation system compared to international standards**. The report also describes numerous **strategic measures and innovations** in the areas of research, technology and innovation.

When the Research Funding Act is passed, the circumstances surrounding the central research and research funding institutions will change fundamentally. For this reason, all the **key players in non-university research and research funding** are presented in a monitoring section of this report for the first time.

One main focus of the Austrian Research and Technology Report 2020 is the topic of **artificial intelligence**. Artificial intelligence is becoming increasingly important in education and research as well as at companies and authorities thanks to the availability of large volumes of data and the constant improvement in the quality of algorithms. Relevant developments and measures are described for each sector.

Austrian RTI policy is characterised by an **evaluation culture** that is firmly anchored and widely applied in the system. The report thus also provides some insights into this culture and a synopsis of recent evaluations of RTI programmes and research institutions.

Revised global estimate of R&D expenditure for 2019

Due to the economic uncertainties caused by the COVID-19 pandemic, this year's Austrian Research and Technology Report does not include a global estimate of annual R&D expenditure. Instead, Statistics Austria revised its global estimate for 2019 in April 2020.

In 2019, **expenditure on research and development (R&D) in Austria amounted to €12.69 billion**, 4.8% above the figure of 2018 (€12.11 billion). **Estimated research intensity** (percentage of gross domestic expenditure on research and development relative to gross domestic product) was **3.18%** according to the revised global estimate for 2019, which constitutes a slight increase over 2018 (3.14%). This is the **sixth time in a row that Austria has exceeded the European target value of 3%**.

The federal government spent about €3.12 billion on R&D in 2019, around **a quarter (24.6%)** of all R&D conducted in Austria. In the same year, the **regional governments** contributed approximately **€0.55 billion (4.3%)** in R&D funding, putting total public-sector R&D expenditure at €3.66 billion. **Austrian companies** provided **€6.04 billion, or almost half (47.6%) of all R&D funding.** This is slightly less than previous years in percentage terms (2018: 48.0%; 2017: 49.0%). **€2.02 billion (15.9%)** of R&D funding **came from abroad** and mainly comprised R&D funded by foreign companies on behalf of their Austrian subsidiaries as well as return flows from the EU's research programmes. The **research premium** contributed **€758.0 million** in 2019, some 6% of R&D expenditure. Other public funding and the private non-profit sector played only a relatively minor role in 2019 with a combined total of 1.6%.

R&D survey 2017

According to Statistics Austria's 2017 R&D survey, **€11.29 billion was invested in R&D**. R&D expenditure had thus **risen by €790 million or 7.53%** since the previous survey in 2015. Since the nominal growth in GDP over the same period was almost identical at 7.56%, research intensity (R&D expenditures as a percentage of GDP) did not increase, unlike in previous periods. At 69.9%, the business

enterprise sector was responsible for the largest share of R&D expenditure, followed by the higher education sector with 22.4%. The government sector accounted for 7.1% and the private non-profit sector for 0.5%.

Looking at R&D expenditure by economic sector, manufacturing dominates, with a combined total of almost two thirds (65.5%) of all R&D expenditure. In percentage terms, therefore, the sector contributes nearly three and a half times as much to R&D as it does to Austria's total gross value added. **Manufacturing in Austria is becoming increasingly research-intensive.** Although the proportion of service segments classified as high-technology and knowledge-intensive is still fairly low at 19.6%, it has risen considerably since 2007 (15.7%).

In the higher education sector, there are some relatively significant variations in R&D expenditure across different fields of science, with natural sciences contributing the most at €722 million. **Research at higher education institutions is predominantly funded by the public sector**, self-financing by the institutions (including tuition fees and expert assessments commissioned by third parties) accounts only for a small proportion. At 11.1%, the largest share contributed by the business enterprise sector went towards the engineering sciences, while the natural sciences received the bulk of EU-funded R&D.

The number of people employed in R&D has risen sharply over the past ten years. Whilst 89,500 people (53,300 FTEs) worked in R&D in 2007, by 2017 this had risen to **131,000** (76,000 FTEs). This is a 43% increase in headcount in FTE terms. The proportion of women working in R&D rose slightly from 2007 to 2017. The **proportion of female R&D employees compared to the total** increased from 23.7% to 24.2% (in FTE terms), putting Austria's figure below that for most OECD countries. Women currently make up 36.4% of researchers in the higher education sector and 35.8% of those in the public sector. In percentage terms, therefore, these two sectors employ many more female researchers than the business enterprise sector, where the share is still a modest 16.1% despite a marked rise of 20.7%.

Austria's position in international comparisons

Austria is one of the **world's leading nations** for its **expenditure on research and development**. A research intensity (percentage of gross domestic expenditure on R&D relative to gross domestic product) of 3.17% in 2018 puts Austria second in Europe behind Sweden and ahead of leading innovators such as Finland, Belgium and the USA. Together with Sweden, Germany and Denmark, Austria is one of only four EU countries to have met the European target of 3%.

The country enjoys an **upper midfield** position in terms of its **research and development performance**, which is measured against core quality-oriented parameters such as citation rate and international patent applications. Austria has not yet managed to break into the group of "Innovation Leaders" and has been amongst the top few "Strong Innovators" for several years now.

In the area of digitalisation, the European Commission's Digital Economy and Society Index (DESI) for 2019 places Austria 13th, **midfield** among the EU-28. Austria is only slightly above the EU average, while the field is led by the Nordic countries of Finland and Sweden alongside the Netherlands and Denmark. With regard to its digital strengths, Austria fares relatively well in an international comparison particularly in terms of people's digital skills, international e-commerce by small and medium enterprises (SMEs) and the use of information and communication technologies. The European

Commission's E-Government Benchmark for 2019 puts Austria **in third place for e-government** in Europe, behind Malta and Estonia. However, it could still do more in the areas of ultra-fast fixed broadband networks and companies' use of big data and cloud services.

Austria in Horizon 2020

Participation in Horizon 2020, the eighth EU Framework Programme for Research and Innovation, can be counted as a success for Austria. **Total approved funding for Austria** amounts to **€1.46 billion**. With a success rate of 18.2% in terms of participations, Austria ranks significantly above the average success rate of 15.7% for Horizon 2020 and is second only to Belgium (19.2%) amongst the member states of the European Union. The largest volume of funding for Austria was acquired under Pillar III, Societal Challenges. This amounted to €564.5 million, or 2.8% of the total for Europe. The largest budget share, in relative terms, was allocated under Pillar II, Industrial Leadership, with 3.3%.

All major types of institution contributed to this success. Austrian companies were able to obtain total funding worth €465.9 million over the programme's term (with a particular emphasis on the Industrial Leadership pillar). Overall, more than 500 Austrian companies participated successfully in Horizon 2020, with funding concentrated on the largest successful companies (of which a few managed to carry out no less than several dozen successful funding projects). **At 18.1%, the success rate of Austrian companies was well above average** (EU average: 14.2%), with Austrian companies even leading the country comparison.

Besides companies, however, the universities/higher education institutions and non-university research institutions were the most significant contributors to Austria's successes in Horizon 2020. The universities acquired €518.0 million in funding (predominantly in the Excellent Science pillar, followed by Societal Challenges), while the non-university research institutions were allocated €358.1 million (chiefly for the Societal Challenges pillar). The **success rates for participation in** Horizon 2020 **are also above the relevant European averages both for universities/higher education institutions and for non-university research institutions.** The universities/higher education institutions enjoyed a success rate of 14.4% (compared with the corresponding EU average of 13.6%) and the non-university research institutions one of 20.0% (as against 18.8%).

Key players in research funding and non-university research

When the **Research Funding Act (FoFinaG) is passed**, it will fundamentally change the **circumstances surrounding the central research and research funding institutions**. As well as providing planning security for three years, the amendment and the subsequent Research Funding Act are intended to strengthen the strategic steering and monitoring responsibility of the federal ministries involved while giving the research and research funding institutions more flexibility in their day-to-day activities. For this reason, for the first time the Austrian Research and Technology Report 2020 is presenting the ten key players in research funding and non-university research in a monitoring section. The ten players are:

- Austrian Institute of Technology GmbH (AIT)
- Institute of Science and Technology Austria (IST Austria)
- Austrian Academy of Sciences (OeAW)
- Silicon Austria Labs GmbH (SAL)
- Austria Wirtschaftsservice GmbH (aws)
- Christian Doppler Research Association (CDG)
- Austrian Science Fund (FWF)
- OeAD-GmbH (OeAD)
- Austrian Research Promotion Agency (FFG)
- Ludwig Boltzmann Gesellschaft (LBG).

They are each showcased with a general profile and selected indicators devised in collaboration with the competent federal ministries. The report also looks ahead to future developments.

Thus the **first steps towards implementing the monitoring** of the **federal government's ten key research funding and research performing institutions** called for in the Research Funding Act (FoFinaG) have been taken. The overarching goal is to create a picture of the system as a whole while also respecting the differences between the individual institutions in connection with their roles in that system.

Artificial intelligence

Technologies and applications from the field of artificial intelligence are becoming increasingly important thanks to the availability of large volumes of data and the constant improvement in the quality of algorithms. **Artificial intelligence (AI) refers to artificial systems that demonstrate intelligent, i.e. self-learning, behaviour and thus act with a certain degree of autonomy.** In the future, the use of AI will bring about fundamental changes in many areas of society and the economy and will also be able to help overcome the major societal challenges.

Austrian research institutions cover the whole of the AI-related technological spectrum. Recognisable focal points can be found in the areas of machine learning, symbolic methods, robotics and autonomous systems. **Virtually all Austrian universities are engaged in AI research activities**. Besides the technical universities in Vienna and Graz, the University of Vienna and Johannes Kepler University Linz are also major centres of Austrian AI research in the academic sphere.

At present, it is difficult to obtain a full picture of the AI-related activities being undertaken by Austrian companies. Based on recent analyses, however, it can be assumed that several hundred firms are grappling with the issue of AI and developing or deploying solutions in different ways and to varying degrees. The concentration of companies active in the AI field (i.e. these as a percentage of all companies in a sector) is highest in the pharmaceutical products manufacturing segment (20%), oil processing (20%) and insurance (8%). Overall, it is evident that Austrian companies mainly use AI for automating and optimising processes and for increasing efficiency.

There is currently only limited information available to determine Austria's relative position in the topic area of AI, although the plan to include AI in the next Europe-wide survey of ICT use in companies will improve the situation. Recent analyses by the Austrian Patent Office show that the total number of **AI-related patent applications** has grown sharply, particularly since 2012. These analyses, which cover South Korea and the EU-28 as well as the USA, put Austria in **11th place** for the last available year (2017), closely behind the UK and France. However, South Korea is the runaway leader (followed by Ireland and the USA), filing nearly 13 times as many patents per million inhabitants as Austria.

The potentially disruptive nature of AI itself and its various applications will also drive structural change in Austria. Nevertheless, developing and using AI presents various challenges, particularly of a regulatory nature, but also in terms of technology, as well as issues surrounding its societal and ethical ramifications and questions of security, and data protection. This means that a whole host of relevant skills in using AI are called for. SMEs in particular face a barrier to using it more widely in the form of (high) investment costs and the shortage of skilled workers as well as the issue of the volume and quality of their data relevant for AI purposes.

Culture and practice of evaluation

Evaluations are an important tool in RTI policy and governance and help to support transparency, accountability and evidence-based decision-making. Austria is **one of the leaders in Europe** when it comes to **the number of evaluations** in the RTI sector. Studies dealing with evaluations emphasise the generally high professionalism and quality of Austrian evaluations. Overall, however, the RTI

evaluation market is small (annual volume of less than €1 million). Whilst only a small number of institutions commission evaluations, there are quite a few that can carry them out, some of which operate internationally. Competition is felt to be growing increasingly fierce.

During the reporting period, several evaluations were conducted, including a number of major ones. These include the accompanying evaluation of the pilot call for proposals for Ideas Lab 4.0, the evaluation of OSTA Washington and Beijing and the evaluation of the Austrian Climate Research Programme. The resulting findings have been incorporated into the formulation of measures and policy development.

1. Current Trends

1.1 Funding and R&D performance in Austria

Revised global estimate for 2019

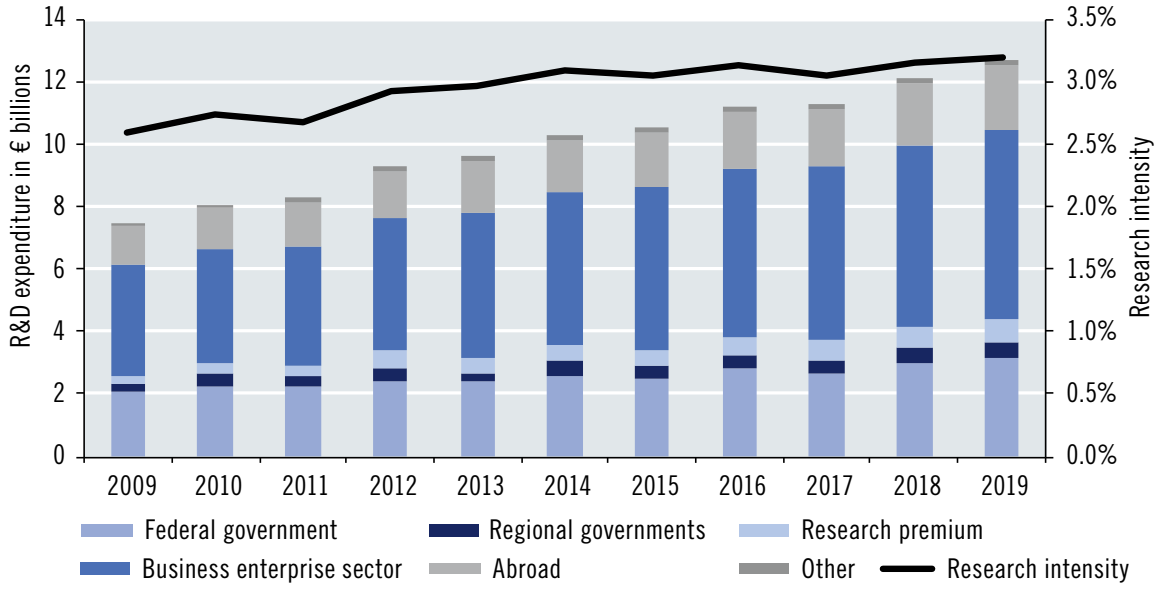
Due to the uncertain economic situation resulting from the COVID-19 pandemic, this year's Research and Technology Report does not include a forecast for 2020 based on the global estimate by Statistics Austria. Instead, the global estimate for 2019 has been revised by Statistics Austria and this is therefore the basis used for the analysis of R&D funding in Austria.

According to the revised global estimate for the year 2019, a total of €12.689 billion was spent on R&D. The federal government provided approximately €3.12 billion for R&D, corresponding to around a quarter (24.6%) of all R&D conducted in Austria. In 2019 the regional governments contributed approximately €0.55 billion (4.3%) of R&D funding, so the total amount of public funds allocated to R&D was €3.66 billion. Austrian companies provided €6.04 billion, or almost half (47.6%) of all R&D funding. This is slightly less than previous years in percentage terms (2018: 48.0%; 2017: 49.0%). €2.02 billion (15.9%) of R&D funding came from abroad; the majority of this sum comprises financing from foreign enterprises for research being carried out in their subsidiaries in Austria, but it also includes funds from EU research programmes. The research premium contributed €758.0 million in 2019, representing around 6% of R&D expenditure. Other public funding and the private non-profit sector played a relatively minor role, with a combined total of 1.6%.

Fig. 1-1 shows the development of R&D expenditure since 2009 by funding source, and the research intensity (= R&D expenditure as a percentage of GDP). The bars represent absolute expenditures at their respective values, and the solid line indicates research intensity.

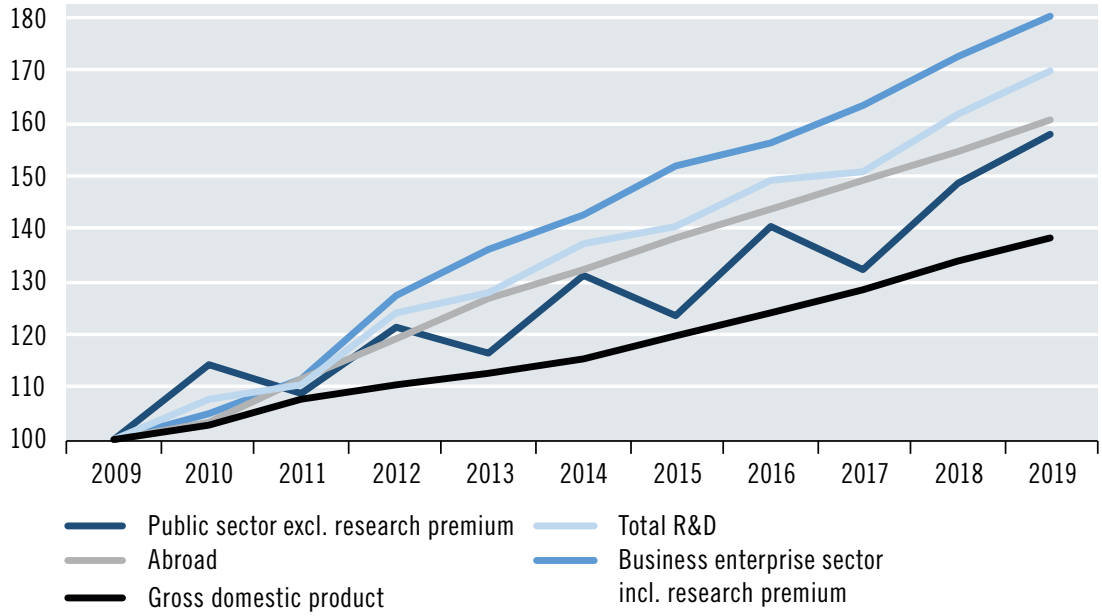
Since 2014 Austria's research intensity has remained consistently above the EU target level of 3%. It should be noted that research intensity is defined as increasing if R&D expenditure grows faster than

Fig. 1-1: Funding of research and experimental development carried out in Austria and research intensity, 2009–2019



Source: Statistics Austria, global estimate as at 28 April 2020. Graphic: WPZ Research; the category "Other" combines the two categories "Other public funding" (incl. the higher education sector) and "Private non-profit sector".

Fig. 1-2: Trend in funding for research and experimental development carried out in Austria, new allocation of research premium, 2009–2019 (index, 2009=100)



Source: Statistics Austria, global estimate as at 28 April 2020. Calculation and graphic: WPZ Research; the category "Public sector excl. research premium" includes the categories "Federal government", "Regional governments", "Other" (= "Other public-sector funding" incl. the higher education sector and "Private non-profit sector").

gross domestic product. Looking back over the period 2009–2019, gross domestic product has grown by 38.36% in terms of nominal values, while R&D expenditure has increased by 69.64% over the same period.

In the last ten years, all the funding sources shown in Fig. 1-1 have grown more substantially than gross domestic product. In contrast to previous years, research premium in line with the guidance in the revised Frascati Manual, is no longer included under government funding in international comparisons, but is regarded instead as funding from the business enterprise sector.

Using this new classification, funding from the business enterprise sector shows a particularly sharp rise, with growth of 80.10%. Business enterprise funding increased from €3,775 billion to €6,798 billion, while public sector funding grew by only 58.16%, from €2,449 billion to €3,874 billion. This discrepancy arises from the respective volumes as depicted in Fig. 1-1: the amount provided by the business enterprise sector is by far the largest, which means the effect of adding the research premium is smaller, relatively speaking. This gives the impression, as can be seen in Fig. 1-2, that the contribution from the public sector is on a downward trend, but this is an issue of definitions. Regardless of what definition we use, it is clear that in terms of both definitions (classifications) it is the funding contribution from the business enterprise sector that has grown the most substantially, and the conclusion that Austrian companies are contributing more and more to funding remains valid.

The increase in funding from abroad was much smaller than from other sources. This category includes not only funding contributions from international organisations including the EU, but also R&D funding from foreign firms, with the latter providing the largest share. In terms of absolute figures too, the amount of funding from abroad grew less than from other sectors, increasing from €1.256 billion in 2009 to €2.017 billion in 2019. Since the "Abroad" category consists largely of funding from for-

eign-based firms, it is not companies as a whole, but Austrian companies that make a disproportionately large contribution to the funding for R&D carried out in Austria.

R&D survey 2017

Changes to the survey methodology

In Austria, national R&D surveys with a mandatory duty of disclosure have been carried out in all sectors of the economy ever since the reporting year 1998. Since 2007 these have taken place every two years, so the survey presented here relates to the reporting year 2017. The R&D surveys are conducted using the methodology defined in the OECD's Frascati Manual, which ensures that the data collected can be used for international comparisons. The reporting year 2017 was the first time that the survey had been based on the 2015 revised edition of the Frascati Manual (previous version: Frascati Manual 2002).[1]

The 2015 Frascati Manual has no major changes in comparison to the previous version, but newly formulated recommendations result in changes to the design of the survey questionnaire, which can lead to discontinuity in data series and consequently to limited comparability of the new data with those from earlier surveys. For practical reasons some Austrian national changes were made at the same time as the transition to the 2015 Frascati Manual.[2]

The most significant change in the new Frascati Manual definitions concerns the interpretation of the research premium. This is now no longer classified as government funding, but instead as internal R&D funding. This means the research premium is now interpreted as funding from the business enterprise sector, with the result that this is correspondingly higher in comparison to previous surveys. This effect is further magnified by the increase in research premium from 10% in the 2015 R&D survey, to the present 12%. Since the research premium is still reported separately, it is nevertheless still possible to make a comparison with previous years, using appropriate conversion calculations.

The definition of "research and experimental development (R&D)" has not changed; it still refers, as before, to "creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge".[3] An addition to the definition is that the activity concerned must be "novel, creative, uncertain in outcome, systematic, transferable and/or reproducible."[4] However, in Austria there were in practice "no or only minimal changes in the reporting practices of companies".[5]

A further change concerns the reporting of external employees as a separate category; this relates to people working in R&D who are not employed by the unit carrying out the R&D. This would be for example self-employed consultants, contractors or leased employees. Previously these were not included if the expenditure on their services was accounted for in other running costs. Furthermore, the higher education sector is now reported as a separate funding sector, whereas previously these institutions were included under "other" in the government sector. The effects of these two changes are minimal, however. There is a larger impact from a change in the collection of data from the institutes' sub-sector ("Kooperativer Bereich"), which is now done using the same questionnaires as for the business enterprise sector, rather than the government sector, as previously.[6]

1 https://www.oecd.org/sti/frascati-manual-2015-9789264239012-en.htm
2 See Statistics Austria (2019).
3 See OECD (2018, 47).
4 See OECD (2018, 47).
5 See Statistics Austria (2019, 19).
6 See Statistics Austria (2019).

Research sectors

Institutions conducting R&D activities are divided into four sectors of performance: business enterprise, government, private non-profit, and higher education. The business enterprise sector includes the company R&D sub-sector and the institutes' sub-sector ("Kooperativer Bereich"). The former comprises private and government enterprises conducting market-oriented research for commercial benefit. The latter refers to institutions that regularly carry out R&D, most of which is done as collaborative projects for other companies. It includes the members of the Austrian Cooperative Research (ACR) association, and the competence centres of the COMET programme. Some research institutes that were previously considered part of the institutes' sub-sector ("Kooperativer Bereich") are categorised in the 2017 R&D survey as belonging to the government sector, in accordance with the European System of National and Regional Accounts (ESA). These are primarily the Austrian Institute of Technology (AIT), JOANNEUM RESEARCH Forschungsgesellschaft mbH, and some research institutions closely associated with them. Due to the relatively large size of these two institutions, there is now a correspondingly large increase in the volume of government R&D funding.

The government sector includes general R&D institutions of the federal government, regional governments, local governments, various Chambers, social insurance institutions and private non-profit institutions funded and controlled by the public sector and, since 2017, it also includes the Austrian Academy of Sciences (OeAW), previously categorised as a higher education institution.

The higher education sector includes the public universities, including teaching hospitals, private universities, universities of the arts, universities of applied sciences, the University for Continuing Education Krems, university colleges of teacher education, federal higher technical institutes/colleges, and other higher education institutions.

The private non-profit sector refers to non-profit institutions whose status is predominantly private or under private law, confessional or other non-public bodies.

With regard to funding, five different sectors are identified: the business enterprise sector, public sector, private non-profit sector, higher education, and funding from abroad. The abroad sector includes funding both from foreign-based firms and from international organisations including the EU.

R&D in Austria

In 2017, R&D expenditure increased in nominal terms by 7.53% compared to 2015, to a total of €11,290 billion (2015: €10,499 billion). Since the nominal GDP has increased by 7.56% – almost the same amount over the period– there was no increase in the research intensity figure, in contrast to the previous period; this remained steady at 3.05% for 2017. The largest proportion of R&D expenditure was attributed to the business enterprise sector, with 69.9%, and the second largest to the higher education sector with 22.4%; the government sector accounted for 7.1% and the private non-profit sector 0.5%.

The proportion of total funding provided by the enterprise sector increased, due to the new classification of the research premium as enterprise funding, from 49.7% in 2015 to 54.7% in 2017. If the research premium volume of €637.4 million is subtracted, then the proportion from the business enterprise sector is 49.0%. Thus, if the figures are adjusted for the research premium element, the share of funding provided by the enterprise sector fell slightly in this period, by 0.7 percentage points. The proportion from the public sector comprised 27.6% in 2017, but if this figure is corrected to allow for the research premium and the higher education sector, which for 2017 is no longer included in the public sector, then the proportion is 34.0% – an increase of 0.8 percentage points. Funding from abroad, and from the EU as a sub-category of this sector, remain unchanged at 16.6% and 1.9% respectively. The shares from the private non-profit sector and the higher education sector in 2017 amount to 0.3% and 0.8% respectively. Table 1-1 shows the volumes and proportions of R&D

expenditure by sector of performance and source of funds in 2017; in addition, values and proportions of the funding sectors shown have been adjusted to exclude the changes in classifications (i.e. shown in terms of the old classifications).

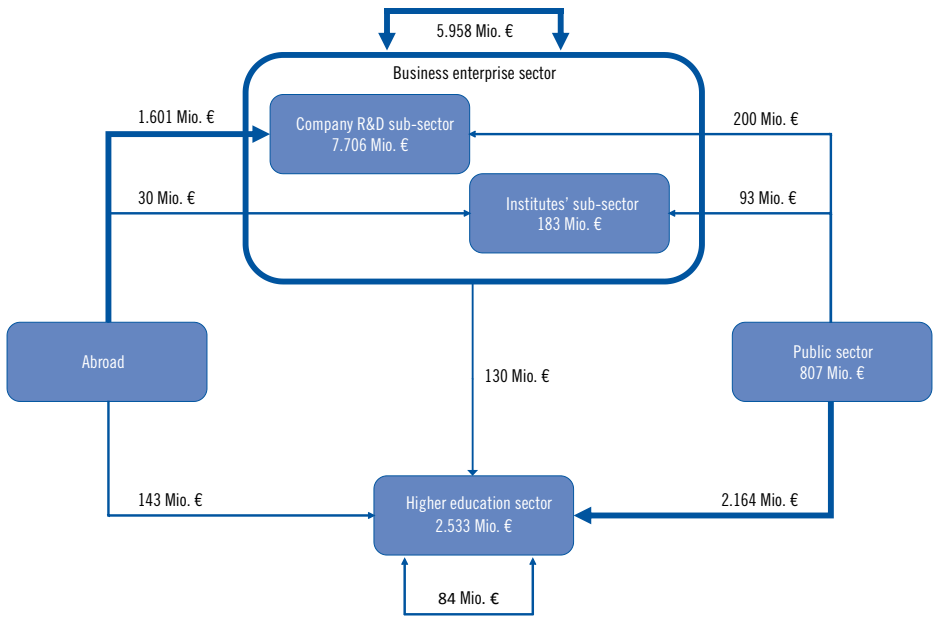
Fig. 1-3 illustrates the funding streams for 2017. The volumes of research carried out are shown in the boxes, while the arrows represent funding streams. The business enterprise sector carried out R&D work with a volume of €7,888 million, of which approximately €7,706 million was in the company R&D sub-sector and approximately €183 million in the institutes' sub-sector ("Kooperativer Bereich"). The higher education sector is largely financed from public funding, with €2,164 million, while their own funds, which since 2017 have been reported separately, make only a small contribution, as do enterprise funding and funds from abroad. Due to the

Table 1-1: R&D expenditure by sector of performance and source of funds, 2017

Sector of performance	In € millions	Shares in %	Source of funds	In € millions	Shares in %	Adjusted volumes in € millions	Adjusted shares in %
Business enterprise sector	7,888	69.9	Business enterprise sector	6,170	54.7	5,533	49.0
Institutes' sub-sector	183	1.6	Public sector	3,118	27.6	3,844	34.0
Company R&D sub-sector	7,706	68.3	Private non-profit sector	39	0.3	39	0.3
Higher education sector	2,533	22.4	Higher education sector	88	0.8	0	0.0
Government sector	807	7.1	Abroad	1,874	16.6	1,874	16.6
Private non-profit sector	62	0.5	Abroad excl. EU	1,668	14.8	1,668	14.8
			EU	207	1.8	207	1.8
Total	**11,290**	**100**	**Total**	**11,290**	**100**	**11,290**	**100**

Source: Statistics Austria. Calculations: WPZ Research.

Fig. 1-3: R&D performance and funding, 2017



Note: For reasons of clarity, the private non-profit sector and flows from the higher education sector are not shown with the exception of own funding, which is assigned to the public sector in terms of source of funds. "Abroad" includes the EU.

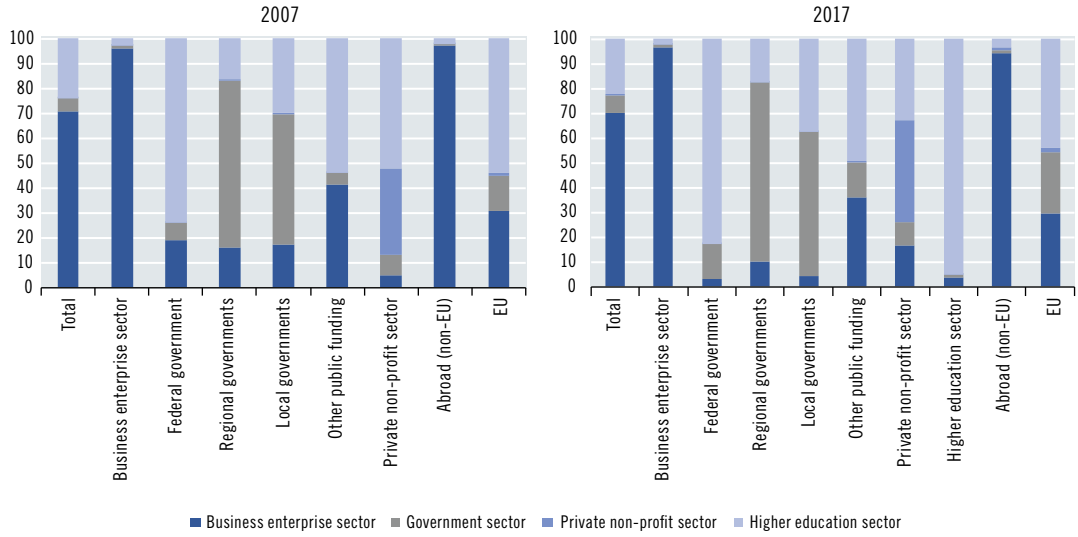
Source: Statistics Austria. Calculations and graphic: WPZ Research.

new category definitions described at the beginning of this section, the value of research carried out by the institutes' sub-sector ("Kooperativer Bereich") has decreased in comparison to previous years, while that of the public sector has increased correspondingly. Similarly the volume of publicly-funded research carried out in the business enterprise sector has fallen due to the new interpretation of the research premium.

Fig. 1-4 shows funding streams in the years 2007 and 2017. The "Total" column for 2017 illustrates the values of research activity in each sector of performance, as shown in Table 1-1, as proportions of the total value. The other columns divide the total value of each source of funds according to the proportions allocated to each sector of performance. The enterprise sector total of €6,170 million shown in Table 1-1 is thus split into 96.6% for the business enterprise sector itself, 1.13% for the government sector, 0.21% for the private non-profit sector, and 2.1% for the higher education sector, with analogous splits for all other sources of funds. The sources of funds shown under "Abroad excl. EU" includes mainly foreign-based firms, with the majority of funding in this category being allocated to R&D facilities within Austrian companies. Of public funding (= federal government + regional governments + local governments + other public funding), 9.30% goes to the business enterprise sector, representing 3.68% of funding in that sector. Due to the new classification of the research premium described above, which was introduced in 2017, this proportion is smaller than in 2007. Comparability is also limited by the above-mentioned re-classification of the higher education sector, valid since 2017, and the new classification of the Austrian Institute of Technology (AIT) and the JOANNEUM RESEARCH Forschungsgesellschaft mbH as government institutions.

Despite this limited comparability, some conclusions can nevertheless be drawn from the 2017 data, by combining the higher education sector and the research premium as funding sources with the federal government, for better comparability. Table 1-2 shows the development between 2007 and 2017, both in absolute terms and in relative terms. In absolute terms, the volume of research performance has increased most substantially in the business enterprise sector with a nominal total of €3,043 million, but in relative terms the increase is greatest in the government sector, at 119.6%. The volume of R&D

Fig. 1-4: Distribution of funding by sector of performance (in %), 2007 and 2017



Note: "Higher education institutions" as a source of funds were subsumed under "Federal government" in 2017.
Source: Statistics Austria. Calculations and graphic: WPZ Research.

Table 1-2: Growth in R&D funding by sector of performance and source of funds, 2007–2017

Sector of performance	Growth in funding by source of funds in %								
	Total	Business enterprise sector	Federal government	Regional governments	Local governments	Other public-sector Funding	Private non-profit sector	Abroad (excl. EU)	EU
Business enterprise sector	62.8	65.5	127.5	-7.4	-80.4	24.5	322.1	42.7	97.2
Government sector	119.6	104.0	160.2	60.8	-14.6	351.1	33.6	689.6	258.9
Private non-profit sector	254.2	410.5	25.4	66.1	-77.4	153.3	43.6	20001.6	129.3
Higher education sector	54.7	38.1	59.0	57.5	-2.5	32.3	-24.3	95.1	68.0
All	**64.4**	**65.4**	**79.2**	**49.2**	**-23.0**	**43.8**	**20.6**	**47.7**	**104.5**

Sector of performance	Growth in funding by source of funds in € millions								
	Total	Business enterprise sector	Federal government	Regional governments	Local governments	Other public-sector Funding	Private non-profit sector	Abroad (excl. EU)	EU
Business enterprise sector	3,042.6	2,106.5	400.8	-3.2	-1.2	34.6	5.0	469.7	30.3
Government sector	439.3	35.7	187.1	107.5	-0.7	54.1	0.9	18.3	36.4
Private non-profit sector	44.2	10.5	0.1	0.4	-0.1	1.2	4.9	25.2	2.0
Higher education sector	895.9	35.8	718.6	24.7	-0.1	58.9	-4.1	25.2	36.9
All	**4,422.0**	**2,188.4**	**1,306.7**	**129.5**	**-2.0**	**148.7**	**6.7**	**538.4**	**105.6**

Note: "Higher education institutions" and "Research premium" as a source of funding were subsumed under "Federal government" in 2017 for ease of comparability.

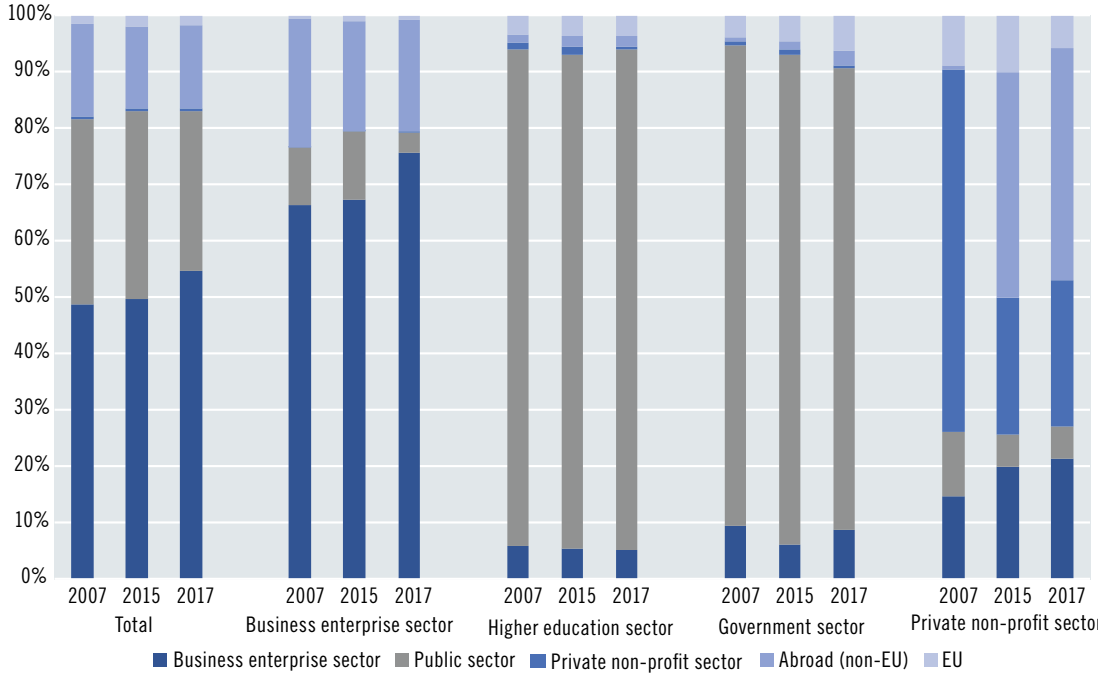
Source: Statistics Austria. Calculations: WPZ Research.

performance in the business enterprise sector as a proportion of the total volume has therefore increased again despite the smaller growth. The same is true for the funding of R&D in the enterprise sector: although the growth in R&D funding from the government has increased by a higher factor, company-internal funding has increased much more sharply in absolute terms, with €2,107 million, than funding from the public sector (= total from federal government, regional governments, local governments and other public funding) at €401 million (including the research premium and the higher education sector). The picture is similar for funding from sources abroad other than the EU, which largely means foreign firms: in relative terms this has risen modestly at 42.7%, but in absolute terms the total value of €470 million represents the second-largest growth, after that from Austrian companies. The increase in R&D performance in the higher education sector is largely funded by the federal government, in both absolute and relative terms.

Fig. 1-5 provides more detail for the data in Table 1-2, showing the structure of funding within the sectors of performance for 2007, 2015 and 2017 as percentages. The reduction in public funding for 2017 can be attributed to the new categorisation of the research premium discussed above. There is a parallel increase in funding for R&D in the enterprise sector provided by the companies themselves. Significant changes occurred only in funding from the private non-profit sector (PNP), however due to the small volumes involved this has very little impact overall.

Fig. 1-6 gives an overview of the OECD countries for the year 2017, both with regard to R&D intensity and to the proportions of funding. The countries with the highest research intensity are Israel (4.82%), the Republic of Korea (4.29%) and Switzerland (3.37%). Sweden, the EU country with the highest R&D intensity (3.37%), is in fourth position in the OECD, followed by Japan (3.21%), Germany (3.07%) and Denmark (3.05%). Austria's research intensity of 3.05%

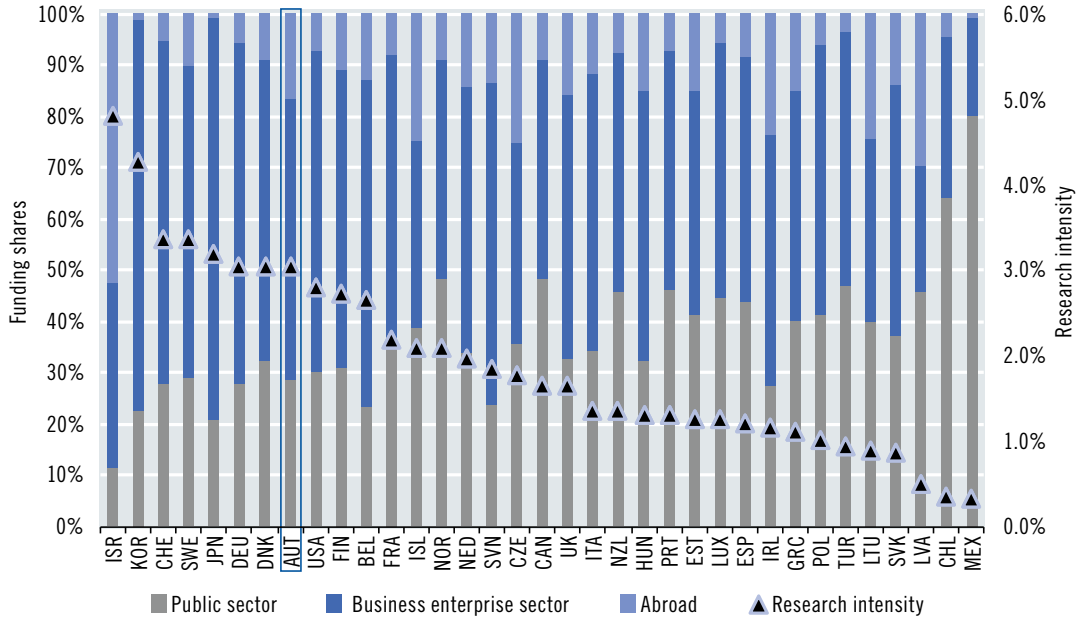
Fig. 1-5: R&D expenditure by source of funds, 2007, 2015 and 2017 in %



Note: The figure shows the origin of funding (Y-axis) within a sector of performance (X-axis). "Higher education institutions" as a source of funds were subsumed under "Federal government" in 2017 for ease of comparability.

Source: Statistics Austria. Calculations and graphic: WPZ Research.

Fig. 1-6: Research intensity and funding in OECD countries, 2017



Note: Arranged by degree of research intensity. The category "Public sector" includes the categories "Government" and "Other national sources". No data available for Australia; data for the Republic of Ireland and the United Kingdom are from 2016.

Source: OECD. Calculations and graphic: WPZ Research.

places it in eighth position in the OECD, and fourth in the EU. Austria's proportion of funding from the public sector, at 28.8%, is below the OECD weighted average of 30.4%. Austria receives 16.6% of its R&D funding from abroad, which is significantly higher than the OECD weighted average of 7.2%.

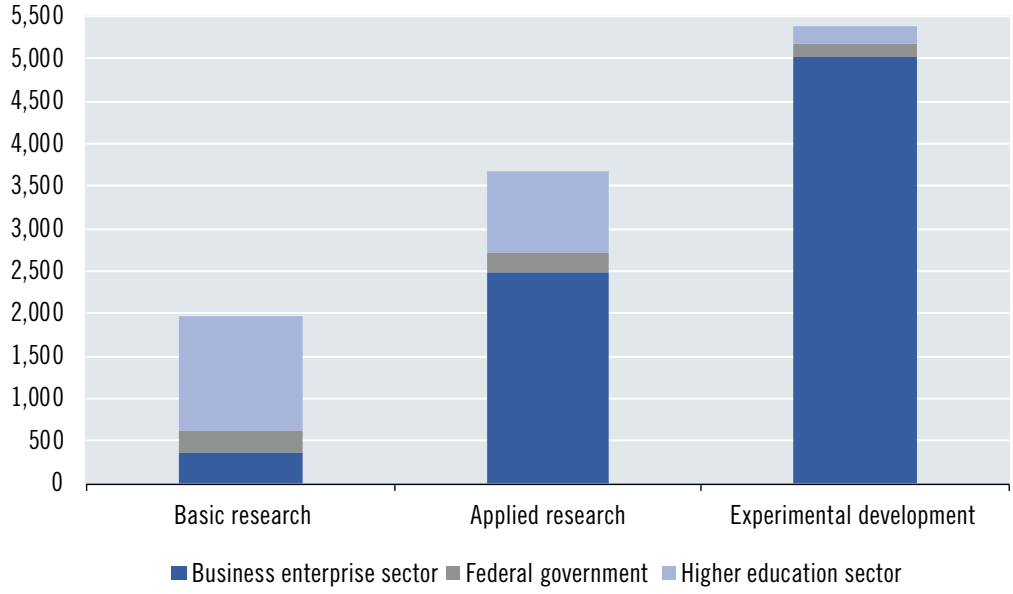
Distribution of R&D expenditure

R&D expenditure is broken down into basic research, applied research and experimental development. Fig. 1-7 shows the way expenditure for these categories is split across different sectors of performance. The largest share (48.9%) is attributed to experimental development, which is predominantly (93.3%) carried out in the business enterprise sector. The business enterprise sector dominates in applied research too (67.6%), although the higher education sector (26.0%) is also a major contributor in this area, with the latter dominating in basic research (68.8%).

Despite the substantial increase in total volume over the course of time, there has been little change in the split between different types of expenditure. As shown in Table 1-3, staff costs make up around half the expenditure, though this is decreasing slightly as a proportion. Current costs have increased slightly as a proportion of the total, from 41% in 2007 to 43.3% in 2017. On the other hand, expenditures on facilities and equipment, as well as for buildings and land, have fallen in relative terms.

In the higher education sector there are significant variations in R&D expenditure across different fields of research: as in previous years, the largest proportion was attributed to the natural sciences, at €722 million in 2017. This volume has decreased, however, in comparison to the 2013 level of €738 million, so the gap has reduced between the natural sciences and other fields of research, where the nominal volumes have all increased since 2013. As can be seen from Table 1-4, R&D in higher education institutions is predominantly financed by the public sector, with self-financing by higher education institutions

Fig. 1-7: R&D expenditure by type of research and sector of performance (in € millions), 2017



Note: The private non-profit sector was not included on account of its minimal share.

Source: Statistics Austria. Calculations and graphic: WPZ Research.

Table 1-3: Types of expenditure, 2007, 2015 and 2017

Type of expenditure	2007		2015		2017	
	In € millions	in %	In € millions	In %	In € millions	In %
Staff costs	3,513.1	51.2	5,206.9	49.6	5,622.2	49.8
Current material expenses	2,818.6	41.0	4,573.7	43.6	4,887.2	43.3
Expenditure on facilities and equipment	449.2	6.5	582.0	5.5	665.3	5.9
Expenditure on buildings and land	86.9	1.3	136.6	1.3	115.1	1.0
Total	**6,867.8**	**100.0**	**10,499.1**	**100.0**	**11,289.8**	**100.0**

Source: Statistics Austria. Calculations: WPZ Research.

Table 1-4: Funding R&D expenditure in the higher education sector by field of science, 2017

Fields of science	Entities performing R&D	Total	Business enterprise sector	Public sector					Private non-profit sector	Higher education sector	Abroad (excl. EU)	EU
				Federal government	Regional governments	Local governments	Other	Combined				
	Number	In € millions	In %	In %	In %	In %	In %	In %	In %	In %	In %	In %
1.0 to 6.0 combined	1,259	2,533	5.1	73.1	2.7	0.1	9.5	85.4	0.5	3.3	2.0	3.6
1.0 to 4.0 combined	707	1,932	6.2	69.8	2.9	0.1	10.6	83.4	0.4	3.5	2.3	4.2
1.0 Natural sciences	241	722	2.7	70.1	2.4	0.1	15.0	87.5	0.3	1.5	1.7	6.2
2.0 Engineering sciences	225	532	11.1	65.1	4.1	0.2	9.4	78.8	0.2	3.1	2.4	4.4
3.0 Human medicine, health sciences	180	599	6.5	71.7	2.9	0.0	6.5	81.1	0.8	6.6	3.1	1.9
4.0 Agricultural sciences, veterinary medicine	61	79	2.3	83.8	0.8	0.0	8.2	92.9	0.7	1.0	1.6	1.5
5.0 and 6.0 combined	552	601	1.7	83.9	1.8	0.1	6.1	92.0	0.7	2.8	1.2	1.7
5.0 Social sciences	353	383	2.4	83.3	1.5	0.1	4.8	89.8	0.6	4.0	1.3	1.9
6.0 Humanities	199	219	0.6	85.0	2.3	0.1	8.5	95.8	0.9	0.6	1.0	1.2

Source: Statistics Austria. Calculations: WPZ Research

themselves[7] constituting only a small proportion. At 11.1%, the largest share contributed by the business enterprise sector went towards the engineering sciences, while the natural sciences received the bulk of EU-funded R&D. It is noteworthy that the proportion of EU-financed research has decreased since 2013, and the nominal value has barely increased – by only 0.52%; after adjustment for inflation this in fact represents a decrease.[8] This development can be attributed in large measure to the Austrian Academy of Sciences (OeAW), which receives a relatively high level of funding from the EU, but since 2017 has been included in the government sector figures rather than the higher education sector.

Looking at R&D expenditure by economic sector, manufacturing dominates, with a combined total of almost two thirds (65.5%) of all R&D expenditure. In percentage terms, therefore, the sector contributes nearly three and a half times as much to R&D as it does to Austria's total gross value added. Interestingly this ratio has increased slightly since 2007 (from 3.43 to 3.46), while the manufacturing sector's share of total gross value added has fallen noticeably (from 20.3% to 18.9%). This means that manufacturing

7 Including the higher education institutions' own funds, derived from income from expert assessments, testing and studies carried out for third parties; also income from donations and sponsorships as well as tuition fees.

8 For 2013 data see the 2016 Research and Technology Report.

is Austria is increasingly research-intensive. The dominance of medium-technology industries is evident from the proportion of industries categorised as medium-high and medium-low technology. These industries together make up almost half (47.7%) of all R&D expenditure. The proportion of high-technology, knowledge-intensive service segments remains substantially lower, at 19.6%, but has increased in comparison to 2007 (15.7%).

It is interesting to note that the proportion of high-technology industries in manufacturing has decreased since 2007, from 16.7% to 14.4%. The relevant industries here are the manufacture of pharmaceutical products (code 21, according to the Austrian Statistical Classification of Economic Activities – ÖNACE) and of computer, electronic and optical products (ÖNACE code 26). This decrease can partly be explained by the re-classification of some larger organisations conducting R&D in this area, which are linked to the services sector activity of scientific research and development (ÖNACE code 72). This effect also manifests itself in the increased proportion of service segments categorised as high-technology, knowledge-intensive industries.

Employment in R&D institutions

In parallel with increasing research expenditure, the number of people employed in R&D has also grown significantly since 2007, as shown in Table 1-6. In terms of full-time equivalent positions (FTE), R&D staffing has increased most in the private non-profit sector, followed by the government sector. The latter has more than doubled; this figure includes the Austrian Institute of Technology (AIT) and the JOANNEUM RESEARCH Forschungsgesellschaft mbH (classified in the government sector since

Table 1-5: R&D expenditure and employees in the business enterprise sector by economic sub-sector and knowledge intensity, 2007 and 2017

	2007				2017			
	Employees in R&D, full time equivalents	R&D expenditure	Gross value added (GVA)	R&D as a percentage of GVA	Employees in R&D, full time equivalents	R&D expenditure	Gross value added (GVA)	R&D as a percentage of GVA
	Proportion of all sectors in %			In %	Proportion of all sectors in %			In %
Agriculture, forestry and fishing	0.0	0.0	1.6	0.0	0.0	0.2	1.3	0.3
Mining	0.1	0.2	0.4	0.8	0.1	0.1	0.3	0.9
Manufacturing	69.6	69.8	20.3	6.6	62.7	65.5	18.9	8.3
Types of technology								
High technology	14.4	16.7	1.7	18.4	12.5	14.4	1.8	19.4
Medium-high technology	39.6	39.6	6.8	11.2	35.9	38.0	6.7	13.5
Medium-low technology	9.7	8.9	6.0	2.8	10.5	9.8	5.6	4.2
Low technology	4.6	4.1	4.9	1.6	2.7	3.1	4.1	1.8
Cannot be allocated	1.4	0.6	0.9	1.2	1.1	0.2	0.7	0.7
Energy and water supply	0.2	0.3	3.3	0.2	0.3	0.5	2.8	0.4
Building	0.5	0.4	6.9	0.1	0.8	1.0	6.5	0.4
Services	29.5	29.3	67.5	0.8	36.2	32.8	70.1	1.1
Knowledge intensity								
High-technology, knowledge-intensive	18.6	15.7	4.2	7.1	22.7	19.6	5.8	8.1
Other services	10.9	13.6	63.3	0.4	13.5	13.2	64.3	0.5

Note: Economic sub-sectors as per Austrian Statistical Classification of Economic Activities (ÖNACE) 2008. Types of technology as per Eurostat: high technology (industries 21–26), medium-high technology (industries 20, 27–30), medium-low technology (industries 19, 22–25, 33), low technology (10–18, 31–32); industries 12, 13, 14 and 19 are included in the category "Cannot be allocated" due to data not being published. Knowledge intensity as per Eurostat: "High-technology, knowledge-intensive" includes industries 59–63 and 72 as well as industry 58 on account of aggregated data. Other services: the remainder. GVA = gross value added.

Source: Statistics Austria. Calculations: WPZ Research.

Table 1-6: Employees in R&D by sector of performance, 2007 and 2017

	Employees in R&D						R&D expenditure in € millions			R&D expenditure per full time equivalents in € thousands		
	Headcount			Full time equivalents								
	2007	2017	Growth	2007	2017	Growth	2007	2017	Growth	2007	2017	Growth
Higher education sector	35,269	48,363	37%	13,613	17,680	30%	1,637	2,533	55%	46.42	52.38	13%
Government	5,500	10,314	88%	2,488	5,266	112%	367	807	120%	66.78	78.20	17%
Business enterprise sector	48,352	71,327	48%	36,989	52,478	42%	4,846	7,888	63%	100.22	110.60	10%
PNP	337	1,028	205%	162	585	260%	17	62	254%	51.56	59.87	16%
Total	**89,458**	**131,032**	**46%**	**53,252**	**76,010**	**43%**	**6,868**	**11,290**	**64%**	**76.77**	**86.16**	**12%**

Note: PNP = private non-profit sector.

Source: Statistics Austria. Calculations: WPZ Research.

2017, according to the new classification system). In the higher education sector it is noticeable that the growth in employment in terms of headcount is significantly higher than when measured by full-time equivalent positions; this is largely attributable to the incidence of part-time positions. Growth in the business enterprise sector is also higher in terms of headcount, and corresponds roughly to the overall trend, which is very much influenced by the size of the enterprise sector. R&D expenditure per full-time equivalent position has only grown at a moderate rate, in nominal terms by 12.2% across all sectors of performance.

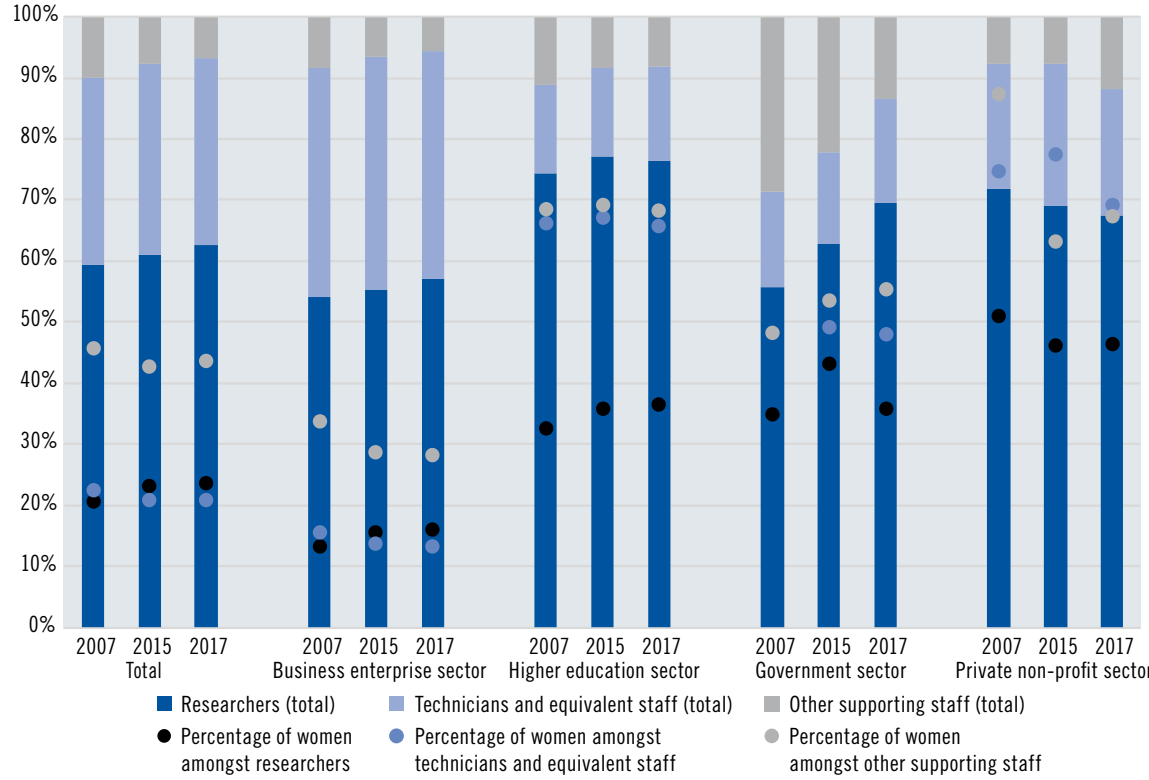
Women in R&D

The proportion of women working in R&D rose slightly from 2007 to 2017. The proportion of female R&D employees compared to the total has increased, in terms of full-time equivalent (FTE) positions, from 23.7% to 24.2%, i.e. the proportion has increased by 2.1%. This growth has primarily occurred in research personnel, while the proportions of non-research personnel in R&D units have decreased significantly, as can be seen in Fig. 1.8.

The overall perspective, across all sectors, shows that: the higher the proportion of women was amongst research staff in 2007, the less this increased by 2017. In the private non-profit sector, where the ratio of women in 2007 was over 50%, this proportion has actually decreased. Women currently make up 36.4% of researchers in the higher education sector and 35.8% of those in the public sector. Institutions that are predominantly or completely government organisations overall employ far more female researchers than the business enterprise sector does; in the latter, the proportion of women did in fact increase by 20.7% between 2007 and 2017, but in 2017 was still only 16.1%.

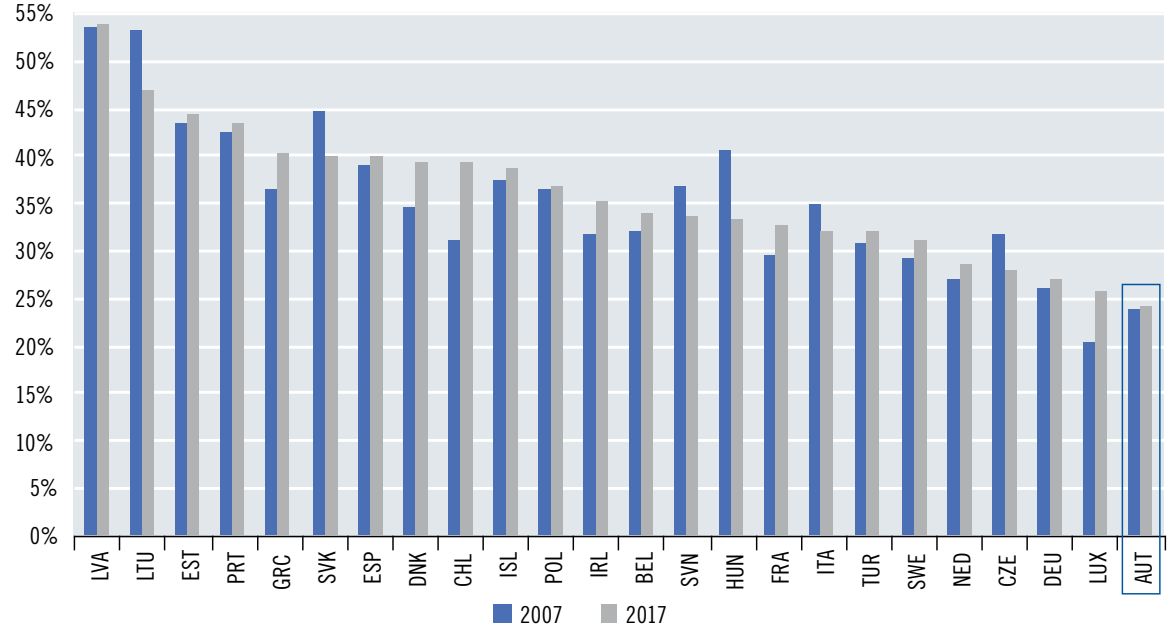
Fig. 1-9 shows that despite this increase over the period 2007–2017, the proportion of female researchers in Austria is lower than in most OECD countries. In fact, amongst the countries shown here, for the relevant observation period Austria has fallen behind Luxembourg and is now in last place. In international comparisons it is noticeable that countries with a medium income level – and here it is particularly those with formerly centralised economies – have the highest levels. The top seven consist of four countries (Latvia, Lithuania, Estonia, Slovakia) that were part of the Council for Mutual Economic Assistance (COMECON), and three southern European countries (Portugal, Greece, Spain). The proportion of women amongst R&D personnel in the business enterprise sector is relatively small throughout Europe, and frequently lower than that in the higher education sector or the government sector. Countries with a small proportion of R&D in the business enterprise sector therefore often show relatively high proportions of women. In contrast, leading research countries such as Germany, the Netherlands, Sweden and France show low ratios of female researchers; in all the countries listed the proportion of women in 2017 was below one third.

Fig. 1-8: Employment structure of R&D staff in full time equivalents, 2007, 2015 and 2017



Source: Statistics Austria. Calculations: WPZ Research.

Fig. 1-9: Percentage of female researchers in full time equivalents in OECD countries, 2007 and 2017



Note: Arranged by proportion of women in 2017. No data are available on the countries omitted. Data for Belgium and Iceland are from 2007 and 2011; France: 2011 and 2017; Greece: 2010 and 2017; Ireland: 2007 and 2015.

Source: OECD. Calculations and graphic: WPZ Research.

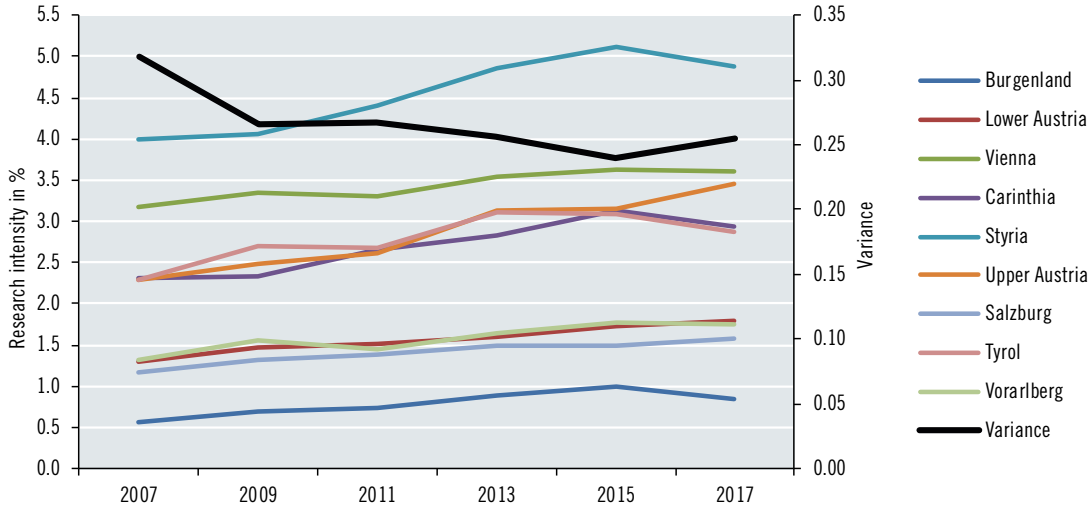
Regional distribution of R&D

The volumes of research carried out vary quite significantly between individual federal states. Styria has the highest research intensity by far, with 4.87%. The EU target of three percent is otherwise only met in Upper Austria and Vienna; in all the other federal states the research intensity level is below the target.[9] There is also a disproportionately high number of young, research-intensive companies (start-ups) based in the three federal states mentioned.[10]

In absolute terms, over two thirds (69.57%) of R&D expenditure is accounted for by Upper Austria, Styria and Vienna. This is a far larger proportion than the contribution of these three federal states to Austria's GDP (55.05%). So Austrian R&D is significantly over-represented in these states compared to their economic output, and particularly in Styria. However, the dominance of Vienna and Styria has decreased since 2007 (combined share of R&D in 2007: 55.43%; of GDP: 38.93%), while the proportion in Upper Austria has increased.

Fig. 1-10 shows the development of research intensity ratios by region since 2007 in detail. In all federal states the figures for 2017 are higher than in 2007; the highest growth in research intensity tended to be in those federal states which had the lowest levels at the beginning of the observation period. This trend is documented by the variance in the logarithmically calculated research intensity: it decreased significantly from 2007 to 2009, and then more slightly until 2015, since when it has increased slightly. Thus despite the consistent increase in research intensity throughout Austria, there is a trend towards reduced regional differences over time. Exceptions are Carinthia and Tyrol, at the medium level, which show low rates of increase in research intensity; in both states the research intensity has actually decreased in recent times.

Fig. 1-10: Research intensity of federal states, change over time and variance, 2007–2017



Note: The variance has been determined based on research intensity figures calculated logarithmically in order to adjust for the general growth effect.

Source: Statistics Austria. Graphic and calculations: WPZ Research.

9 Values for the individual states are: Burgenland 0.85%, Lower Austria 1.80%, Vienna 3.60%, Carinthia 2.94%, Styria 4.87%, Upper Austria 3.46%, Salzburg 1.59%, Tyrol 2.88%, Vorarlberg 1.75%.

10 See Keuschnigg and Sardadvar (2019). For a more detailed description of the start-up scene in Austria, see also Leitner et al. (2019) https://austrianstartupmonitor.at/en/

1.2 Austria's position in international comparisons

The following sub-chapter is divided into three sections, each with a different strategic objective. It presents a transnational comparison that enables Austria's current position to be gauged in terms of its performance and performance capabilities in research, technology and innovation. It opens with a number of central research and development (R&D) indicators, which permit a comparative statement to be made about Austria's input in and output from research and development (Section 1.2.1). It then goes on to present Austria's position in the field of digitalisation (Section 1.2.2) based on indicators on the use, application and availability of information and communication technologies (ICT). As well as being important from the perspective of rapid technological change, these aspects also form a key pillar of a country's innovativeness and its ability to compete on the international stage. The next section concludes with an analysis of relevant indicators that allow conclusions to be drawn about Austria's capability to innovate and thus its competitiveness (Section 1.2.3).

The indicators used in the empirical assessments and figures below are taken from different formats, which are themselves presented in different ways depending on the available data:

- **Eurostat database:** The statistical office of the European Union, known as Eurostat, is the EU's administrative entity responsible for preparing official statistics. Headquartered in Luxembourg, Eurostat publishes country comparisons using official data on various topics on its website. In addition to data from EU member states, information on leading non-EU economies, such as the USA, is also included for many indicators.
- **Global Innovation Index 2019 (GII)**[11]: The Global Innovation Index (GII) draws on a total of 80 indicators and covers 129 economies. Its indicators are used to rank countries in terms of their capability to innovate. This ranking is published annually by the French business school INSEAD, Cornell University and the United Nations' World Intellectual Property Organization (WIPO). It takes account of both the index as a whole and more detailed information on the use of, application of and access to information and communication technologies.
- **Global Competitiveness Report 2019 (GCR)**[12]**:** The Global Competitiveness Report (GCR) measures the growth potential of 141 economies using a total of 103 indicators, divided into 12 main categories. It is published by the World Economic Forum (WEF). The indicators are based on publicly available data and surveys of business leaders (WEF's Executive Opinion Survey). Both the index as a whole and individual indicators on innovation capability (structural and relationship capital) have been studied for the purposes of this report.
- **Global Social Mobility Index:** Published by the World Economic Forum, the Global Social Mobility Index compares countries' performance in terms of social mobility. Social mobility here means the ability of individuals or groups to move between different socio-economic positions. For example, a change in a person's job or professional standing can be interpreted as a move up or down, with their salary, for instance, serving as the indicator.
- **Education at a Glance 2019**[13]**:** In its "Education at a Glance" report, the Organisation for Economic Co-operation and Development (OECD) publishes an annual compilation of education indicators for the purposes of international comparison, focusing on participation in education, graduate ratios,

11 See Cornell University, INSEAD and WIPO (2019).
12 See World Economic Forum (WEF) (2019).
13 See OECD (2019a).

investment in education and teaching/learning settings. It covers OECD member states and a number of other countries.

- **European Innovation Scoreboard 2019 (EIS)[14]:** The European Innovation Scoreboard analyses and compares the innovation performance of EU member states as well as other European and non-European countries. An analysis of strengths and weaknesses enables the countries to identify where they are making progress and spot key areas where they need to improve their innovation performance. A total of 27 different indicators are included and these are divided into four main categories and ten innovation dimensions.
- **Innovation Indicator:** The Innovation Indicator was compiled by the Fraunhofer Institute for System and Innovation Research (ISI) and the Leibniz Centre for European Economic Research in Mannheim (ZEW) on behalf of the Federation of German Industries (BDI). This composite indicator for the measurement of national innovation potential consists of 38 input and output indicators. In turn, they are divided into the following five sub-indicators: education, research, industry, government and society.[15]
- **OECD – Main Science and Technology Indicators:** The OECD publishes important indicators on a wide range of topics in its database,[16] including industry, education, energy and transport as well as research and development. The database contains information on OECD countries and selected non-member states. Indicators on R&D expenditure and triadic patent applications have been selected for this report.
- **The Atlas of Economic Complexity**[17]: Produced by Harvard University, the Atlas of Economic Complexity features an economic complexity index calculated from foreign trade data. It reflects economies' specialisation of their goods exports in the complex products segment.
- **Digital Economy and Society Index (DESI) Report 2019[18]:** The Digital Economy and Society Index (DESI) is published annually by the European Commission and covers five dimensions: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology and Digital Public Services, as well as ICT research and development. This report assesses the index as a whole, as well as sub-indicators on connectivity, digital skills (human capital) and the integration of digital technology.
- **SCImago Journal & Country Rank[19]:** The SCImago Journal & Country Rank database is a portal accessible by the general public that provides indicators on academic and scientific publications. These are based on the SCOPUS database run by the Elsevier publishing company and cover 239 countries.

A comparison of relevant indicators drawn from the abovementioned sources is presented below for the 28 EU member states, with the corresponding EU average for the indicators shown in the respective graphic. Where values for individual countries are missing, the EU average has been calculated based on available data. Where the underlying data permit it, there is also a comparison with the USA, Canada, Brazil, South Africa, China and Australia, representing the largest economies on their continents (in terms of GDP). In addition, Switzerland is included as another important player among the global research and innovation leaders, where data are available. This method allows Austria to be ranked on a global scale with regard to scientific and innovation policy aspects and progress with implementing the federal government's RTI strategy[20] to be gauged.

14 See European Commission (2019b) and (2019c).
15 See Federation of German Industries (BDI) et al. (2020).
16 See OECD (2019b).
17 See The Growth Lab at Harvard University (2019).
18 See European Commission (2019f).
19 See Scimago Journal & Country Rank (2019).
20 See Federal Chancellery (BKA) et al. (2011).

1.2.1 Development of Austria's position in terms of the key performance RTI indicators

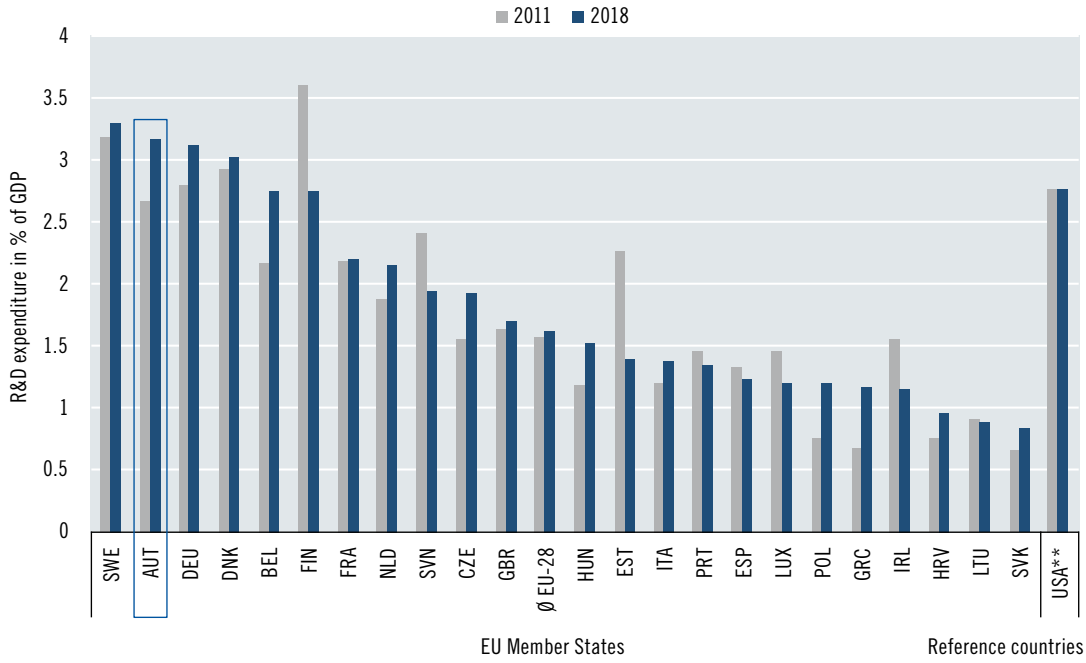
Based on the Austrian Research and Technology Report 2019,[21] the trend in R&D intensity is used as an input indicator, while patent applications and scientific publications serve as a basis for determining R&D output.

One of the main indicators from the research statistics is research intensity, which measures gross domestic expenditure on R&D as a percentage of gross domestic product (GDP). Fig. 1-11 illustrates research intensity levels in 2011 and 2018. It shows that, in 2018, Austria was second in the EU behind Sweden, with R&D expenditure making up 3.17% of its GDP. There are four countries in all – these two plus Germany and Denmark – that spend more than 3% of their GDP on R&D.[22]

As had also been the case in previous years, Austria significantly increased R&D expenditure as a percentage of its GDP – back in 2011, it had been a mere 2.67%. Although the data for 2018 are still provisional, the trend of the past few years shows that R&D in Austria is on the rise and that the country is currently one of the European leaders in terms of its R&D intensity.

Government funding for R&D via public spending by EU member states has flatlined for several years now and stood at some €99 billion in 2018.[23] Re-

Fig. 1-11: R&D expenditure as a percentage of gross domestic product (GPD) 2011 and 2018*



* Country data not available for the reference years: CHE, CHN, CAN, AUS, BRA, ZAF.
** Last available data selected (2017).

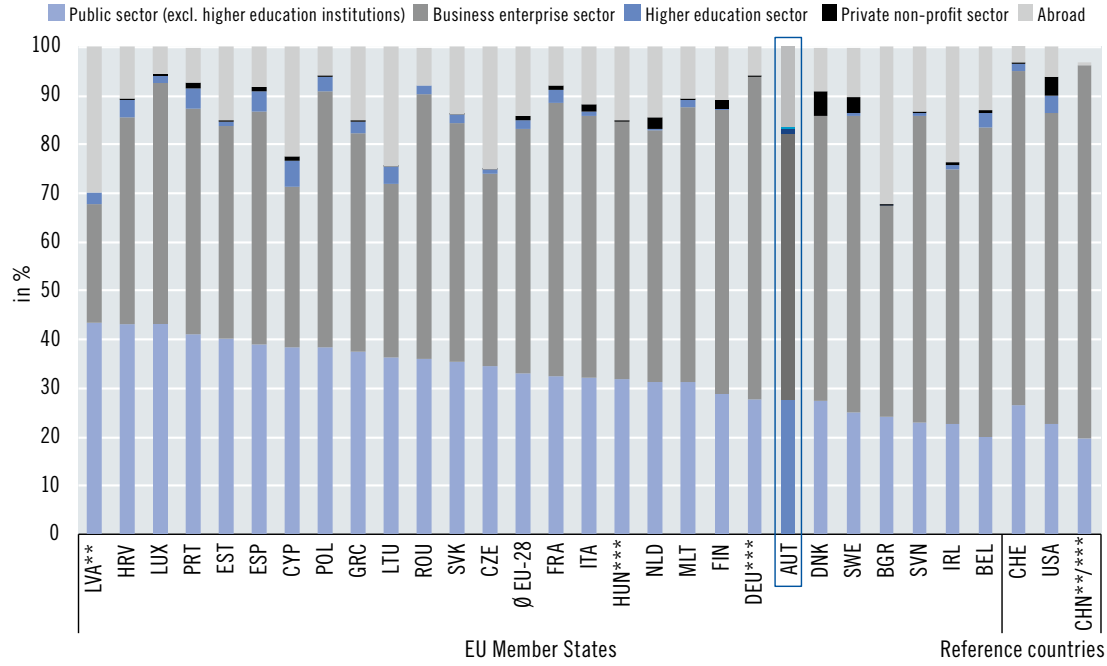
Source: Eurostat (2020). Graphic: iit. The 2018 data are provisional.

21 See Federal Ministry of Education, Science and Research (BMBWF), Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019).

22 R&D intensity ("research intensity") measures R&D expenditure as a percentage of gross domestic product (GDP). Several R&D intensity values are used in this report due to different data being available at different times. Under its mandatory duty of disclosure, Statistics Austria calculates official data as part of its R&D survey every two years (e.g. 2013, 2015 and most recently 2017). R&D intensity stood at 3.05% in 2017 according to Statistics Austria. The OECD produces annual estimates of R&D intensity to enable international comparisons. This was 3.17% in 2018. Meanwhile, Statistics Austria also makes annual forecasts as part of its global estimate, which put R&D intensity at 3.19% for 2019 and at 3.18% following the estimate's revision. Due to the COVID-19 pandemic, it was not possible to prepare a global estimate for 2020.

23 See Schiefer (2020).

Fig. 1-12: Breakdown of R&D expenditure by source of funds, 2017*



* Country data not available for the reference year: BGR, CYP, HRV, IRL, MLT, AUS, BRA, ZAF.
** No data available for the reference year in the "Private non-profit sector" category.
*** No data available for the reference year in the "Higher education sector" category.

Source: Eurostat (2020). Graphic: iit.

search intensity is a key political priority, primarily on account of the European target for countries to be spending three percent of their total annual economic output on R&D by 2020. Whereas the EU as a whole is missing this target by some margin, Austria has hit it consistently since 2014.

Fig. 1-12 shows the make-up of Austria's R&D expenditure in an international comparison, broken down into the following sources of funding: the public sector (excluding higher education institutions), the higher education sector, the business enterprise sector and the private non-profit sector as well as funding from abroad. The various funding percentages by sector are presented as a stacked bar chart, meaning that the total expenditures for each country add up to 100% in each case.

Adding together funding from the business enterprise sector and abroad reveals that these two sectors accounted for a total of 68.8% of Austria's funding in 2017, above the EU-28 average. In terms of the country's RTI strategy, this figure is in line with or higher than the target level of obtaining two thirds of funding from the private sector.[24] However, funding from the Austrian business enterprise sector – i.e. excluding funding from abroad – stands at 55% and is thus below the target set in the RTI strategy. Nevertheless, it must be borne in mind in this regard that, in particular, a few research-intensive companies in Austria are subsidiaries of multinational corporations and that their research is funded on an intragroup basis via international payment flows. The very fact that significant funding flows into Austrian (companies') research from abroad thus demonstrates the country's performance capacity as a centre for research. Something else to consider is the fact that tax incentives for research are now classified as funds of the entity engaging in R&D – i.e. mostly the companies – due to new rules in the sur-

24 Ibid.

vey methodology (see Frascati Manual 2015). This means, for instance, that government R&D funding fell by 5 percentage points between 2015 and 2017, with funding from firms rising accordingly.

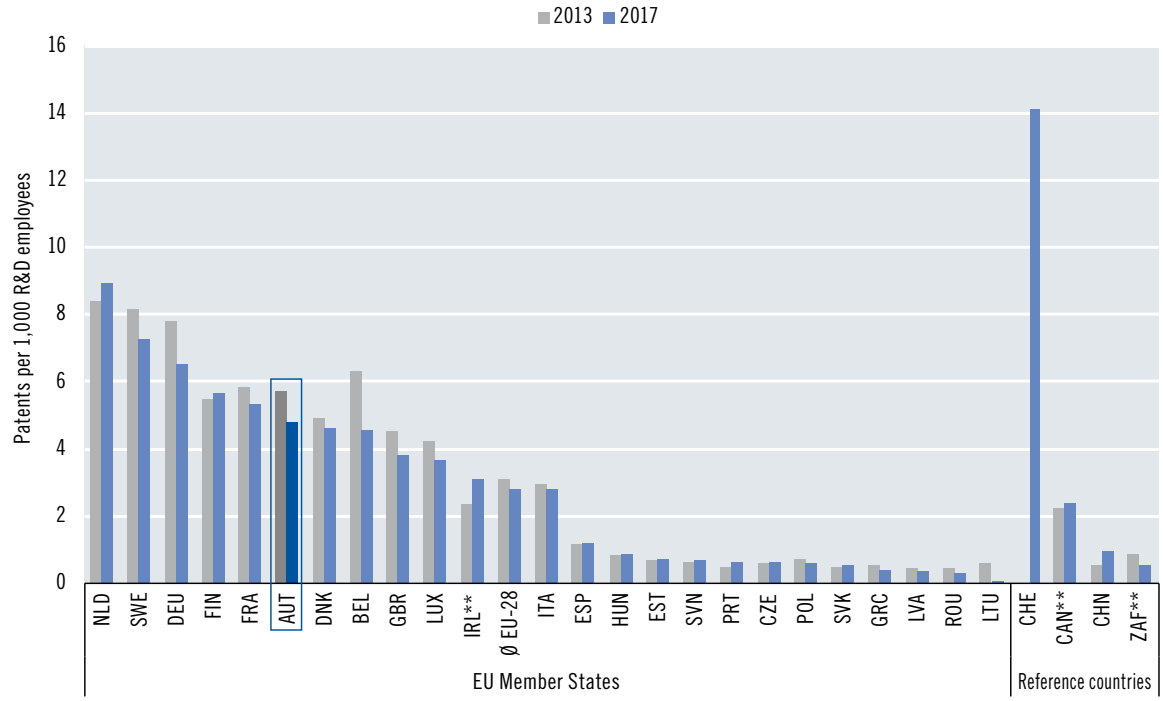
Overall, it can be established that Austrian companies are making an essential contribution to research and development funding, accounting for over half of total funds, and are thus playing a key role in ensuring the country's capability to innovate and thus its competitiveness on the international stage. Making up 29%, funding from direct government (28%) and higher education (1%) funds is also largely in line with the RTI strategy's target figure of one third of R&D funding from the public sector. In addition, the public sector accounts for a similarly high percentage of R&D funding in other countries that are strong on innovation such as Germany, Finland and Denmark.

Number of patent applications

The OECD defines a triadic patent as a set of patents for the same invention registered simultaneously with the European Patent Office (EPO), the Japanese Patent Organization (JPO) and the United States Patent and Trademark Organization (USPTO). The concept of the triadic patent lends itself particularly well to international comparisons and allows conclusions to be drawn about a country's R&D output (i.e. its capability to innovate). It reflects the technological and economic value of inventions as patent applications in several countries can serve as an indicator of the quality of inventions.

Fig. 1-13 depicts triadic patent intensity according to the country of origin for the years 2013 and 2017.[25] It appears as the number of patents per 1,000 R&D employees. Many countries recorded a decline in patent intensity between 2013 and 2017, including

Fig. 1-13: Patent intensity (triadic patents) by country of origin, standardised by number of R&D employees, 2013 and 2017*



* Country data not available for the reference years: BGR, CYP, HRV, MLT, USA, AUS, BRA.
** Last available data selected (2016).

Source: OECD (2019b). Graphic: iit.

25 See OECD (2019b).

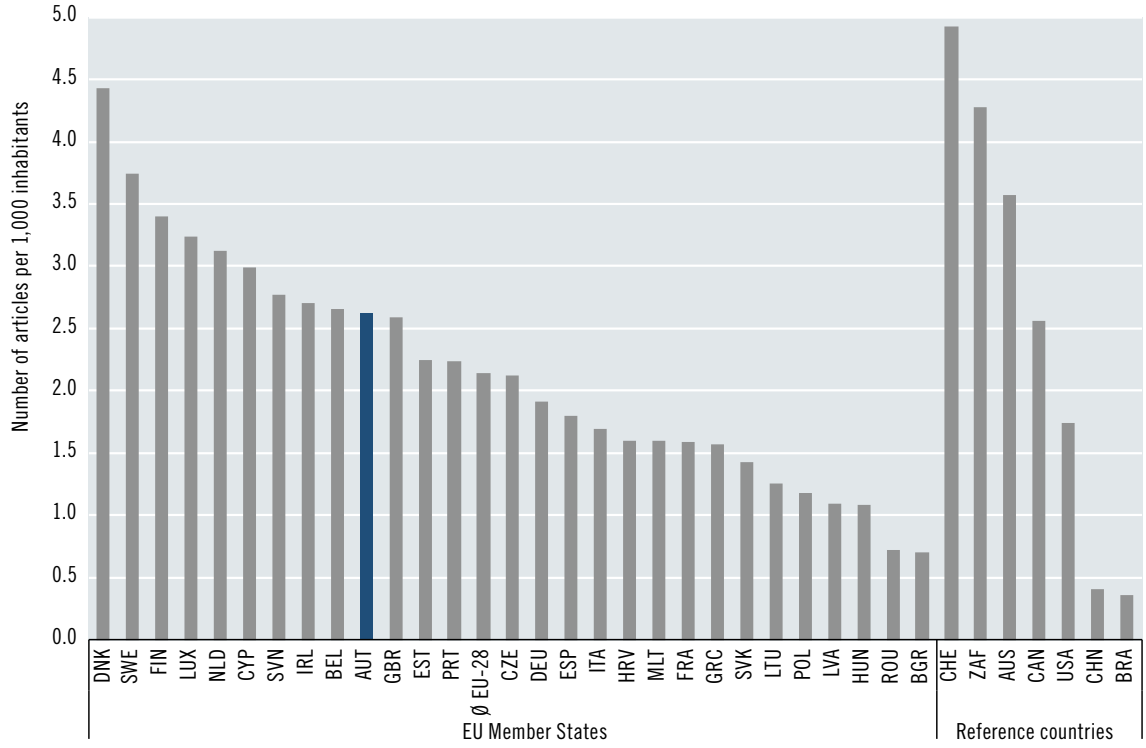
Austria, where patent applications dropped from 5.73 per 1,000 R&D employees in 2013 to 4.87 in 2017. As in 2013, Austria was placed sixth out of the EU-28 in 2017, although it was only just behind France (5.32) and Finland (5.59). Leading the EU field were the Netherlands (8.81) and Sweden (7.51). At 14.1 patent applications per 1,000 R&D employees, Switzerland boasts the highest figure amongst the countries covered here.

Austria's international position in terms of scientific publications

Another key output indicator for a country's scientific performance is the number of scientific and technological publications it generates. This report only considers the citable publications (e.g. scientific studies, reviews, books and articles) produced in the various countries, expressed in relation to population size.[26] This quantitative evaluation of scholarly research is based on the assumption that research results only become relevant when they are reported to the outside world and can be cited.

This bibliometric analysis of the data is underpinned by the SCImago publication database.[27] Fig. 1-14 shows citable published articles for 2018, standardised by country population. Austria (2.61) is tenth out of the EU-28, putting it in a strong midfield position. It is interesting to note that the countries responsible for the most publications – the USA (1.74) and China (0.40) – lag well behind Austria's technological and scientific output in their population-weighted publication output as presented here. Denmark is the leader in the EU, publishing 4.43 scientific articles per 1,000 inhabitants.

Fig. 1-14: Number of scientific (citable) articles in all disciplines, standardised by country population, 2018

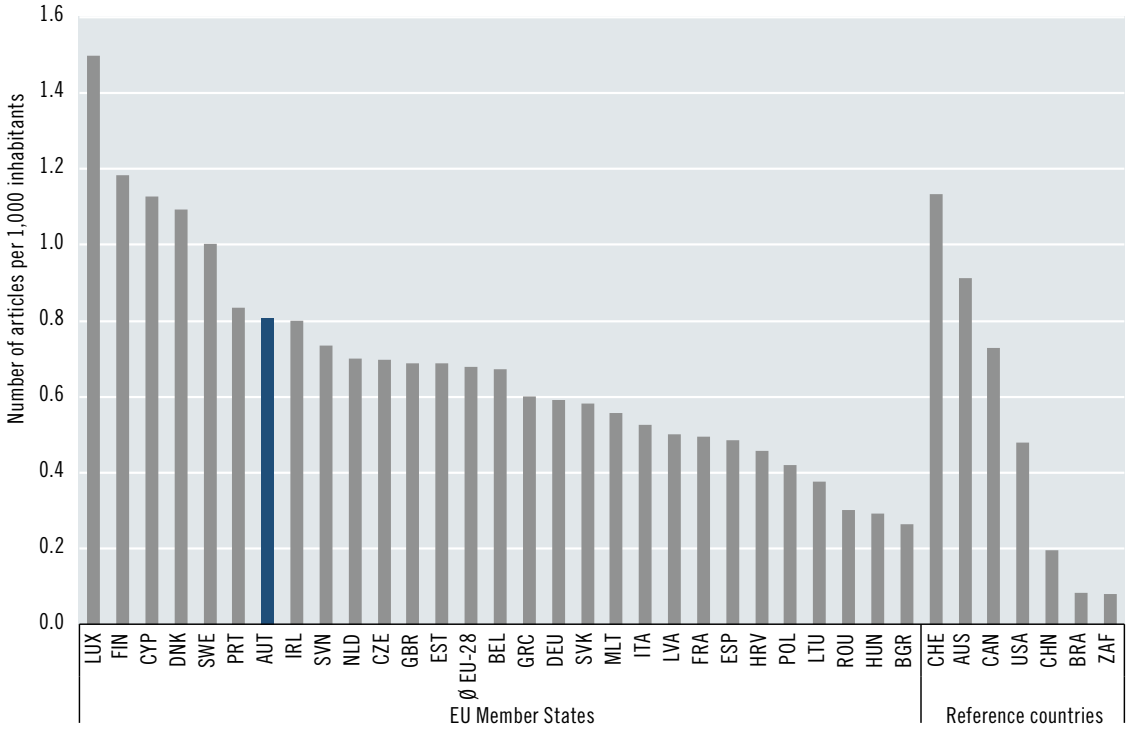


Source: Scimago Journal & Country Rank (2019). Graphic: iit.

26 As scientific publications are not just written by people in an R&D role, the total population of the country in question is used to standardise the figures.

27 See Scimago Journal & Country Rank (2019).

Fig. 1-15: Number of scientific (citable) articles in the fields of computer science and engineering, standardised by country population, 2018



Source: Scimago Journal & Country Rank (2019). Graphic: iit.

In addition to the total number of publications, the number of articles relating to computing (SCImago specialism: "Computer Science") and the engineering sciences (SCImago specialism: "Engineering") are also analysed to produce a further indicator. In view of the onward march of digitalisation, looking at these areas separately allows conclusions to be drawn about Austria's scientific output in the fields of science, technology, engineering and mathematics (STEM) as well as ICT, which will be especially important for countries' future competitiveness and capability to innovate.

Fig. 1-15 shows the number of "Computer Science" and "Engineering" articles published per 1,000 inhabitants. Austria (0.81) is the seventh-placed European country, just behind Portugal (0.83) but ahead of the Netherlands, an "Innovation Leader". This puts Austria back among the top places. The country also compares well to its peers outside Europe, coming in ahead of the USA (0.48) and Canada (0.73) but just behind Australia (0.91). The best performer, both within the EU and overall, is Luxembourg (1.50).

All in all, it can be established that Austria's R&D expenditure (as a percentage of GDP) is high and the federal government's target breakdown of R&D funding (two thirds from the business enterprise and one third from the public sector) has been achieved – although only if R&D funding from abroad is added to the funds obtained from its domestic private sector. Austria's RTI output is also high. Its number of scientific publications is in the upper mid-range compared with other European countries, both overall and in terms of computer science and engineering publications. Its patent intensity is falling, although this downward trend is observable in many countries and not just in Austria. One plausible explanation for this trend (albeit one hard to verify) lies in the fact that patents are no longer being seen as the best possible way to protect innovations at present as digitalisation is on

the rise. Patents contain a detailed description of inventions and innovations and thus make them easier to imitate – occasionally also with a virtually identical methodology, prompting legal questions over the scope of patent protection. This can give medium-sized companies in particular a strategic incentive to avoid patent costs and legal disputes over intellectual property and instead to invest financial resources in continuous research output, in keeping the methods they use confidential or in their sales and marketing.[28] At the same time, companies, and particularly start-ups, are growing increasingly conscious of innovation protection and their need for an IP strategy (comprising a strategic mix of intellectual property rights) if they are to succeed.

Austria's position from the perspective of global innovation rankings

Austria's current performance is above average in many areas of RTI, including the digital skills of its population. In others, however, such as ICT use by companies, its potential for innovation could be exploited even further, enabling the country to progress to a leading position in the innovation rankings in the future. One meaningful way to get a general idea of Austria's place in the international standings might be to consolidate the many individual areas of innovation into a single index and thus obtain an overall value for Austria that can be compared against different countries. Three main overarching international indices for innovation are presented below: the Global Competitiveness Index,[29] the Global Innovation Index[30] and the European Innovation Scoreboard.[31] They are complemented by the Innovation Indicator,[32] which is produced in Germany. All the indices listed here use different indicators with different strategic objectives, which causes a degree of variance in terms of how data are presented as well as discrepancies in the rankings.

The Global Competitiveness Index (GCI) compares economies in terms of their competitiveness and is based on indicators that reflect economic productivity and growth. These indicators are grouped into twelve overarching dimensions representing corresponding composite indices: 1) Institutions, 2) Infrastructure, 3) Macroeconomic stability, 4) ICT adoption, 5) Health, 6) Skills, 7) Product market, 8) Labour market, 9) Financial system, 10) Market size, 11) Business dynamism, and 12) Innovation capability.

With a GCI score of 76.6 in 2019, Austria came 21st out of the economies analysed, up one on the

Table 1-7: Austria's international position in various innovation indices

Austria's position	Global Competitiveness Index 2019	Global Innovation Index 2019	European Innovation Scoreboard 2019	Innovation Indicator 2020
Value	**76.6** (scale 0 to 100) vs. 2018 (value 76.3)	**50.94** (scale 0 to 100) vs. 2018 (value 51.32)	2018: **125** (Scale 0 to 180) vs. 2017 (value 122)	**50** (out of 100)
Ranking	**21** (out of 141) vs. 2018 22 (out of 140)	**21** (out of 129) vs. 2018 21 (out of 126)	2018: **9** (out of 28) vs. 2017 10 (out of 28)	**9** (out of 35) vs. 2018 11 (out of 35)
EU-28 comparison	7 (out of 28)	13 (out of 28)	2018: 9 (out of 28) vs. 2017 10 (out of 28)	6 (out of 17)
Number of countries	141	129	28	35
Number of individual indicators	103	80	27	38

Source: World Economic Forum (2019); Cornell University, INSEAD and WIPO (2019); European Commission (2019b); BDI et al. (2020); own graphic.

28 See Council for Research and Technology Development (2019a).
29 See World Economic Forum (WEF) (2019).
30 See Cornell University, INSEAD and WIPO (2019).
31 See European Commission (2019b).
32 See Federation of German Industries (BDI) et al. (2020).

previous year (see Table 1-7). The countries placed higher scored between 76.7 (Israel) and 84.8 (Singapore), meaning that Austria was only a tenth of a point off the world's top 20. The best performers behind Singapore were the USA (83.7) and Hong Kong (83.1). Leading the European field, meanwhile, were the Netherlands (82.4), Switzerland (82.3) and Germany (81.8). Austria's performance in a number of individual indicators has been particularly impressive. In the "Macroeconomic stability" sub-index, for instance, it achieved the highest score (100 out of 100) and thus claimed first place. The country also enjoys a very good position in the areas of "Infrastructure" (89, 10th) and "Innovation capability" (74, 14th). Other areas, however, require significant improvement, such as "ICT adoption" – comprising the sub-indices "Mobile-cellular telephone subscriptions per 100 population", "Mobile-broadband subscriptions per 100 population", "Fixed-broadband internet subscriptions per 100 population", "Fibre internet subscriptions per 100 population", and "Internet users as a percentage of the adult population" – in which Austria is placed 50th in an international comparison. The government has responded to this mediocre performance in key areas of digitalisation with appropriate measures, including defining a "Digital Roadmap" and launching the "Broadband Austria 2020" initiative.

The Global Innovation Index (GII) reflects countries' innovation capability. Updated annually, this overview comprises indicators such as infrastructure, market and entrepreneurial development, knowledge and technology output, and creativity output. Austria retained 21st place between 2018 and 2019 with only a minimal change to its overall score (51.32 in 2018; 50.94 in 2019) (see Table 1-7). Leading the field are Switzerland (67.24), Sweden (63.65) and – up from sixth place – the USA (61.73). The Netherlands dropped out of the top three, falling from second in 2018 to fourth in 2019 (61.44). In terms of the individual indicators, Austria's performance in this index was very strong in the area of "Tertiary Education" (3rd), "Research & Development (R&D)" (18th) and "Knowledge Workers" (17th). The country also came 25th in the two lower-level sub-indicators of knowledge and technology output and creativity output, putting it on the fringes of the leading group of countries. Austria's performance was much poorer in the areas of "Investment" and "Knowledge Diffusion" – which are based on information on market capitalisation, on venture capital finance and exports of ICT services and on foreign direct investment – as it came in 81st and 40th respectively in an international comparison.

The European Innovation Scoreboard (EIS) is a way to analyse and compare the research and innovation performance of the EU-28 countries and selected non-member states based on 27 input and output indicators. Austria climbed from tenth to ninth between 2017 and 2018 and retained its membership of the group of "Strong Innovators" together with (in order of ranking) Luxembourg, Belgium, the UK, Germany, Ireland, France and Estonia (see Table 1-7). The EIS classifies the best performers as "Innovation Leaders", a group that comprises Sweden, Finland, Denmark and the Netherlands. Luxembourg and the UK dropped out of this group in 2018, having been members in the previous year.

Austria's innovation performance has improved since 2011 according to the EIS (from 113 points to 125 points in 2018). In terms of individual dimensions of innovation, Austria's strongest area at present is "Linkages", where it is in first place ahead of Belgium. This sub-index includes collaboration between innovative SMEs, public-private co-publications and private funding to cover R&D expenditure by the public and higher education sectors. Austria's eighth place in the "intellectual assets" sub-index (patent and trade mark applications plus uses of designs) and the "life-long learning" (all the learning and educational activities of 25- to 64-year-olds) sub-index suggests that key targets in the federal government's RTI strategy[33] for sustainable growth and increased efficiency are being met. In other areas, however, Austria

33 See Federal Chancellery (BKA) et al. (2011).

has some catching up to do, especially with regard to venture capital expenditure, the percentage of the population employed in fast-growing companies, and exports of knowledge-intensive services.

In the "Innovation Indicator", an international comparison published by the Federation of German Industries (BDI) together with the Fraunhofer ISI and the Leibniz Centre for European Economic Research (ZEW), Austria is currently in ninth place (out of a total of 35 countries). This puts it ahead of strong innovators such as South Korea and Finland. Although Austria's indicator score of 50 points (out of a possible 100) in the "Innovation Indicator 2020" is unchanged on its performance in the "Innovation Indicator 2018", it has gone up two places in the country rankings.

In the overall analysis, Austria's technological and scientific performance and innovation capability put it in a strong midfield position globally. Although the country has not yet managed to break into the group of Innovation Leaders overall, it has enjoyed a top position among the Strong Innovators for some time now. Here too, however, Austria is already amongst the leaders when it comes to individual indicators such as R&D intensity. This suggests that efforts to pursue the RTI strategy on an on-going basis should continue in order to achieve a balance between input and output factors and focus even more strongly on input than has been the case to date.

1.2.2 Development of Austria's position in terms of digitalisation

As in the Austrian Research and Technology Report 2019, the European Commission's Digital Economy and Society Index (DESI)[34] and Global Innovation Index[35] are used as the basis for comparison in order to gauge Austria's standing in the digitalisation rankings. These two data sources are well suited to a comparative analysis of developments in digitalisation as they contain very detailed information on the availability and use of information and communication technologies and their employment in industry, business and administration. This information also allows countries to be compared on specific aspects of digitalisation.

The following section assesses Austria's position within the EU based on the DESI index with its five dimensions of Connectivity, Human Capital, Internet Use, Integration of Digital Technology and Digital Public Services. An indicator is calculated, analysed and compared for each dimension. These overarching indicators are composed of several sub-indicators; the box below shows the make-up of each indicator. Countries can also be compared at sub-indicator level.

Indicators and weighting of the Digital Economy and Society Index (DESI) 2019

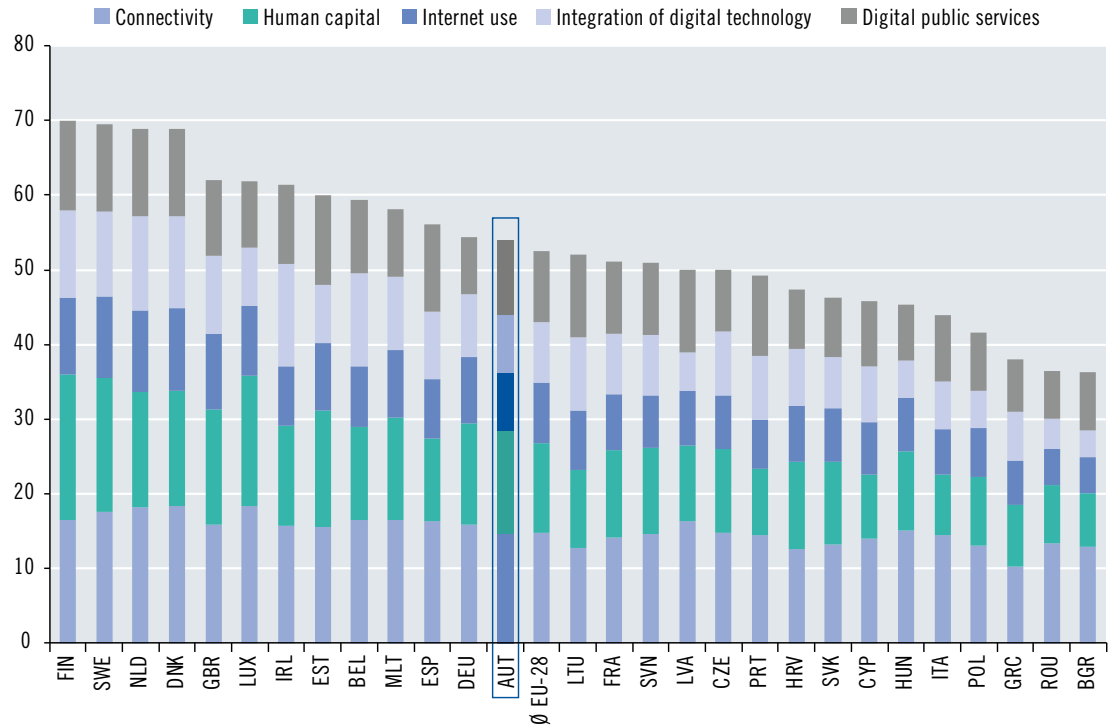
- **Indicator 1: Connectivity**
  Connectivity is calculated as the weighted average of the following five sub-indicators: landline broadband (18.5%), mobile broadband (35%), fast broadband (18.5%), ultra-fast broadband (18.5%) and a price index (9.5%).
- **Indicator 2: Human capital**
  Human capital is calculated as the weighted average of two sub-indicators: basic knowledge of internet use (50%) and advanced skills (50%).
- **Indicator 3: Internet use**
  Internet use is calculated as the weighted average of the following three sub-indicators: use of content (25%), communication and online activities excluding transactions (50%) and online transactions by citizens (25%).
- **Indicator 4: Integration of digital technology**
  Integration of digital technology is calculated as the weighted average of two sub-indicators: the digitalisation of firms (60%) and e-commerce (40%).

34 See European Commission (2019f), (2019d).
35 See Cornell University et al. (2019).

■ **Indicator 5: Digital public services**
This dimension encompasses electronic government services in administration (80%) and electronic data processing in the healthcare system (20%).

These five indicators make it possible to compare the EU 28 countries (see Fig. 1-16). Austria ranks 13th when the countries are compared using the cumulative result of all five dimensions.[36] This means that, despite a slight improvement (see Table 1-8), Austria is only marginally above the EU average of 52.5 with a score of 53.9 (out of a possible 100). The field is led by the Nordic countries of Finland, Sweden and Denmark alongside the Netherlands. Very little separates these countries in the index. Austria is around fifteen points off this group in the index and just under ten points behind the UK in fifth.

Fig. 1-16: Digital Economy and Society Index, 2019



Source: European Commission (2019f). Graphic: iit.

Table 1-8: Trend in the DESI indicator in Austria and comparison with the EU average

	Austria		EU average
	Ranking	Value	
DESI 2019	13	53.9	52.5
DESI 2018	12	51.9	49.8
DESI 2017	12	49.2	46.9

Source: European Commission (2019f).

36 The online analysis tool for the DESI index on the European Commission website allows users to change the weighting of the five dimensions. Fig. 1-16 shows the score produced by applying the following weightings: indicators (1) Connectivity and (2) Human capital at 25% each, indicators (3) Internet use and (5) Digital public services at 15% each, and indicator (4) Integration of digital technology at 20%. This weighting is used as the standard method for comparing digitalisation in different countries (see https://digital-agenda-data.eu).

Table 1-9: Connectivity (Indicator 1) in the digital economy and society index

	Austria				EU average
	DESI 2017*	DESI 2018	DESI 2019		DESI 2019
	Value	Value	Value	Ranking	Value
Fixed broadband coverage % of all households	98% 2016	98% 2017	98% 2018	11	97% 2018
Fixed broadband usage % of all households	68% 2016	71% 2017	69% 2018	21	77% 2018
4G network coverage % of all households (average of all providers)	89% 2016	97% 2017	98% 2018	8	94% 2018
Mobile broadband usage Contracts per 100 inhabitants	77 2016	83 2017	87 2018	19	96 2018
5G readiness Radio frequencies allocated as a % of total harmonised 5G frequencies	N/A	N/A	33% 2018	7	14% 2018
Fixed broadband coverage (NGA) % of all households	87% 2016	90% 2017	91% 2018	9	83% 2018
Usage of fast broadband connections % of all households	16% 2016	19% 2017	23% 2018	24	41% 2018
Ultra-fast broadband coverage % of all households		56% 2017	58% 2018	20	60% 2018
Usage of ultra-fast broadband connections % of all households	3% 2016	5% 2017	7% 2018	25	20% 2017
Broadband price index Value (0 to 100)	91 2016	91 2017	93 2018	4	87 2017

* Not all indicators in the DESI reports are updated annually; some therefore refer to the previous year. For each value in the table, the year to which the data relate is given below.

Source: European Commission (2019f). Graphic: iit.

To provide an even more detailed insight into Austria's standing in terms of information and communication technology, the relevant sub-indicators for connectivity (see Table 1-9), human capital (see Table 1-10) and integration of digital technology (see Table 1-11) are shown below. The aim is to paint a more accurate picture of the scale of technical linkages and infrastructure, people's digital skills and the degree of digitalisation at companies. Taken together, these indicators provide a good overview of the position enjoyed by digitalisation in the economy and society. Sub-indicators for internet use and digital public services from the DESI are not shown here in detail as information on internet use is presented later on using sub-indices from the Global Innovation Index.

Looking at the sub-indicators for connectivity, Austria is above the EU average for its 4G coverage, 5G readiness and fixed broadband coverage, but consistently below the average – in some cases considerably – for how much this infrastructure is used (see Table 1-7). For instance, one in three people in Austria has access to a 5G frequency, compared to the EU average of 14%. However, only 23% of all Austrian households were using fast broadband connections in 2019 (EU: 41%), while only 7% were using ultra-fast broadband connections (EU: 20%). The DESI report points to the switch from fixed to mobile broadband services as a potential explanation for this poor performance, an argument that could also be supported by Austria's high level of 4G coverage. In addition, the country's above-average broadband price index indicates relatively cheap prices, suggesting that high costs are not the reason for the low take-up.

In terms of human capital, Austria is above the EU average for all the sub-indicators assessed. This is the case for basic and advanced skills and software skills as well as the percentages of ICT specialists and ICT graduates (see Table 1-10). One noticeable aspect of the connectivity comparison is the fact that Austria possesses above-average digital skills compared with the rest of the EU even though households use comparatively fewer fixed and mobile broadband services.

Table 1-10: Human capital (Indicator 2) in the digital economy and society index

	Austria				EU average
	DESI 2017*	DESI 2018	DESI 2019		DESI 2019
	Value	Value	Value	Ranking	Value
At least basic digital skills % of population	65% 2016	67% 2017	67% 2017	8	57% 2017
More than basic digital skills % of population	35% 2016	36% 2017	36% 2017	9	31% 2017
At least basic software skills % of population	69% 2016	71% 2017	71% 2017	7	60% 2017
ICT specialists % of workers	4.0% 2015	4.2% 2016	4.4% 2017	8	3.7% 2017
Female ICT specialists % of female staff	1.2% 2015	1.5% 2016	1.5% 2017	10	1.4% 2017
ICT graduates % of all graduates	4.5% 2014	4.0% 2015	4.1% 2016	12	3.5% 2015

* Not all indicators in the DESI reports are updated annually; some therefore refer to the previous year. For each value in the table, the year to which the data relate is given below.

Source: European Commission (2019f). Graphic: iit.

Table 1-11: Integration of digital technology (Indicator 3) in the digital economy and society index

	Austria				EU average
	DESI 2017*	DESI 2018	DESI 2019		DESI 2019
	Value	Value	Value	Ranking	Value
Electronic exchange of information % of all companies	41% 2015	40% 2017	40% 2017	7	34% 2017
Social media % of all companies	19% 2016	21% 2017	21% 2017	11	21% 2017
Big data % of all companies	N/A 2016	N/A 2016	6% 2018	26	12% 2018
Cloud services % of all companies	10% 2016	11% 2017	11% 2018	23	18% 2018
SMEs with e-commerce % of all SMEs	15% 2016	16% 2017	13% 2018	18	17% 2018
Sales from e-commerce % of SME sales	6% 2016	6% 2017	7% 2018	22	10% 2018
International e-commerce % of all SMEs	10% 2015	14% 2017	14% 2017	2	8% 2017

* Not all indicators in the DESI reports are updated annually; some therefore refer to the previous year. For each value in the table, the year to which the data relate is given below.

Source: European Commission (2019f). Graphic: iit.

Austria is within the mid-range of European countries in terms of its integration of digital technology (see Table 1-11). Looking at the individual sub-indicators for this index dimension reveals three things in particular: firstly, only a relatively small percentage of firms in Austria make use of big data and cloud services. In 2018, only 6% of all Austrian companies used any big data (EU average: 12%). Cloud services (including hosting corporate databases, finance or accounting software, CRM software, processing capacity for running own software as a cloud service) were used by 11% of all Austrian companies in 2018 (EU: 18%). Secondly, Austrian companies exchange information electronically comparatively frequently (40% of all Austrian companies as against an EU average of 34%). Thirdly, e-Commerce and e-Commerce turnover are below the EU average, while the percentage of SMEs with online shops even appears to be falling. Interestingly, however, cross-border e-commerce in Austria is above the EU average, with the country possibly benefiting from its relatively small size and

its borders with other nations where people speak the same language.

Since 2001, the EU Commission has devoted an annual report – the "eGovernment Benchmark"[37] – to digital public services, which is one of the five DESI dimensions. This comparison is based on the four indicators of user-centricity, transparency, cross-border mobility and key enablers (key technological elements for online service processing). Austria has moved up three places in the current ranking and is now third out of the 36 countries studied behind only Malta and Estonia. Austria also enjoys a top position in the categories of availability and user-friendliness as well as key technologies (e.g. electronic ID cards and electronic document transfer) and can even boast maximum points in the e-delivery sub-category thanks to its "right to electronic communications with the authorities". The only area still requiring some catching-up work is the use of e-government, with Austria only just above the European average in terms of settling matters involving public authorities online.

Austria's standing with regard to the availability, use and application of ICT is presented below, including with the help of the three indicators from the Global Innovation Index.[38] As in the Austrian Research and Technology Report 2019, two indicators are assessed: (1) Availability and (2) Use of the internet, mobile broadband and data transfer.[39] These are based on data from the World Telecommunication/ ICT Indicators Database and use scores of between 0 and 100 as the values from the sub-indicators either express a percentage or are standardised. A further indicator used in addition to those presented in the 2019 report is (3) "Online creativity", which is included in the Global Innovation Index 2019. To enable internationally comparable data to be studied, this analysis is based on the registration of internet domains, the scope of entries in Wikipedia and the spread of mobile applications ("apps"). An indicator of this kind can be interpreted as a rough indication of creative work in the digital economy and openness to digital applications.

Indicators on the use of ICT in the Global Innovation Index

■ **Indicator 1: Availability of information and communication technologies**

The availability of information and communication technologies is calculated using the weighted average of five sub-indicators, each of which contributes 20% to the overall indicator score:

- landline telephone connections per 100 inhabitants;
- mobile telephone contracts per 100 inhabitants;
- data transmission to other countries (international bandwidth) in bit/s;
- percentage of households with at least one computer;
- percentage of households with internet access.

■ **Indicator 2: Use of information and communication technologies**

The use of information and communication technologies is calculated using the weighted average of three sub-indicators, each of which contributes one third to the overall indicator score:

- percentage of internet users;
- fixed broadband connections per 100 inhabitants;
- registered mobile broadband connections per 100 inhabitants.

■ **Indicator 3: "Online creativity"**

The online creativity indicator is made up of four sub-indicators:

- generic top-level domains per thousand inhabitants aged 15–69;

37 See https://ec.europa.eu/digital-single-market/en/news/egovernment-benchmark-2019-trust-government-increasingly-important-people

38 See Cornell University, INSEAD and WIPO (2019).

39 See Federal Ministry of Education, Science and Research (BMBWF), Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019).

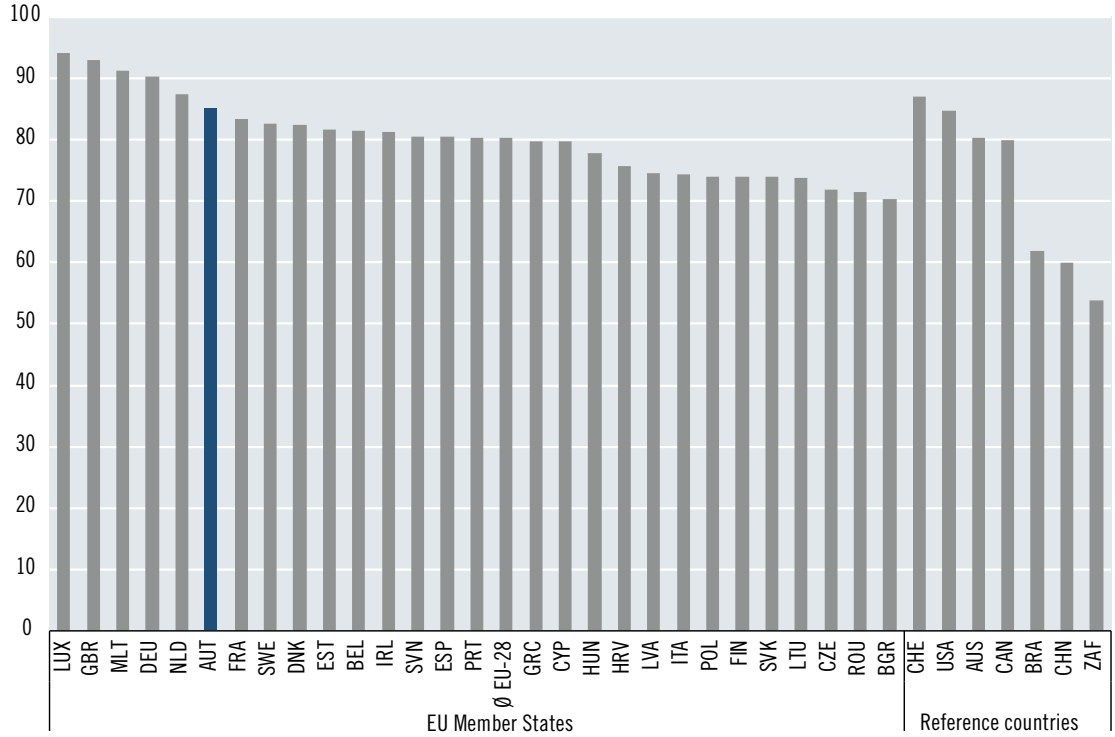
– country-specific top-level domains per thousand inhabitants aged 15-69;
– Wikipedia entries and amendments per million inhabitants aged 15-69;
– number of downloads of mobile apps by country of origin of the company developing the app (standardised by GDP).

Fig. 1-17 shows the results for ICT availability. Austria's score of 74.7 puts it seventh out of the 28 EU countries and at a similar level to Canada and the USA in terms of the non-European countries included. Given the composition of the indicator, therefore, it can be established that the number of landline and mobile telephone contracts, data transmission, computer use and Internet access are all relatively strong in Austria compared with other countries. One objective for the future might be to retain this leading international position in ICT availability.[40]

Interestingly, Austria's leading position in ICT availability does not translate into a leading position in terms of its use, with the country only 16th in the EU (see Fig. 1-18). That said, there is no significant gap between Austria and the leaders: with a score of 74.7, the country is only 5.3 points off France in sixth place in the EU rankings.

Fig. 1-19 shows the results of the international comparison for the "Online creativity" indicator. This places Austria 12th, putting it in a midfield position at EU level. Europe's leading lights are Luxembourg, the Netherlands and the Scandinavian countries. The gap between Austria with 36.2 points (out of a possible 100) and Luxembourg with 67.6 is also comparatively high, indicating that Austria definitely still has untapped potential in the creation of mobile

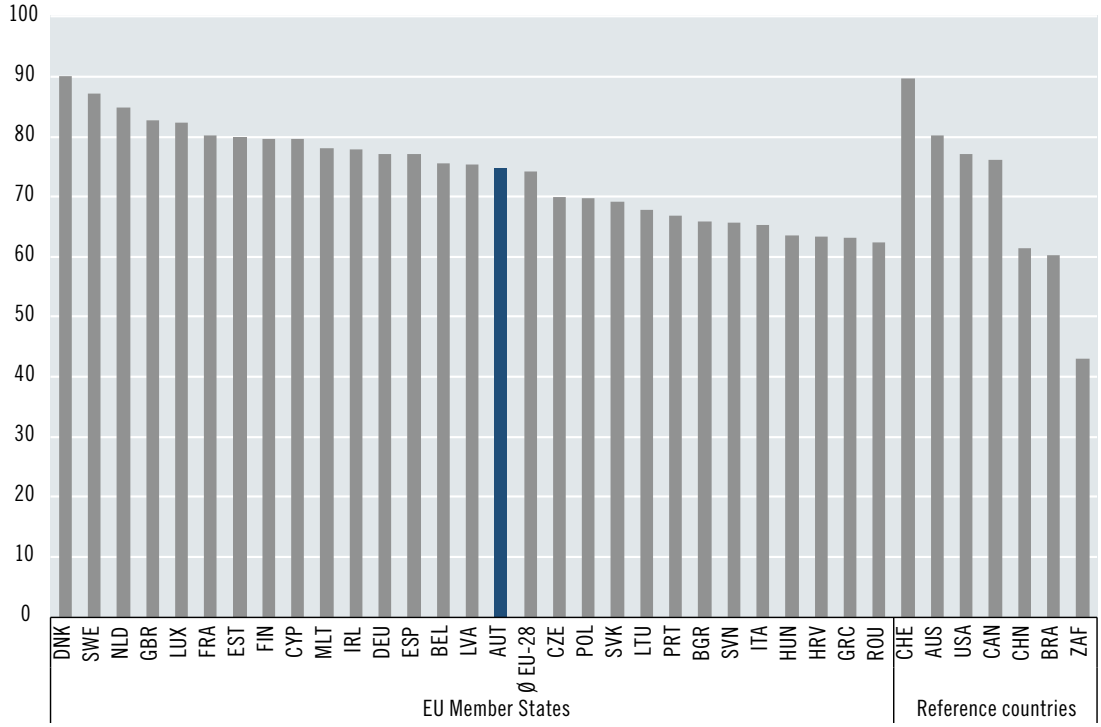
Fig. 1-17: Availability of information and communication technologies, 2018



Source: Cornell University, INSEAD and WIPO (2019). Graphic: iit.

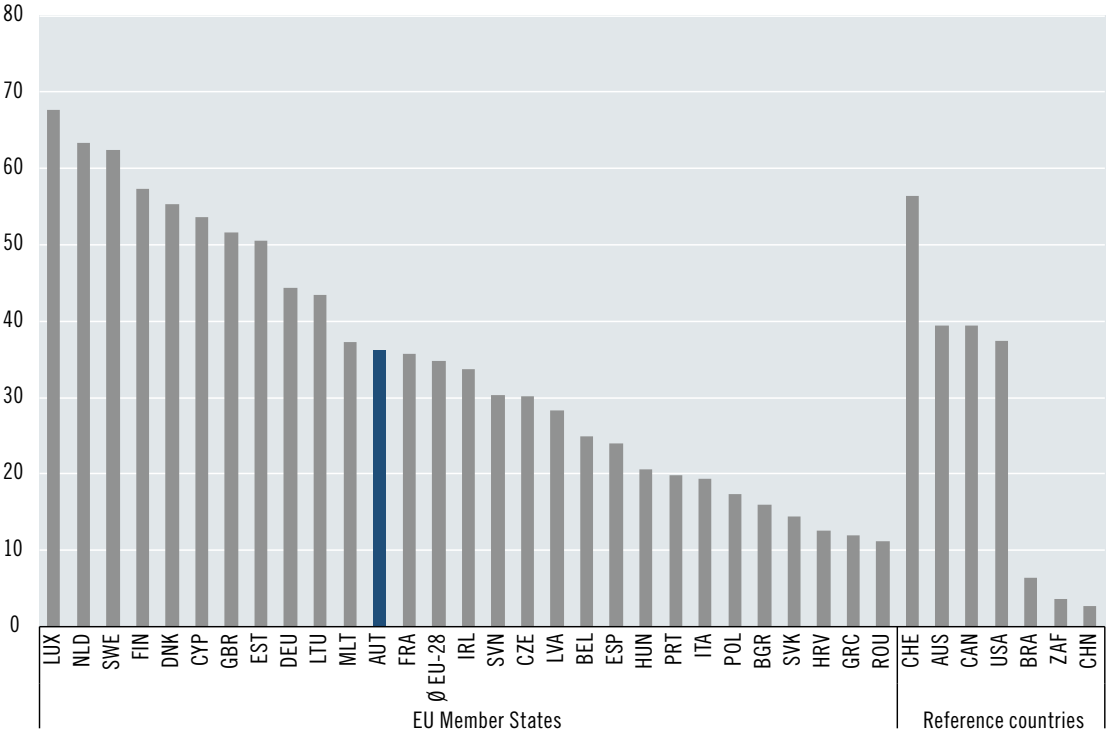
40 See Council for Research and Technology Development (2019b).

Fig. 1-18: Use of information and communication technologies, 2019



Source: Cornell University, INSEAD and WIPO (2019). Graphic: iit.

Fig. 1-19: Online creativity, 2018



Source: Cornell University, INSEAD and WIPO (2019). Graphic: iit.

apps by companies and the use of internet domains. Compared with the non-European countries included, Austria is at a similarly high level to Australia, Canada and the USA.

Overall, four conclusions can be drawn from the digitalisation indicators presented in this report: firstly, the availability of information and communication technologies in Austria is above average in an international comparison. Secondly, the use of information and communication technologies by private households in Austria is at an average level compared to other countries. Thirdly, the digital skills of people in Austria are above average in an international comparison. Fourthly, the use of big data, cloud services and e-commerce amongst Austrian companies is below average compared to other countries.

Improvements are therefore required, particularly in how society, business and industry use the opportunities presented by digitalisation. In view of the technical requirements and the skills of the general public, increasing this level in the future is a realistic objective. This is being supported by various measures at policy level, including the "fit4internet",[41] "KMU.DIGITAL",[42] "Digital Pro Bootcamps"[43] and "Digital Innovation Hubs"[44] funding programmes, which focus particularly on fostering digital transformation at medium-sized enterprises.

1.2.3 Austria's innovation capability and competitiveness

This chapter takes a look at Austria's capability to innovate and competitiveness, primarily using indicators that represent the starting point or framework for innovative activities and thus reflect the country's ability to act innovatively in the future. It thus illustrates what preconditions are already in place for Austria to achieve its aim of becoming an "Innovation Leader" and what areas of potential still need to be harnessed if it is to advance to a position of this kind.

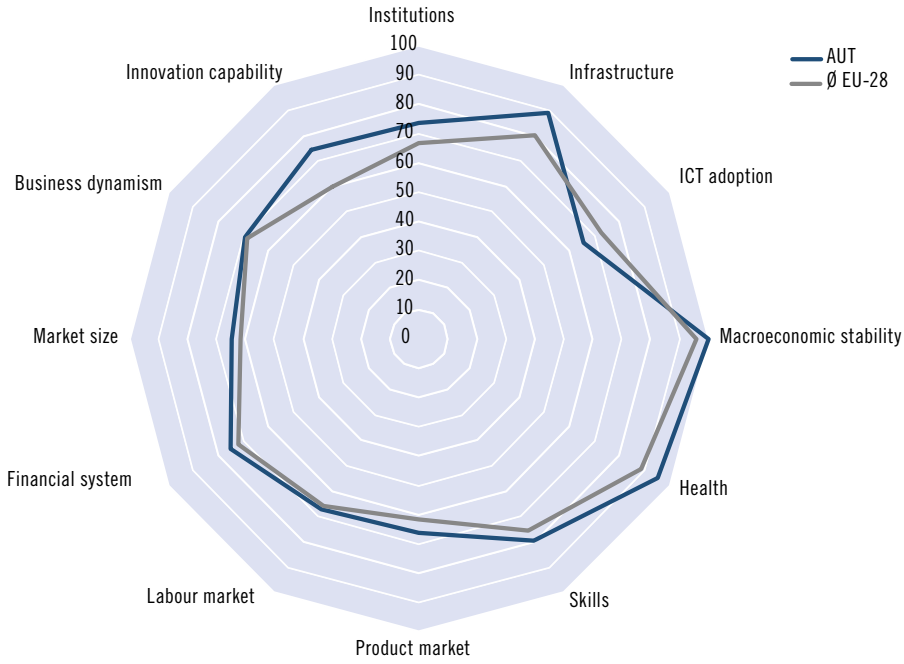
The chapter starts with an analysis of general competitiveness that draws on data from the Global Competitiveness Report before going on to examine Austria's capability for innovation based on the concept of the Innovation Capability Indicator devised by the German Institute for Innovation and Technology (iit).[45] This indicator is built on four pillars, each representing a key factor in a country's capability to innovate: (1) Human capital, (2) Complexity capital, (3) Structural capital and (4) Relationship capital. The methodology used to select indicators for these four pillars mirrors that in the Austrian Research and Technology Report 2019 in order to ensure comparability from one year to the next.[46] Some new indicators have also been included in order to complement the assessments made in the previous report in a meaningful way. The choice of indicators used depends on the availability of data and the frequency of various surveys. For instance, the European Commission's general innovation survey follows a two-year cycle, meaning that new results can only be presented every other year.

Competitiveness

The twelve abovementioned composite indicators from the Global Competitiveness Report 2019 are used to analyse competitiveness. These sub-indices are based on a total of 103 indicators from various data sources and can range from 0 to 100. The higher

41 See www.fit4internet.at
42 See www.kmudigital.at
43 See www.ffg.at/digital-pro-bootcamps
44 See www.ffg.at/dih
45 See Hartmann et al. (2014).
46 See Federal Ministry of Education, Science and Research (BMBWF), Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019).

Fig. 1-20: Dimensions of the Global Competitiveness Report: Austria's position compared to the EU 28 Member State average



Source: World Economic Forum (WEF) (2019).

a country's score for a particular sub-index, the better its performance in this dimension.

The rankings are calculated using both "hard" data and executive surveys, ensuring that a large number of countries are covered. To enable many countries to be compared with one another, the hard data is often restricted to fairly basic information that is gathered to the same extent in all the countries assessed. This means that unique features of individual countries can only be taken into consideration to a very limited degree. Survey sizes also vary from country to country. The results of the rankings should therefore be interpreted with caution on account of these limitations.

Fig. 1-20 presents Austria's position and the average of all 28 EU countries for all twelve dimensions. The results show that Austria is above the EU-28 average in all dimensions apart from the introduction and use of information and communication technologies. In terms of its capability to innovate, it infrastructure capacity and institutional situation, Austria is ahead of the EU average by some margin. The findings also indicate that more needs to be done – by both Austria and the rest of the EU – in the areas of product market efficiency (especially with regard to the complexity of customs regulations and a lack of competition caused by a handful of firms dominating the market), development of the labour market (with regard to integrating international specialists and labour productivity, amongst other things), and the introduction and use of ICT (with regard to the use of the mobile telephone and broadband network, amongst other things).

Innovation capability

The following analysis of Austria's capability to innovate is based on the Innovation Capability Indicator, which was developed by the German Institute for Innovation and Technology (iit).[47] The iit Innovation Capability Indicator defines the capability for innova-

47 See Hartmann et al. (2014).

tion as the ability to generate new content and to translate it into products, processes and services which can compete on the market. The indicator takes account of existing knowledge and human capital as well as the ability to consolidate various types of knowledge. The iit Innovation Capability Indicator comprises the following four areas or "pillars":

- **human capital**: employees' continuing education and training as well as life-long learning;
- **complexity capital**: the diversity of useful knowledge which makes it possible to produce complex products;
- **structural capital**: the ability to consolidate knowledge within a firm;
- **relationship capital**: the ability to consolidate knowledge beyond organisational borders.

The assessments are based on data from the OECD, the European Innovation Scoreboard, the Atlas of Economic Complexity and the Global Competitiveness Report by the WEF. As in the Austrian Research and Technology Report 2019, indicators that also reference non-European countries are used so that comparative statements about Austria's capability to innovate can be made at a global level. The section below explains the individual pillars that make up the iit Innovation Capability Indicator, describes the indicators behind the various assessments and presents the results.

Human capital

Human capital is defined as the sum total of all knowledge and skills within the population that can be put to use in the production process. This includes formal educational and training qualifications as well as informal knowledge and skills. In other words, rich veins of human capital can also be particularly fertile sources of research and innovation.

The focus below is on human capital in society, which is crucial for the innovation capability. This is represented by two indicators: firstly, the percentage of the population with tertiary education is analysed and compared in order to quantify the proportion of potential employees with higher education degrees. This is because, theoretically speaking, tertiary education empowers people to innovate to a greater extent than other educational pathways. Secondly, another indicator reports on graduates in STEM and ICT subjects in order to provide a separate analysis of high-tech skills, which are particularly important – especially given the onward march of digitalisation. An excursus discusses social mobility in Austria and how it might influence capability to innovate. The degree of social mobility in a society determines the extent to which its available human capital can be tapped. Socially righteous societies utilise all their talents, which boosts their capability to innovate. Austria's social mobility is analysed using the World Economic Forum's Global Social Mobility Index,[48] whereas the first two human capital indicators are taken from the OECD's "Education at a Glance 2019" report.[49]

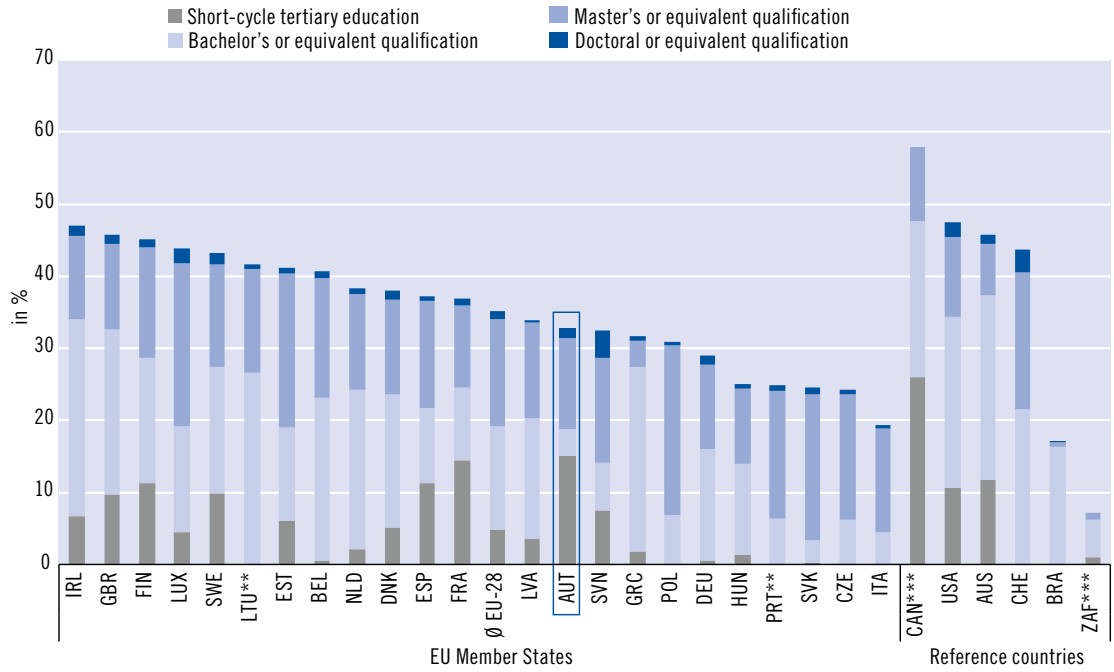
Fig. 1-21 shows the percentage of 25- to 64-year-olds with a tertiary education degree. This includes both "short-cycle tertiary education" (e.g. a degree from a College for Higher Vocational Education (BHS) or a university or other higher education institution course) and bachelor's and master's degrees and equivalent qualifications as well as PhDs. Austria's score of 33% puts it in the mid-range in an international comparison. Degrees from short-cycle tertiary education make up nearly half of these, at 15%. The clear leaders in the international comparison, taking account of all tertiary education degrees, are Canada (58%), the USA (47%) and Australia (46%). Note that the comparative quantitative presentation of tertiary education should not be interpreted as the qualitative difference between the education systems of the various countries.

Digitalisation is helping to transform the activities

48 See World Economic Forum (2020b).

49 See OECD (2019a).

Fig. 1-21: Percentage of 25- to 64-year-olds with tertiary education, 2018



* Country data not available for the reference year: CYP, HRV, MLT, ROU, BGR, CHN.
** Country data not available for the reference year (short-cycle tertiary education).
*** Country data not available for the reference year (doctoral or equivalent education).

Source: OECD (2019b). Graphic: iit.

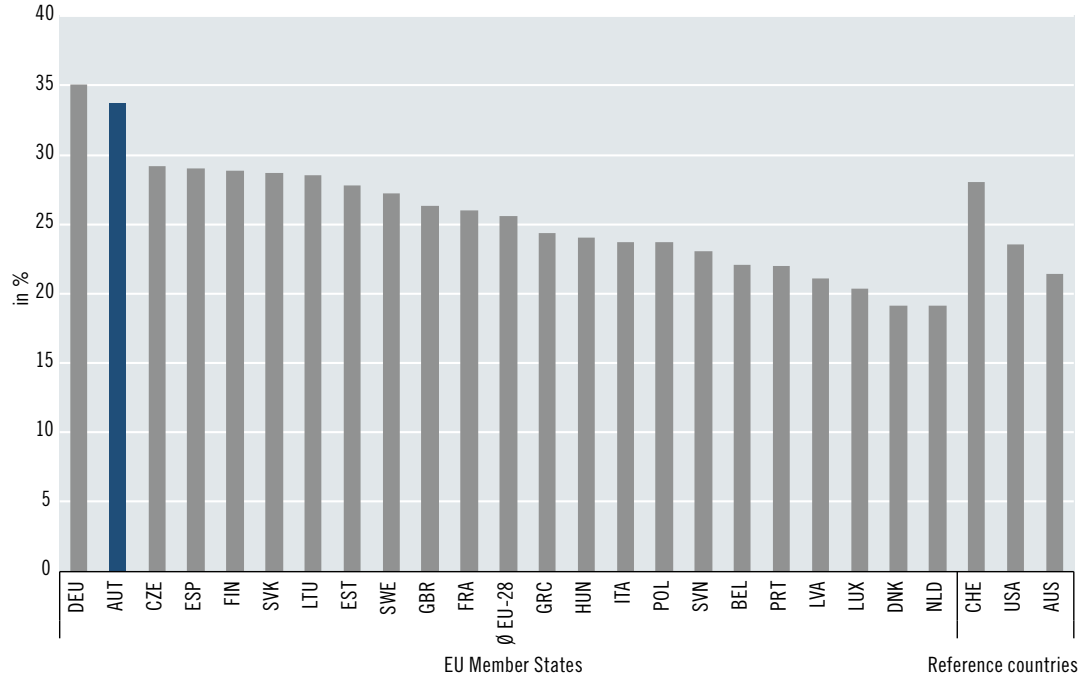
and content that jobs involve as well as the qualifications and skills they require. This would suggest that the demand for workers with a scientific and/or technical education will also increase in the future. With this in mind, Fig. 1-22 shows the percentage of graduates with a tertiary-level STEM or ICT degree. Austria enjoys a leading position amongst the countries included here and, with 34% of its graduates holding degrees in STEM and ICT subjects, is in second place behind Germany (35%).

Excursus: social mobility, human capital and innovation capability

The stock of human capital available to a society is linked to the opportunities it affords for social mobility. A high degree of social mobility allows a country to harness the full potential of its human capital: giving all citizens equal access to education, healthcare, public services and the labour market prevents talented individuals from slipping through the cracks because they are socially disadvantaged. In turn, this human capital increases the country's capability to produce innovations.

Conversely, innovations can also influence social mobility. They can empower "newcomers" to enter markets, generate economic and technological benefits and squeeze out established companies as well as helping to propagate a culture of innovation that permits more "newcomers" to challenge competitors that have been around for some time. This can trigger social mobility. In addition to increasing their inventors' opportunities for advancement, however, innovations also bring social benefits to the rest of society by increasing productivity and economic growth and thus promoting employment opportunities and fostering prosperity. Nevertheless, the relevant literature also contains arguments in favour of a link between capability to innovate and income inequality. For instance, it can be argued that innovations lead to a high level of in-

Fig. 1-22: Percentage of graduates in the tertiary sector in STEM and ICT courses of study, 2017



* Country data not available for the reference year: IRL, CYP, HRV, MLT, ROU, BGR, BRA, CHN, ZAF, CAN.
Source: OECD (2019b). Graphic: iit.

equality at the upper end of the income distribution scale in that they enable inventors to build up huge profits by having a technological edge and saving on costs while needing fewer staff.[50] All in all, there is no clear consensus in the literature regarding the precise causal mechanisms underlying the connection between social mobility and innovation capability. Nonetheless, this section presents and compares the degree of social mobility in Austria based on the assumption that social mobility unlocks potential for innovations in society.

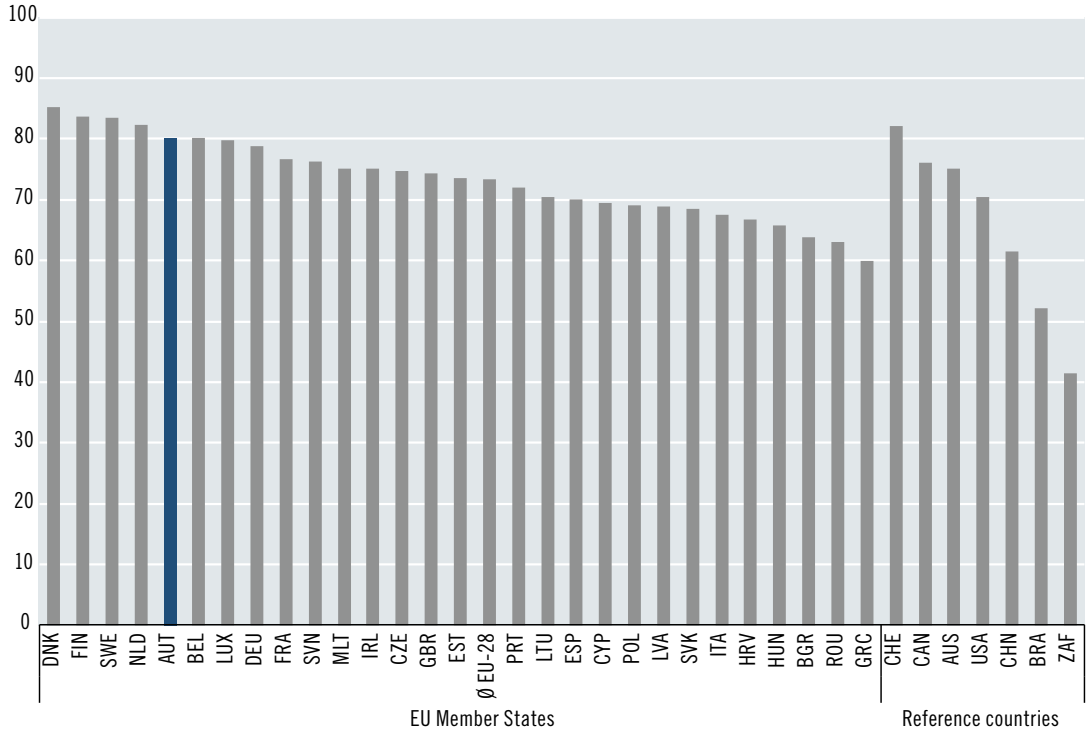
Social mobility is measured using the World Economic Forum's multi-dimensional Global Social Mobility Index.[51] This index is based on indicators from ten key areas (health, access to education, quality of education system and educational inequality, life-long learning, access to technologies, employment opportunities, income distribution, employment conditions, social protection, inclusive institutions) and ranges from 0 to 100.

Fig. 1-23 shows the scores of EU countries and the seven non-European reference countries included for comparison purposes. Austria is fifth in the European rankings behind the Scandinavian countries and the Netherlands. With a score of 80.1, Austria is well ahead of the European average of 73.4 and is only bettered by Switzerland amongst the non-EU member states.

Austria's overall position suggests that the country is essentially well placed to form human capital. Its rather mediocre showing in terms of tertiary education must be seen in the context of the Austrian education system and its unique features, particularly the strong role played by vocational education. This is not necessarily a weakness – in fact, it is often seen as one of the country's specific strengths.[52]

50 See Aghion et al. (2019).
51 See World Economic Forum (2020b).
52 See OECD (2010), OECD (2018b).

Fig. 1-23: The Global Social Mobility Index, total values, 2020



Source: World Economic Forum (2020b). Graphic: iit.

Additional data from the same OECD source on the 25- to 34-year-old age group (40% of tertiary education graduates) also indicate that the percentage of graduates with tertiary-level degrees will keep on rising.

Complexity capital

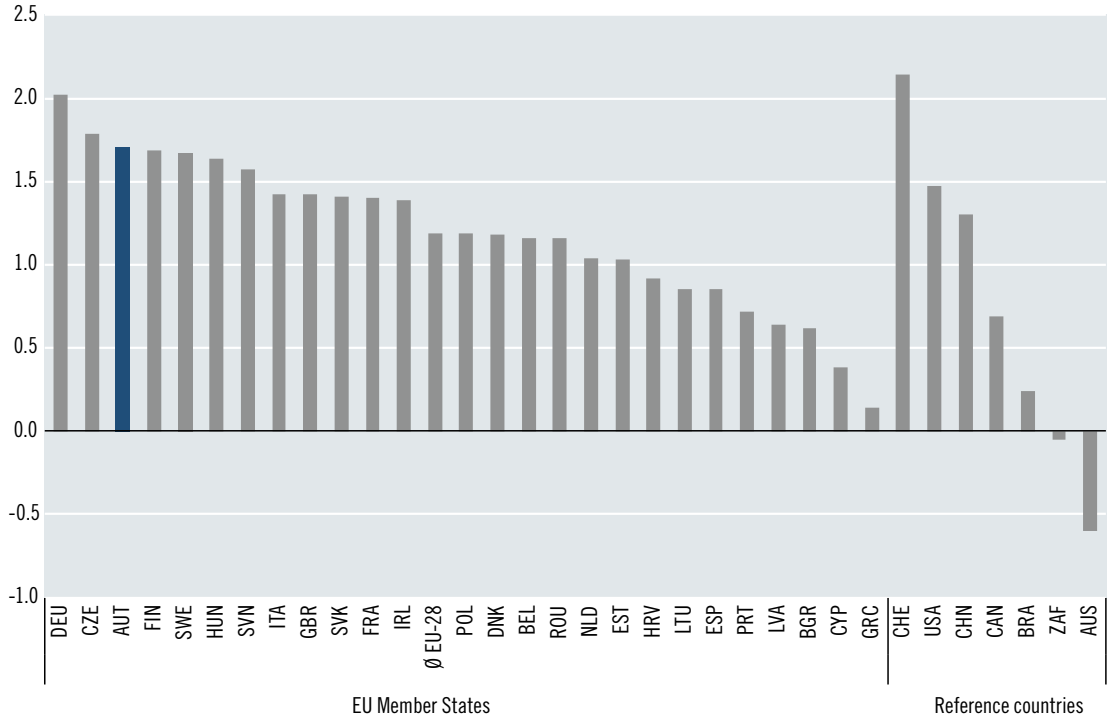
Innovation research shows that, in addition to the size of its human capital, the intensity and the diversity of a country's useful knowledge is key to its innovation capability. The iit Innovation Capability Indicator calls this heterogeneity of knowledge "complexity capital". It is calculated using the Economic Complexity Index[53] developed by scientists from MIT and Harvard University.

This index reflects how various economies specialise in terms of their goods exports in the complex products segment. In other words, an economy will be deemed economically complex if a high percentage of its total export volume is made up in particular by the kind of complex products that hardly any other country can make. If a country only exports products that (many) other countries export as well, its economic complexity rating will fall. Economic complexity can thus also be interpreted as the ability to create new products and place them on the global market. In this sense, the indicator measures a country's capability to innovate (innovative products) as well as its competitiveness (placing innovative products on the global market for a competitive price). The index is standardised and ranges from -2.5 to +2.5.

Fig. 1-24 shows Austria's position in international comparisons based on the most recently available

53 See The Growth Lab at Harvard University (2019).

Fig. 1-24: Economic complexity, 2017*



* Country data not available for the reference years: LUX, MLT.
Source: The Growth Lab at Harvard University (2019). Graphic: iit.

data (from 2017). The results illustrate that Austria has a high degree of economic complexity, coming third out of the EU-28 behind Germany and Czechia. The country also measures up well compared with the non-EU member states selected for this study. Austria's high ranking in terms of economic complexity conforms to the data on competitiveness, among others. Thus, it can be concluded that Austria is in a good position not only to generate innovations in the future, but also to successfully position itself on the international market.

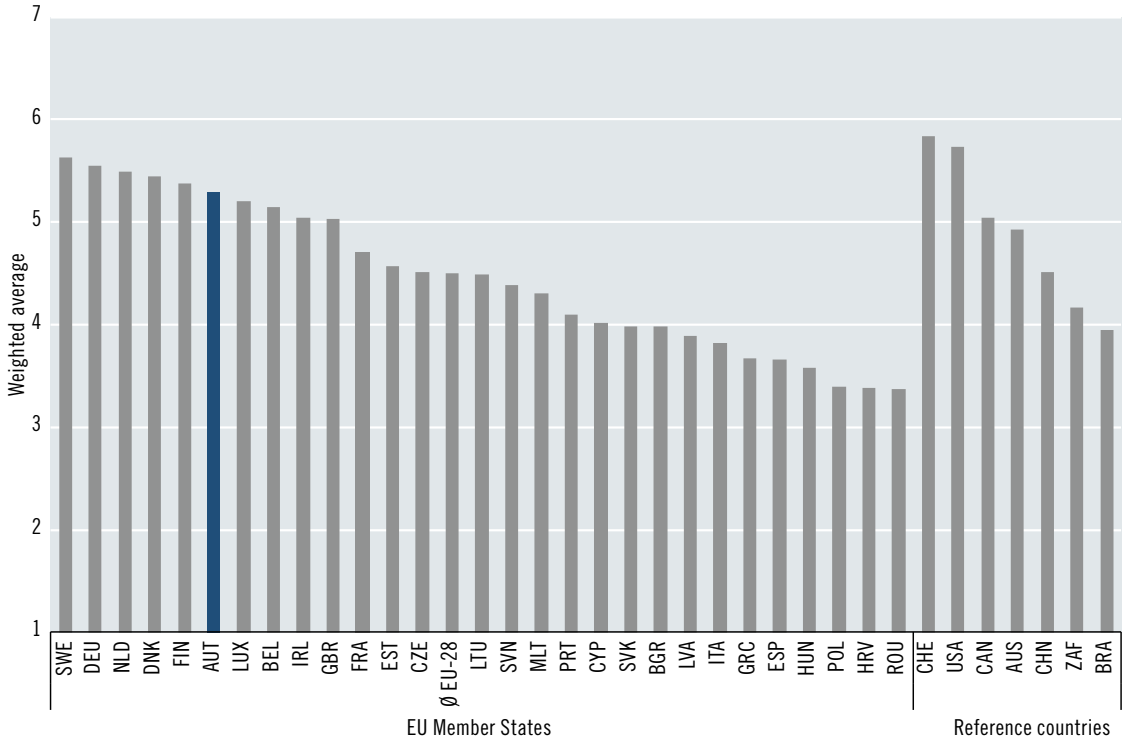
Structural capital

The potential for groups, organisations, networks or societies to produce innovations is closely linked to their capability to combine all manner of different skills, abilities and strands of knowledge. This capability is termed "structural capital" and is a characteristic feature of innovation at company or organisation level. Structural capital reflects structures and processes that bring disparate strands of knowledge together within a company and thus lay the structural foundations for innovation. This includes R&D-focused organisational units, organisational formats conducive to learning and work contexts that stimulate innovation.

The Austrian Research and Technology Report 2019 operationalised structural capital using the "Work organisation conducive to learning" indicator from the European Working Conditions Survey. This indicator records different ways of structuring work so as to promote innovation, such as autonomy at work and the opportunity to learn new things. As the latest data on the indicator are not yet available, however, two other indicators that also allow conclusions to be drawn about structures conducive to innovation are used here to measure structural capital. They are taken from the World Economic Forum and the European Innovation Scoreboard 2019.

One of the questions asked in the World Economic

Fig. 1-25: Cooperation on implementing new ideas at companies, 2019



Source: World Economic Forum (2020a). Graphic: iit.

Forum's Executive Opinion Survey, which is evaluated in the Global Competitiveness Report,[54] runs as follows: "*In your country, to what extent do people collaborate and share ideas within a company?*"

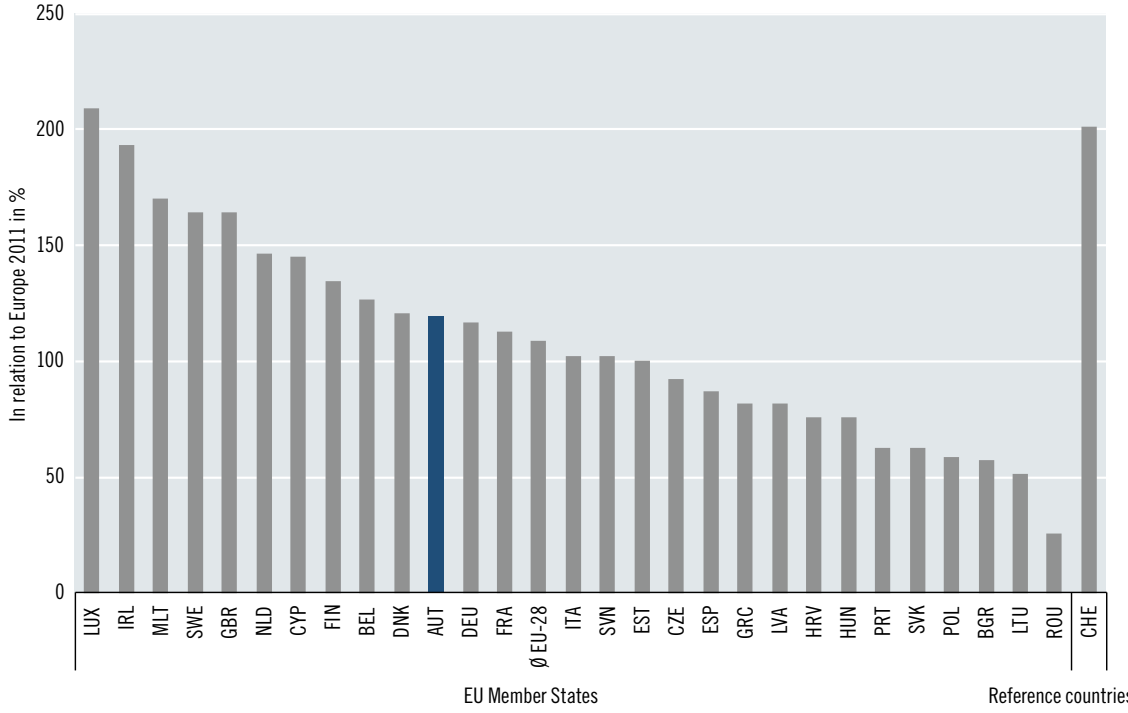
This question is an accurate reflection of the structural capital dimension outlined above, making it a suitable alternative to the data from the European Working Conditions Survey. The possible answers are given a score on a scale from one ("*not at all*") to seven ("*to a great extent*"). The mean values for each country are then calculated based on the executives' responses, as illustrated in Fig. 1-25.

The results put Austria sixth in the EU with a score of 5.3. First place in the EU goes to Sweden (with 5.6). Looking at the other reference countries included for comparison purposes, it is interesting to note that both Switzerland (5.8) and the USA (5.7) score even higher. Overall, this indicator suggests that Austrian companies are very good places to incubate ideas and innovations and that ideas are shared more effectively there than in many of the other reference countries. These results mirror the evaluation of the European Condition Working Survey presented in the Austrian Research and Technology Report 2019.

To shine more light on structural capital, the following section takes a look at an indicator on employment involving knowledge-intensive activities.[55] This indicator serves as a benchmark for the spread of knowledge-intensive work contexts that are conducive to learning and can thus also be interpreted as an indication of structural capital. It looks at how many people, as a percentage of the total workforce, were employed in economic sub-sectors employing

54 See World Economic Forum (2019), (2020a).
55 See European Commission (2019b).

Fig. 1-26: Employment in knowledge-intensive activities (comparison with Europe in the 2011 reference year), 2019



* Country data not available for the reference years: LUX, MLT.

Source: European Commission (2019b). Graphic: iit.

at least 33% academics in 2018. This percentage is then compared to the EU average for 2011.

Fig. 1-26 shows that Austria had 19% more employees in knowledge-intensive economic sub-sectors in 2018 than the EU did in 2011. Taking the EU as a whole, this figure was 9% higher in 2018 than in 2011. Austria thus boasts an above-average percentage of employees in knowledge-intensive jobs compared with the 2011 EU average. Switzerland and ten EU countries score higher than Austria.

Overall, the results indicate that, although Austria ranks above the average, a few countries have performed much better in the index. One explanation could be the relatively low percentage of the population with a higher education degree – 33% in 2018 compared with e.g. 47% in Ireland (see Fig. 1-21). This percentage is used to define knowledge-intensive sectors,[56] without accounting for the fact that people with vocational qualifications also have a major hand in making fields of activity more knowledge-intensive in countries with highly developed vocational education systems such as Austria.[57]

Relationship capital

Finally, the fourth pillar of the capability to innovate is relationship capital. Interaction amongst individuals and companies and collaboration between companies and research institutions can play a key role in generating knowledge and transferring knowledge and technology and can thus contribute significantly to the development of new products and processes. Because of the complexity of (particularly technical) innovations as well as for financial reasons, the interaction between various players is decisive when it

56 See European Commission (2019c).

57 Note that the indicator can also be influenced by the relative sizes of a country's manufacturing and services sectors. The bigger the country's manufacturing sector is relative to its economy as a whole, the lower its index score might be.

comes to driving forward innovations on a technological level and developing and launching new or improved products and technologies.

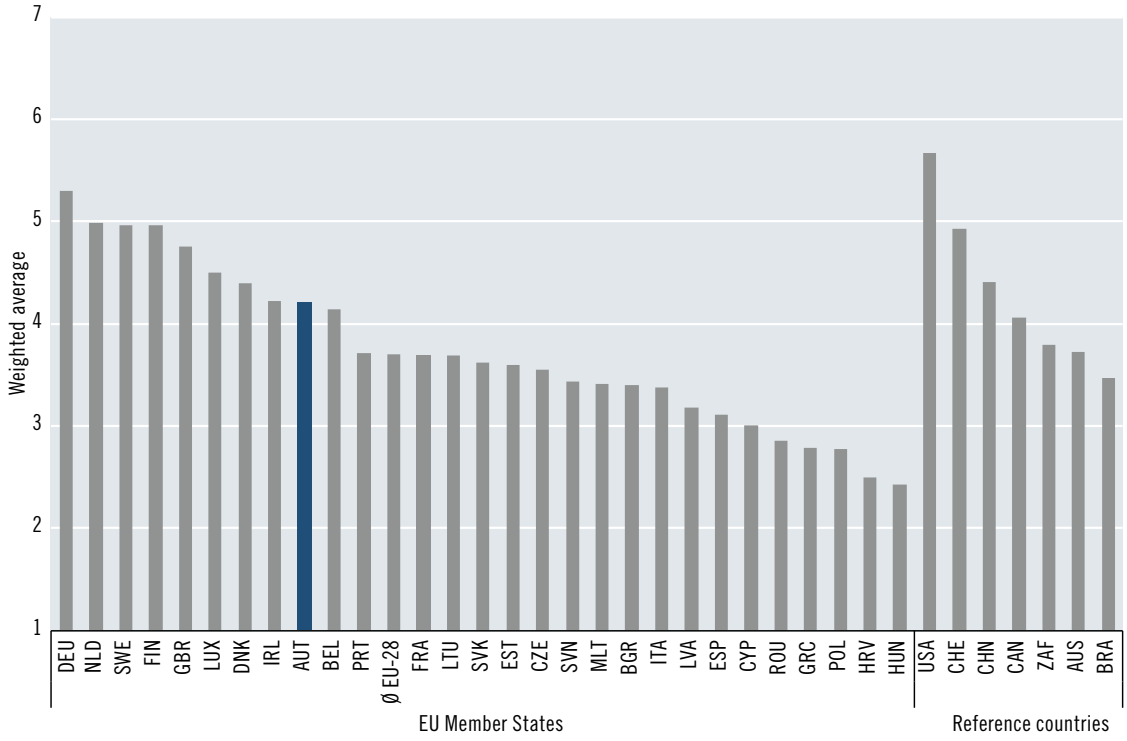
To reflect relationship capital and analyse and compare it on an international scale, this report uses two questions from the global harmonised Executive Opinion Survey conducted by the World Economic Forum:[58] *(1) "In your country, to what extent do companies collaborate in sharing ideas and innovating?"*) and (2) "*In your country, to what extent do business and universities collaborate on research and development (R&D)?"*

Both the scale of collaboration between different companies and the scale of collaboration between companies and higher education institutions are important elements of relationship capital. The possible answers are assigned a score on a scale from one ("*not at all*") to seven ("*to a great extent*"), with higher values denoting closer collaboration.

Fig. 1-27 illustrates the results for the question on collaboration between companies. It shows that Austria is ninth in the EU with a score of 4.2, while Germany is the EU's top performer with 5.3. In terms of the non-European reference countries included for comparison purposes, both the USA and Switzerland also score highly with 5.7 and 4.9 respectively. A score of 4 on the Likert scale from one to seven is to be regarded as a neutral value that indicates neither a little nor a lot of collaboration. In this respect, Austria's score of 4.2 is only marginally positive, albeit somewhat higher than the European average.

Results for the question "*In your country, to what extent do business and universities collaborate on research and development (R&D)?"* are presented in

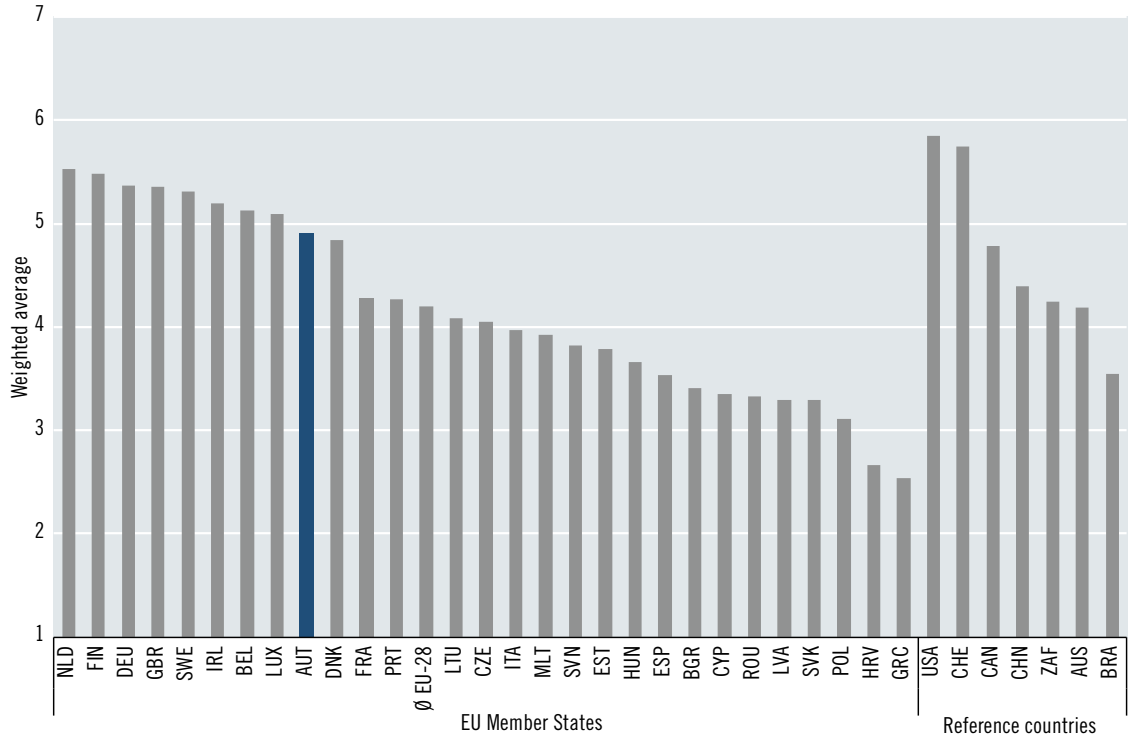
Fig. 1-27: Inter-company collaboration on ideas and innovations, 2019



Source: World Economic Forum (2020a). Graphic: iit.

58 See World Economic Forum (2020a).

Fig. 1-28: Collaboration between companies and higher education institutions on research and development, 2019



Source: World Economic Forum (2020a). Graphic: iit.

Fig. 1-28. This paints a very similar picture to the indicator for inter-company collaboration: Austria's score of 4.9 puts it ninth in the EU. However, all the EU countries are outdone by both the USA and Switzerland. The ten best-performing countries in the EU are the same for both indicators covered in this section – the only difference is the order in which they rank.[59] The findings presented here make it clear that Austria has a comparatively good level of collaboration on research and development between different stakeholders, something reaffirmed by the European Innovation Scoreboard's "Linkages" sub-index, as mentioned above. However, this sub-index looks at different dimensions. Austria's performance in all these dimensions is above average: the country boasts the fifth-highest percentage of SMEs to have R&D cooperation agreements with other companies and organisations based in the EU, the third-highest number of research articles co-authored by the public and private sector relative to its population size, and the fifth-highest private-sector funding for public-sector R&D expenditure. This gives it the highest score in the EU for in the "Linkages" sub-index.[60]

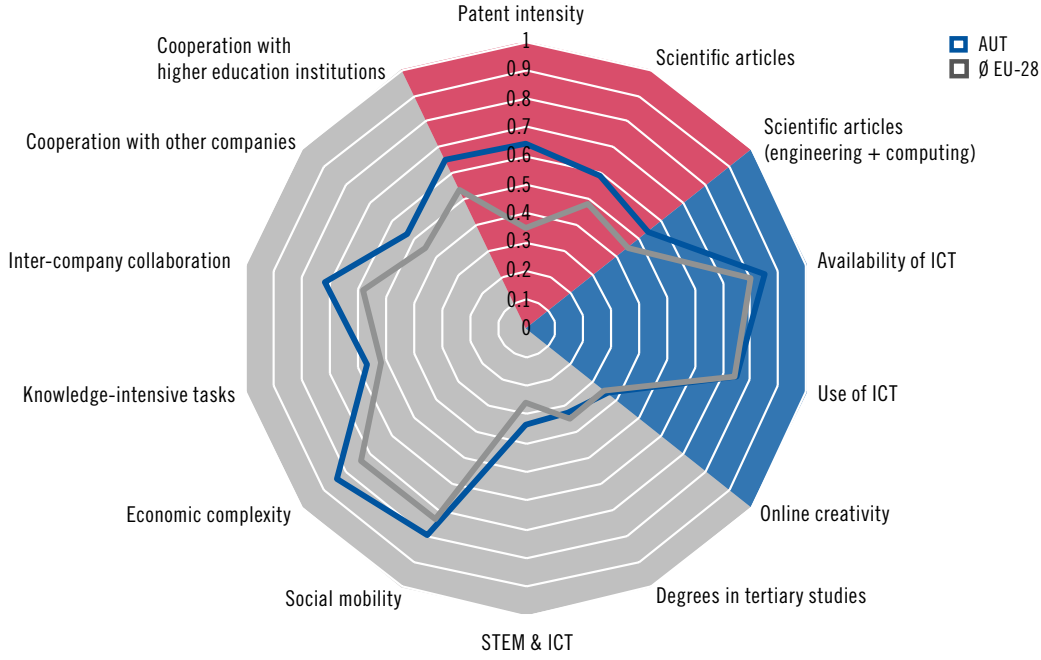
1.2.4 Summary

This chapter used various indicators to examine Austria's position in terms of its performance – i.e.

59 The indicators used here are weighted more heavily towards executives' perception of the extent to which various stakeholders collaborate, whereas the relationship capital indicators in the Austrian Research and Technology Report 2019 look at the number of actual collaborations. This leads to differences within the results: whilst the findings presented here place Austria in a good midfield position, it was considered one of the top performers in the 2019 report. One explanation for the country's different rankings could be that executives only see modest potential for increasing the scope and intensity of collaboration even though there are already many such partnerships in place.

60 See European Commission (2019b).

Fig. 1-29: Radar chart showing evaluated indicators compared with the EU-28 average



Note: RTI indicators are marked in red, digitalisation indicators in blue and innovation capability indicators in grey.
Source: Graphic: iit.

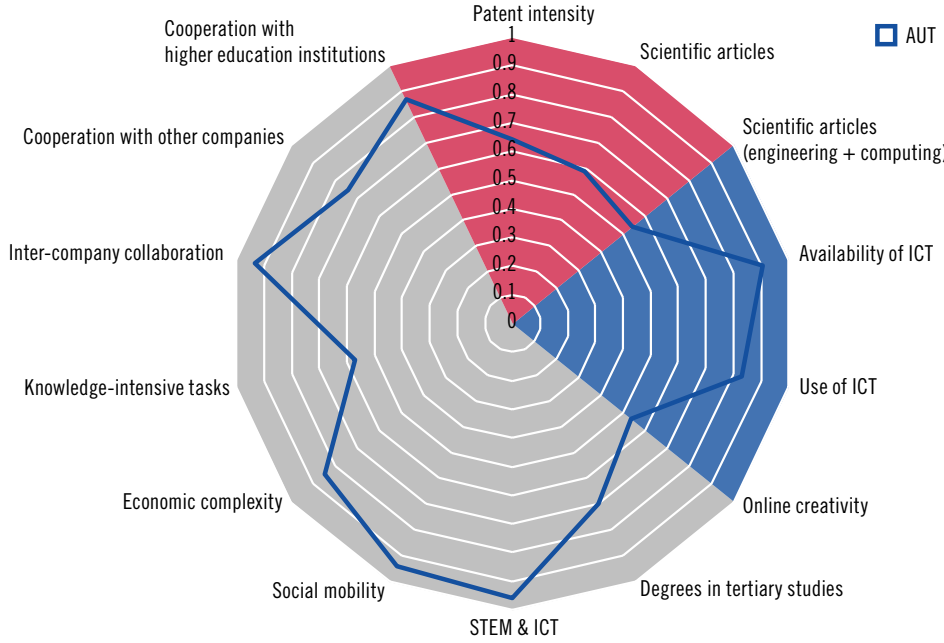
inputs and outputs – in research and development, with regard to digitalisation and its innovation capability. It revealed that Austria lies within the upper midfield range compared with the rest of Europe in terms of its research and development performance, which were analysed based on publication output and number of patent applications.

Austria is in a midfield position for digitalisation overall, although a more nuanced assessment indicates areas in which it is stronger and weaker. One of the country's particular strengths lies in the digital skills of its population, while the availability of information and communication technologies is also relatively high in an international comparison. There is potential for Austria to improve in terms of the use of information and communication technologies by its private households and the use of big data and cloud services by its companies, both areas in which it lags behind the international average.

This chapter also examined Austria's competitiveness and innovation capability. Its competitiveness was analysed based on the Global Competitiveness Report. An evaluation of this report shows that Austria performs very well in all dimensions examined – including in terms of technological maturity, political and economic circumstances and the qualification of people – and is better positioned in these areas than the average of the 28 EU countries. Austria also achieves good to very good results in the analysis of innovation capability. According to the indicators evaluated, the Austrian economy is in a position to generate complex products and processes and to establish them on a global market, the population is well educated, and firms cooperate relatively often with higher education and research institutions in an international comparison.

Fig. 1-29 summarises the international indicators assessed in this section. As the individual benchmarks use different scales, they have been standardised for the purposes of this figure so that each now ranges from 0 to 1. The RTI indicators studied in Section 1.2.1 are shown in red, the digitalisation indicators from section 1.2.2 in blue and the innovation capability indicators from Section 1.2.3 in grey. The

Fig. 1-30: Radar chart showing evaluated indicators relative to the highest value amongst the EU-28*



* Austria's score relative to the highest value in the EU-28, and percentage shares. The outer edge of the radar chart represents the highest value amongst the EU-28 in each case.
Note: RTI indicators are marked in red, digitalisation indicators in blue and innovation capability indicators in grey.
Source: Graphic: iit.

graphic illustrates the results explained above and highlights how Austria enjoys a relatively strong position compared with the EU average for many of the elements that make up its capability to innovate.

Fig. 1-30 presents an analysis of the indicators from a different perspective, showing Austria's score in relation to the highest score in the EU for each indicator. Instead of comparing Austria with the EU average, it indicates how far behind the European "champion" the country is. The graphic makes it clear that Austria is very close to the top spot, particularly in terms of social mobility and the percentage of its STEM and ICT graduates.

1.3 Austria and the EU Research, Technology and Innovation Policy

The achievements of Austrian institutions and researchers within the current European RTI Framework Programme, Horizon 2020, are outlined in Section 1.3.1. Austria's participation in the RTI Framework Programmes is a long story of success that has been continued in Horizon 2020. Now, as the end of the current, eighth programme period approaches, the total amount of funding acquired through the various programme lines has reached almost €1.5 billion.

A report on the latest developments and structural aspects of the next EU Framework Programme for Research, Horizon Europe, follows in Section 1.3.2. In comparison to Horizon 2020 there are some changes, such as the establishment of the European Innovation Council (EIC), the introduction of Missions, and the new format for partnerships, on which more detail is provided below.

1.3.1 Austria's performance in Horizon 2020

The data used for the analyses that follow are based on the reporting date of 1 March 2020; they were provided by the European Commission via eCORDA, and prepared by the Austrian Research Promotion Agency (FFG). Overall the current data confirm once again the positive achievements of Austrian institu-

tions and researchers from science and industry under the current (eighth) EU Framework Programme for Research, Horizon 2020. Since the current programme period concludes at the end of 2020, these data also allow at least a provisional overall evaluation of Austria's participation in Horizon 2020. The total amount of project funding allocated to Austria has now reached €1.46 billion.

Austria's 3,571 participations constitute a 2.9% share of the overall total of 123,701 participations in funded Horizon 2020 projects. This places Austria in eleventh position in international rankings, just behind Switzerland (3,641) and ahead of Denmark (2,931). Naturally enough the larger European countries have the highest numbers of participations in absolute terms: Germany (14,758), United Kingdom (13,304), Spain (12,568) and Italy (11,255).

The proportion of funding approvals received by Austria from the Horizon 2020 budget stands at 2.8%, approximately parallel with the share of participations. The proportion of Austrian project coordinators amongst all coordinators is 2.6% (in absolute figures a total of 735), with Austrian universities taking comparatively few coordinating roles.

With a success ratio of 18.2% in terms of participations, Austria ranks significantly above the average success ratio of 15.7% for Horizon 2020, and second only to Belgium (19.2%) amongst the member states of the European Union.[61]

The involvement of Austrian participants in individual "pillars" and their subdivisions (see Table 1-12) varies greatly according to their nature. From the budgetary perspective, the major programme areas ("pillars") of "Societal Challenges", "Excellent Science" and "Industrial Leadership" are the most significant. In this respect the largest amount of funding was acquired for Austria under Pillar III, "Societal Challenges", amounting to €564.5 million. The Austrian share under Pillar III represents 2.8% of all budgetary support for projects under this pillar. In Pillar I, "Excellent Science", €482.6 million was allocated to researchers based in Austria, corresponding to a 2.6% share in this pillar. In Pillar II, "Industrial Leadership", €370.5 million was allocated to Austria: a 3.3% share of the budget, i.e. above-average representation of this pillar in Austria, in contrast to the other two pillars. With a 2.3% share of participations and 2.3% of coordinations, Austrian contributions to the "Excellent Science" pillar are significantly below the averages for Austria under Horizon 2020, which stand at 2.9% and 2.6% respectively. The Austrian shares in the other two pillars are above average by a similar amount: "Industrial Leadership" (3.5% and 2.9%) and "Societal Challenges" (3.0% in both regards). Austria's performance in the programme line "Science with and for society" is significantly above average: here the proportion of Austrian coordinations is 11.0%, the proportion of funding acquired is 7.2% and the share of project participations is 6.1%. However, it should be noted that this programme line only has a small amount of budgeted funding (only 0.7% of the total funding is allocated to this programme line). Austrian participation is particularly low in the similarly modest funding areas of "Cross-cutting issues" (1.8% of all participations and 1.1% of all coordinations) and EURATOM (0.8% of all participations and 3.1% of coordinations).

It is under Pillar III, "Societal Challenges", that Austrian institutions have the highest levels of participations, in the thematic clusters "Intelligent, environmentally friendly and integrated transport", with 4.1% (coordinations 3.5%, and budget 3.4%) in comparison to all participations in this cluster, "Integrative, innovative and reflexive societies" with 4.0% (coordinations 2.7%, and budget 3.6%), and "Secure, clean and efficient energy" with 3.4% (coordinations 3.4%; budget 3.5%). These thematic Societal Challenges may be seen as Austrian areas of strength in comparison to the rest of Europe. Below-average level participations occur particularly in the clusters "Food safety and security, sustainable agriculture and forestry, maritime and limnological research and

61 For comparison: The success ratio for Swiss participations is 18.2%, and for US participations 18.6%.

Table 1-12: Austria's performance in Horizon 2020 according to pillars, project participations, projects, coordinations and budget

	Approved participations (all countries)	Approved Austrian participations	Austria's share (in %)	Approved coordinations (all countries)	Approved coordinations (Austria)	Proportion of projects with Austrian coordinators out of all coordinations (in %)	EU contribution (all countries, in € millions)	EU contribution (Austria, in € millions)	Austria's share of the EU contribution (in € millions)
Horizon 2020 total	**123,701**	**3,571**	**2.9**	**28,355**	**735**	**2.6**	**51,693.1**	**1,460.1**	**2.8**
Excellent Science	39,139	913	2.3	15,590	359	2.3	18,490.2	482.6	2.6
of which ERC	5,920	158	2.7	5,496	148	2.7	9,795.3	266.6	2.7
Industrial Leadership	28,425	982	3.5	5,968	172	2.9	11,096.0	370.5	3.3
Societal Challenges	51,059	1,518	3.0	6,032	180	3.0	19,811.7	564.6	2.8
Spreading Excellence and Widening Participation	1,046	34	3.3	321	1	0.3	703.4	9.9	1.4
Science with and for Society	1,576	96	6.1	164	18	11.0	326.6	23.6	7.2
Cross-Theme	795	14	1.8	184	2	1.1	403.9	6.1	1.5
EURATOM	1,661	14	0.8	96	3	3.1	861.3	2.9	0.3

Source: EC/Austrian Research Promotion Agency (FFG) as of March 2020.

bio-economy" with 2.1% (coordinations 2.3%; budget 2.1%) and "Health, demographic trends and well-being" with 2.3% (coordinations 2.6%; budget 2.1%). In purely quantitative terms, the clusters "Transport" (€155.6 million), "Energy" (€123.1 million) and "Health" (€105.9 million) are the most significant for Austria within this pillar.

It is within the "Industrial Leadership" pillar that Austrian institutions have the highest proportion of participations, particularly in the thematic clusters "Materials"[62] with 3.8% (coordinations 2.2%; budget 4.5%), and "ICT" with 4.0% (coordinations 3.9%; budget 3.5%); these industry-related themes are recognised strengths for Austria. To lesser extent this is also true for the "Advanced Manufacturing" cluster, with a participation share of 3.5% (coordinations 6.0%; budget 4.5%), and "Biotechnology", with 2.8% (coordinations 0.9%; budget 2.9%). In the "Excellent Science" pillar, Austrian institutions have an above-average proportion (3.6%) of project applicants within the programme area "Future and newly emerging technologies (FET)" (coordinations 4.5%; budget 3.3%), and in applications to the "European Research Council (ERC)" with 2.7% (coordinations 2.7%; budget 2.7%). There are comparatively low levels of participation in "Research infrastructures", with 1.9% (coordinations 3.0%; budget 1.6%). In terms of monetary value, the ERC with €266.7 million and the Marie Skłodowska Curie Actions (MCSA), with €117.6 million, are of particular relevance to Austria, despite relatively low levels of participation in the MCSA, at 2.1%.

The largest number of Austrian participations – relative to the total number – under Horizon 2020 come from the business enterprise sector (37.6%), of which almost two-thirds are in small and medium-sized enterprises (SMEs). This is followed by the higher education sector (27.9%) and the non-university research sector (23.3%). These three sectors combined make up almost 89% of Austrian participations in Horizon 2020 projects. The rest is attributable to the public sector (3.3%) and the "other" category (7.8%).

In monetary terms, €497.6 million (or 35.7%) is attributed to higher education institutions, €465.9 million (or 33.5%) to companies and €348.9 million (or 25.0%) to non-university research institutes.

62 Nanotechnologies, Advanced Materials and Production (NMP) programme.

These different types of institutions are involved to a varying degree in each programme line. In terms of funding acquired, the proportion for the Austrian higher education sector under Pillar I ("Excellent Science") is 68.4%. This can be attributed – unsurprisingly – to a high proportion of participations in European Research Council (ERC) projects, at 73.9%. However, in the programme lines FET and MCSA, the higher education sector's share of acquired funding is very high, at 70.7% and 65.9% respectively. The corresponding proportion for the non-university sector under Pillar I is 18.2%, and for the business enterprise sector, 12.3%. Within Pillar II ("Industrial Leadership") and Pillar III ("Societal Challenges") in contrast, the picture – measured in terms of acquired funding – is completely different. Under these two pillars the level of participation by the Austrian business enterprise sector is ahead of that by the Austrian non-university sector. The share of participation by the Austrian higher education sector in these two areas, in contrast, is just under 20% for the former, and approximately 20% for the latter. In terms of funding acquired, the proportion for the Austrian business enterprise sector under Pillar II is 54.5%. The corresponding share for the Austrian non-university sector is 25.5%, and for the higher education sector, 16.4%. Under Pillar III ("Societal Challenges"), in terms of funding acquired, the proportion for the Austrian business enterprise sector is 37.9%. The corresponding proportion under this pillar for the non-university sector is also comparatively high, at 29.7%. For the higher education sector the proportion of funding acquired under Pillar III is just 22.0%. In the horizontal programme area "Science with and for society", Austrian participation can be broken down by organisation type and amount of funding acquired: Higher education sector: 28.0%, business enterprise sector: 12.4%, and non-university sector: 44.3%. In the programme area "Spreading excellence and expanding participation" the proportions are 48.9% (higher education sector) and 41.5% (non-university research).

Excursus: Highlights of participation by Austrian companies in Horizon 2020

In December 2019 the Austrian Research Promotion Agency (FFG) published a "Thematic Dossier"[63], providing a more detailed analysis of the performance of Austrian companies with regard to their participation in the various different programme lines and instruments of Horizon 2020. Selected aspects of this are outlined here.

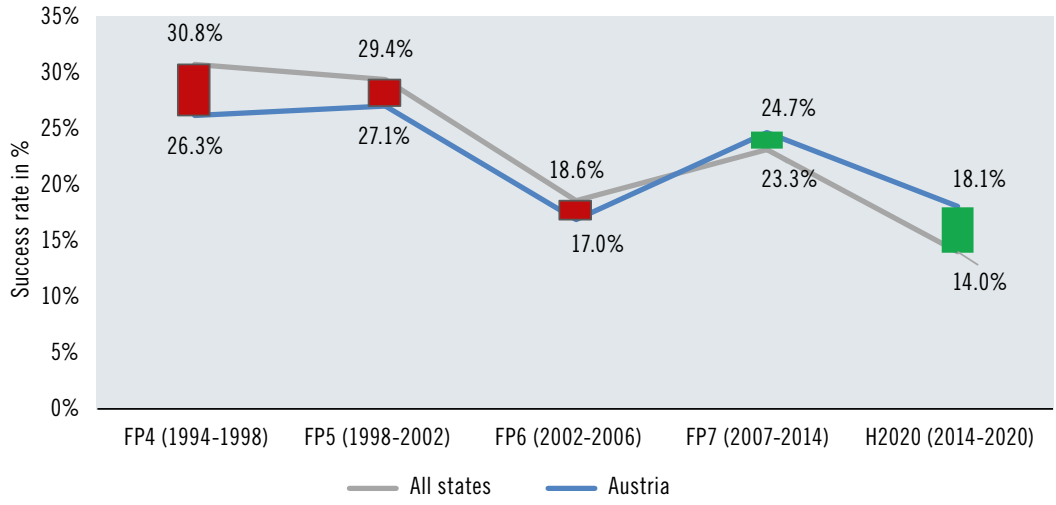
Fig. 1-31 shows the success rates of Austrian companies with their participation projects in each programme period. A general pattern emerges showing that over the first three programme periods during which Austria was involved as a full member, the lag behind success rates compared to the overall average was steadily decreased and from the 7th Framework Programme onwards an above-average success rate was achieved. In the current Framework Programme, Austrian success rates are now ahead of the average for all countries by four percentage points.

This success rate of 18.1% for Austria's companies in Horizon 2020 is the highest amongst all EU member states (just ahead of France and Belgium). Austrian SMEs are also achieving above-average success. Their success rate is 15%, placing them in second position in European comparisons, just behind Belgium (15.3%) and well ahead of the European average of 11.6%. So far around 280 Austrian SMEs have benefited from funding of around €170 million (or 42% of the total funds awarded to the Austrian enterprise sector) under Horizon 2020. The new SME instrument in Horizon 2020 has also proved attractive for Austria's SMEs. With 113 participations, Austrian SMEs received approximately €42 million through this instrument.

These successes come from approximately 500 companies that have all been successful in acquiring project participations. For comparison, in the fourth Framework Programme, during which Austria first became a full member of the EU and began to contrib-

63 See Austrian Research Promotion Agency (FFG), 2019.

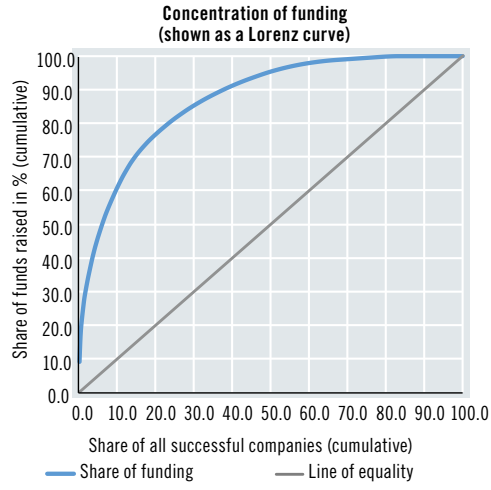
Fig. 1-31: Long-term trend in the success rates of Austrian companies in the EU's RTI policy programmes



Source: Evaluation of EU performance monitoring by the Austrian Research Promotion Agency (FFG)

ute to European RTI policy, the number of companies that successfully secured participations was only 186. Looking at the total amounts of funding acquired, it is evident that the majority of funding is awarded to a comparatively small number of highly successful companies. In fact, the most successful Austrian company is involved in 57 projects. Overall more than 60% of the funding secured goes to the top 10 companies (see Fig. 1-32). Around 33%, i.e. approximately 180 Austrian companies, are involved in more than two successful H2020 projects.

Fig. 1-32: Concentration of funding amongst the most successful companies



Source: Austrian Research Promotion Agency (FFG), 2019.

Excursus: Highlights of participation by Austrian universities and research institutions in Horizon 2020

Austria's higher education institutions and non-university research institutions are the other major players after the above-mentioned companies, as far as participation in Horizon 2020 is concerned, and in the acquisition of significant funding for research and development. Higher education institutions have had a total of 939 participations, and acquired €497.6 million in funding, with 786 (and €348.9 million) for non-university research institutions[64]. This means that 2.5% of all European higher education participations are attributed to Austria, while Austrian non-university research institutions attract 3.2% of the total for that sector. Within Austria the proportion acquired by higher education institutions is 27.9%, and by non-university research institutions 23.4%.

64 All figures in this excursus come from a special analysis by the Austrian Research Promotion Agency (FFG), based on the reporting date of 15 December 2019 (completed on 1 April 2020).

Due to the different orientation of individual programme lines, it is natural for striking differences to emerge, as far as the use of each programme by individual types of organisation is concerned. Higher education institutions focus particularly on Pillar I, "Excellent Science". In total they receive €324.7 million through this pillar (64.8% of all H2020 funding acquired by Austrian universities). Within this the European Research Council (ERC) is the largest contributor, with €200.1 million. Austrian universities are therefore evidently capable of attracting substantial funding from this particularly selective Horizon 2020 funding source for their cutting-edge research. In addition to the ERC, the "Marie Skłodowska Curie Actions (MSCA)" also play a quantitatively significant role for higher education institutions, with €74.2 million. In third place under Pillar I is "Future and Emerging Technologies (FET)", with €39.3 million.

Within the "Societal Challenges" pillar, Austrian higher education institutions receive approximately €105.6 million in funding, across 257 participations, amongst which the dominant programme lines are "Health", with €42.8 million (81 participations) and "Environment", with €14.3 million (44 participations). For universities the "Industrial Leadership" pillar plays a comparatively small role (€56.5 million in 144 participations, of which 90 are in the area of ICT).

For non-university research institutions there is a more even distribution of funding acquired across the three pillars, as a result of the broad heterogeneity of this type of institution (from institutions that concentrate on basic research, such as the Austrian Academy of Sciences (OeAW), to very application-oriented research centres). For these institutions the most important pillar is "Societal Challenges", with €156.5 million (553 participations), followed by "Industrial Leadership" with €95.5 million (200 participations) and "Excellent Science" with €81.3 million (159 participations).

As with the enterprise sector, both in the higher education institutions and in the non-university research institutions the funding acquired is concentrated on a few large and particularly successful institutions. There is actually a large number of institutions involved, but quantitatively speaking, the funds are concentrated predominantly on these few selected institutions (see Fig. 1-33).

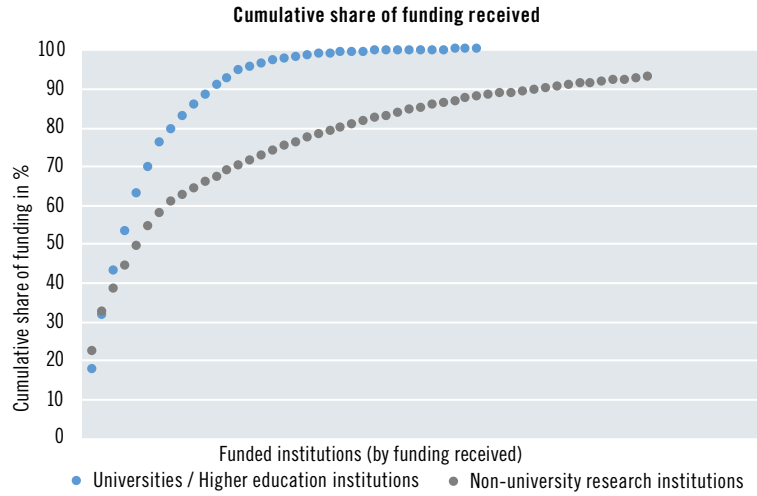
Fig. 1-33 shows that amongst higher education institutions around 63% of the total Horizon 2020 funding is awarded to the five – in absolute terms – most successful (i.e. the University of Vienna, Vienna University of Technology, the Institute of Science and Technology Austria (IST), Graz University of Technology, and the Medical University of Vienna). Amongst non-university research institutions, this concentration is less marked; the five most successful institutions (Austrian Institute of Technology (AIT), Austrian Academy of Sciences (OeAW), the VIRTUAL VEHICLE research centre, JOANNEUM RESEARCH and the Center for Molecular Medicine (CeMM)[65]) receive almost 50% of the funds.

The success rates for participation in Horizon 2020 are above the European averages both for higher education institutions and for non-university research institutions. The universities/higher education institutions enjoyed a success rate of 14.4% (compared with the corresponding EU average of 13.6%) and the non-university research institutions one of 20.0% (as against 18.8%).

One explicit goal for both Austrian and European research and technology policy is to promote collaborative research, and particularly to intensify links between the academic sector (higher education institutions and non-university research institutions) and the business enterprise sector. Over a third of Austrian projects within Horizon 2020 consist of collaborations between private enterprise (companies) and higher education institutions. These projects receive funding totalling approximately €366 million. This represents a 40.2% share of all funding, which also reflects the high level of research collaborations between these sectors in Austria.[66]

65 The Center for Molecular Medicine (CeMM) is a 100% subsidiary of the Austrian Academy of Sciences (OeAW).
66 Austrian Research Promotion Agency (FFG), 2019.

Fig. 1-33: Concentration of funding amongst institutions (universities/higher education institutions and non-university research institutes)



Note: the non-university research institutes only cover the 50 institutions receiving the most funds. Together, these 50 receive 92.8% of all funding awarded to this type of institution.

Source: Austrian Research Promotion Agency (FFG) data, own calculations.

1.3.2 The new Framework Programme

On 7 June 2018 the European Commission presented its proposal for Horizon Europe, the next Framework Programme for Research and Innovation (duration: 2021–2027). This consisted of a Regulation for the establishment of Horizon Europe, including the rules for participation and the resolution on the specific programme to implement Horizon Europe. After Member States reached agreement in the Council of the European Union on 30 November 2018 about the content of the programme, and following a series of three-way discussions, which had been initiated in the second half of 2018 under the Austrian Presidency of the Council, on 27 March 2019[67] the European Council and the European Parliament, communicating through the European Commission, agreed on a "Common Understanding" for Horizon Europe.[68] Following this political agreement, the Commission began the strategic planning process, to prepare the content of the work programme and requests for proposal submissions for the first four years of Horizon Europe.

The basic understanding between the decision makers relates to structures and content of the future EU Research Framework Programme, but at this stage without consideration of the financial provisions, since the budget for Horizon Europe is dependent on the provisions and programme of the next EU multi-annual financial framework.

Fig. 1-34 provides an overview of the configuration and structure of the pillars and programme areas of Horizon Europe.

In autumn 2018 individual Mission areas were laid out at a political level. These are:

1. adapting to climate change, including through societal transformation;
2. cancer research;
3. healthy oceans, seas, coastal and inland waters;
4. climate-neutral and smart cities;
5. soil health and food.

Five fully specified Missions are to be subsequently developed, based on these mission areas. For every mission area a high-level independent committee of

67 The European Parliament officially endorsed the agreement on 17 April 2019.

68 Information taken from the European Liaison Office of the German Research Organisations (KoWi) factsheet, July 2019; https://www.kowi.de/Portaldata/2/Resources/kowi/KoWi-Factsheet_-Common-_Understanding-HE.pdf

Fig. 1-34: Overview of the structure of Horizon Europe

<table>
<tr><th>Pillar I
Open Science
(25.8 billion)</th><th>Pillar II
Global Challenges and Industrial Competitiveness
(52.7 billion)</th><th>Pillar III
Open Innovation
(13.5 billion)</th></tr>
<tr><td>European Research Council</td><td rowspan="4">Clusters:
• Health
• Culture, Creativity and Inclusive Society
• Civil Security for Society
• Digital, Industry and Space
• Climate, Energy and Mobility
• Food, Bioeconomy, Natural Resources, Agriculture and Environment</td><td>European Innovation Council</td></tr>
<tr><td>Marie Skłodowska-Curie Actions</td><td>European Innovation Ecosystems</td></tr>
<tr><td>Research Infrastructures</td><td>European Institute of Innovation and Technology</td></tr>
<tr><td></td><td>Joint Research Centre (non-nuclear)</td><td></td></tr>
<tr><td colspan="3">Widening Participation and Strengthening the European Research Area (2.1 billion)</td></tr>
<tr><td colspan="3">Widening Participation and spreading excellence</td></tr>
<tr><td colspan="3">Reforming and Enhancing the European R&I System</td></tr>
</table>

Source: Austrian Research Promotion Agency (FFG) (2020).

experts has already been established, which is responsible for this development process, from mission areas to the specific mission programmes, with precisely defined targets. For most of the Missions this process is taking place during the course of 2020. The aim of each Mission is then to deliver tangible results with defined objectives for society, and to create public benefit for Europe.

There are a few changes compared with Horizon 2020, the eighth EU Research Framework Programme which runs to the end of 2020. The most important changes are:

- restructuring of the content while maintaining the pillar structure;
- establishment of the European Innovation Council (EIC);[69]
- new association options for industrialised non-EU countries;
- introduction of Missions;
- intention to encourage greater involvement from citizens and from organisations of civil society;
- new approach to partnerships.

Maximum possible continuity with Horizon 2020 is intended for the ERC and for research infrastructures. With the "Marie Skłodowska-Curie Actions (MSCA)", the aim is to create closer synergies in future with other programmes. MCSA Fellows will also be allowed to participate in training programmes of the Knowledge and Innovation Communities (KICs) of the European Institute of Innovation and Technology (EIT).[70]

The following section outlines three important new features: the partnerships in Pillar II, the European Innovation Council (EIC) and the European innovation ecosystem in Pillar III.

In Horizon Europe the formats and instruments used for implementation of public-public and pub-

69 The basic principles of the EIC were already created in autumn 2019, during the final phase of Horizon 2020, with the EIC Pilot. This combines existing instruments (such as FET and the SME instrument) and adds new funding instruments (e.g. Pathfinder and Accelerator). The funding instruments are open to any theme, and are directed towards market-creating innovations with the potential to lead to radically new, pioneering products, services and processes.

70 See KoWi (2019).

lic-private partnerships (previously JPIs, ERA-Nets, JTIs/JUs, EIT, Article 185 measures etc.) will be restructured under the umbrella concept of "European Partnerships". In future there will be three types of partnership with greater differentiation between them, namely: co-programmed, co-funded and institutionalised partnerships. The partnership agreements between the European Union and public or private stakeholders will play an important role in the thematic clusters of Horizon Europe.[71] In preparation for these partnerships, the European Commission carried out a consultation process in the second half of 2019 with the member states (plus Iceland and Norway). The 44 partnership candidates[72] already identified by the Commission were supplemented by four additional ones on the topics of health/antibiotic resistance, sustainable cities, shipping, and geological services. A possible new EIT Knowledge and Innovation Community (KIC) was also identified, on the theme of "Cultural and Creative Industries". Altogether this makes a portfolio of 49 partnerships for the beginning of Horizon Europe. The report on this process[73], published by the European Commission on 28 January 2020, addresses all the proposals for partnerships (both from the European Commission and from the member states). Reference was made not only to the consultation findings but also to aspects of the discussions with the member states represented in the "strategic shadow committee".

One important tool for monitoring and learning from the current partnerships is the EU project ERA-LEARN, coordinated by the Austrian Research Promotion Agency (FFG).[74] This collects data at regular intervals on P2P networks, joint calls and funded R&D projects. Data and analyses of diverse aspects of the current "partnership landscape" are published on the ERA-LEARN web portal. Since 2019 specific "Country reports" have also been produced; the first three of these (Poland, Austria, Spain" have already been published. The report verifies Austria's high rate of participation in PPP calls for proposals (second place after the Netherlands), with 259 projects financed. The limited budget was mentioned as a problematic aspect, particularly in calls on the so-called "Grand Challenges". According to the report, Austrian researchers have appreciated P2Ps as an additional source of funding, but also as a way around the highly competitive situation in Horizon 2020, and at the same time as a preparatory step towards Horizon Europe.[75]

Another new feature of Horizon Europe is the European Innovation Council (EIC) in Pillar III, which is designed to help the EU to take a leading role in pioneering, market-creating innovations.

The EIC will include two complementary programme lines:

a. "Pathfinder" for Advanced Research: The Pathfinder is based on the Future and Emerging Technologies (FET) programmes FET Open and FET Proactive under Horizon 2020. It will be open to any topic, and is intended to support high-risk and innovative technology-oriented proposals from consortia, and also from individual applicants. For this reason Pathfinder projects in particular make it possible to take ideas from basic research with high potential through to a subsequent implementation phase with support from the Accelerator.
b. "Accelerator": The Accelerator is linked to the SME instrument under Horizon 2020 and is designed primarily to support SMEs (including start-ups) and firms up to the scale of mid-caps with their potentially ground-breaking and market-generating innovations. This will be the first time that a so-called blended finance approach

71 Based on information from: https://www.kowi.de/en/kowi/news/horizon-europe-preparation-of-european-partnerships.aspx
72 See Niehoff et al. (2019). The report includes a list of proposed partnerships.
73 ibid.
74 ERA-LEARN: Strengthening partnership programmes in Europe; https://www.era-learn.eu
75 See Amanatidou (2019).

has been used within EU RTI policy. In addition to traditional grants ranging from €0.5 million to a maximum of €2.5 million, there will also be a possibility of equity funding through a specially created European fund (the EIC Fund, as a legally autonomous entity, based in Luxembourg). [76] This equity funding is optional (and not necessarily linked to grant funding, though it may be), with a maximum possible amount of €15 million. There is also a possibility of syndication with private venture capital investors. In addition, free coaching and mentoring is provided, to help companies with scaling-up and growth. This service is facilitated by the Enterprise Europe Network (EEN).

The FET flagships launched under Horizon 2020 (The Human Brain Project, Graphene and Quantum Technologies) will continue to be funded on the same basis as they have so far. However, under Horizon Europe in its current form, no further FET flagships will be funded, although the new FET flagship proposals from Horizon 2020, which are now being more fully developed with the help of a "preparatory action", will be carried over to Horizon Europe, either in the context of Missions, through partnerships or through normal calls for proposals.

In its proposal for Horizon Europe, the European Commission has also, for the first time, suggested an intervention for the development of European innovation systems under Pillar III, with a tentative budget of €500 million. Specifically this proposal anticipates bringing regional and national innovation stakeholders together, and supporting shared cross-border innovation programmes between member states and associated countries. It considers supporting measures ranging from the improvement of soft skills for innovation, to research and innovation programmes, with the aim of increasing the effectiveness of the European innovation system. These measures are intended to complement ERDF support for innovation ecosystems and interregional partnerships in the area of smart specialisation. Building on a consultation process taking place in January 2020, the findings will be used to inform the work programme for 2021.

1.3.3 Summary

The specific details of Horizon Europe are being continuously refined, and now that the exit of Great Britain from the European Union has removed an element of uncertainty, the final configuration essentially just depends on decisions about the next financial framework; meanwhile Horizon 2020 is coming to end of its term. The latest data confirm once again the positive achievements of Austrian institutions and researchers from science and industry under what is now the eighth EU Framework Programme for Research and Innovation.

Since the current programme period of Horizon 2020 comes to an end this year, the data also allow – at least on a provisional basis – a positive overall assessment of Austria's participation. Measured in terms of participations, Austria is in eleventh position in international rankings, just behind Switzerland. The total amount of project funding allocated to Austria has now reached €1.46 billion. With a success rate of 18.2% in terms of participations, Austria ranks significantly above the average success rate of 15.7% for Horizon 2020 and is second only to Belgium (19.2%) amongst the member states of the European Union. The largest volume of funding for Austria was acquired under Pillar III, "Societal Challenges", amounting to €564.5 million, a 2.8% share of the total for Europe. The largest budget share, relatively speaking, was allocated under Pillar II, "Industrial leadership", with 3.3%. With a 2.6% share of budget allocations, 2.3% of participations, and 2.3% of coordinations, Austrian contributions to the "Excel-

76 See Austrian Research Promotion Agency (FFG), 2020: Horizon Europe. 9. EU-Rahmenprogramm für Forschung und Innovation (EU Framework Programme for Research And Innovation) (2021-2027). https://www.ffg.at/sites/default/files/downloads/HORIZON%20EUROPE_FactSheet_17022020_1.pdf

lent Science" pillar are significantly below the averages for Austria under Horizon 2020, which stand at 2.8%, 2.9% and 2.6% respectively.

Austrian companies played a significant role in the country's success in Horizon 2020, making up 37.6% of all participating Austrian institutions; almost two thirds of these are small and medium-sized enterprises. Looking at the total amounts of funding acquired, it is evident that the majority of funding is awarded to a comparatively small number of highly successful companies. Overall, more than 60% of the funding secured was allocated to the top 10 companies. The most successful Austrian company is involved in 71 projects. Overall, more than 500 Austrian companies participated successfully in the Horizon 2020 programme.

In addition to the enterprise sector, it is primarily higher education institutions and non-university research institutions that are the most significant contributors to Austria's successes in Horizon 2020. The universities acquired €518.0 million in funding (predominantly in the "Excellent Science" pillar, followed by "Societal Challenges"), while the non-university research institutions were allocated €358.1 million (amongst which the "Societal Challenges" pillar was the most significant). The success rates for participation in Horizon 2020 are also above the relevant European averages both for universities/higher education institutions and for non-university research institutions. The universities/higher education institutions enjoyed a success rate of 14.4% (compared with the corresponding EU average of 13.6%) and the non-university research institutions one of 20.0% (as against 18.8%).

The next EU Framework Programme for Research, Horizon Europe, will continue the emphasis on industrial R&D and solutions-oriented research and innovation. To this end, Pillar III of Horizon Europe includes corresponding priorities such as the establishment of the European Innovation Council, with the programme lines "Pathfinder for Advanced Research" and "Accelerator", as well as an intervention to develop European innovation ecosystems.

1.4 Strategic measures, initiatives and further developments

Key structural developments such as the main points of the draft Research Funding Act and the steps towards a new RTI strategy are set out below alongside a brief status report on selected sub-strategies and current developments in the higher education sector. The timetable for other future developments will also be dependent on the progression and impact of the COVID-19 pandemic.

1.4.1 Review process for the Research Funding Act

A public review of the Research Funding Act (at the time it was called the "Research Framework Act", (Forschungsrahmengesetz), and was part of the 2019 amendment of the research framework) was carried out in autumn 2019, with many from the RTI community contributing. The key observations and criticisms from stakeholders were taken into consideration and incorporated into the draft **Research Funding Act (FoFinaG)**, which thus contains the following elements:

1. Central research institutions and research funding institutions

The Austrian system of research and research funding institutions is currently highly diverse. A select few are largely funded from the federal budget and have particular ties to the federal government; for this reason, the FoFinaG defines them as central research and research funding institutions and gives them a key role in implementing the RTI strategy in line with their responsibilities and statutory mandate.

2. The RTI Pact

With the RTI Pact, the federal government stipulates, in particular, the strategic priorities for its performance and financing agreements with the central research and research funding institutions every three years in accordance with their responsibilities.

3. Performance and financing agreements

The ministerial departments responsible for RTI then conclude three-year performance and financing agreements with the central research and research funding institutions based on the RTI Pact. By securing resources in this way, the FoFinaG provides the necessary planning certainty for Austria as a centre for RTI while also enabling new priorities to be responded to via a flexible (annual) implementation plan. In addition, the performance and financing agreements enable responsibilities to be shared out in a nuanced manner between the federal ministries and the central research and research funding institutions. Close coordination within the federal government ensures that RTI matters are structured more efficiently, reducing the administrative outlay required.

4. Funding

If Austria is to be strengthened as a leading country for research, it will need to be able to plan its allocation of resources over the long term on top of having an efficient framework. The new act thus stipulates that each of the budgetary sub-divisions relevant to non-university research and research funding are to be fixed for three years and can no longer be reduced.

5. Monitoring and evaluation

To ensure that the focus remains squarely on outcomes and impacts, performance and financing agreements are to be covered by a consistent, impact-oriented monitoring and evaluation system and the corresponding results are to be published in the Austrian Research and Technology Report, which is enshrined in law.

1.4.2 The RTI strategy and other strategic initiatives

With the RTI Strategy 2020 approaching the end of its term, the process for drawing up a new RTI strategy has already begun. The following provides an overview of the events to date.

- Presentation of the OECD Review of Innovation Policy: Austria 2018 on 14 December 2018 at the Europe conference of the Federal Ministry of Education, Science and Research (BMBWF). The review provided key input for formulating the new RTI strategy.
- Austrian government resolution 25/63 in August 2018 on "The action plan for the future of research, technology and innovation". This government resolution and the new government programme for 2020–2024 form the basis for devising a new RTI strategy; the high-level Research, Technology and Innovation Task Force (RTI Task Force, led by the Federal Chancellery (BKA) and featuring representatives from four federal ministries – the Federal Ministry of Finance (BMF), Federal Ministry of Education, Science and Research (BMBWF), Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), and Federal Ministry for Digital and Economic Affairs (BMDW)) has been tasked with preparing the RTI Strategy for 2030.
- To draft the RTI strategy, the RTI Task Force has set up a drafting group involving these ministries as well as five working groups (WGs):
  - WG 1: Research Infrastructure;
  - WG 2: Human Resources;
  - WG 3: Internationalisation;
  - WG 4: EU Missions and EU Partnerships;
  - WG 5: Applied Research and its Impact on the Economy and Society.

The RTI strategy is also incorporating the Research Funding Act and the excellence initiative. The process for determining an RTI strategy is concentrating particularly on a focus on output as well as impact, excellence and openness.

- In a further step, all ministerial departments, the social partners and numerous stakeholders were brought into the process via the drafting group and the five WGs mentioned above. The WGs held several stakeholder workshops.
- An online survey on the individual topics covered by the WGs and the topic of basic research was

conducted between 1 August and 31 October 2019.

- A special *Bundesländerdialog*, an exchange of ideas and information between the federal and regional governments, was held on 15 October 2019 and focused on "smart specialisation". Workshops and dialogue with the federal states provided further input for formulating the federal government's RTI strategy.
- The written submissions from the WGs were handed to the drafting group in late January 2020, with a draft version set to receive interministerial sign-off and be presented to the RTI Task Force by the summer of 2020.

The government programme also envisages holding an annual research summit in the future.

Implementation of the IP strategy

Back in February 2017, the federal government fully implemented or reviewed the implementation of the measures proposed in the IP strategy after two years of being in force. In the third year, the focus was on further expanding a number of offerings that had been well received, particularly in the areas of education and awareness.

(Continuing) education and information provided by the Austrian Patent Office

Two years after it was set up in spring 2018, the IP Academy, part of the Austrian Patent Office, has already held some 160 events nationwide focusing on patents, trademarks and design protection, reaching over 4,000 people in the process. Faced with the challenge of increasing the general understanding of the overall IP system in Austria to pave the way for more targeted, higher-quality IP rights applications in the medium to long term and enable companies to pursue focused IP strategies, the IP Academy is responding quite deliberately with an extensive range of seminars and workshops all about IP.

Its main target groups are students, start-ups and spin-offs but also established firms as well as research and educational institutions. The speakers are proven experts in industrial property rights, mainly technical and legal examiners from the Patent Office. As well as teaching the basics ("Introduction to the world of patent, trademark and design protection"), the programme of events for 2020 also delves deeper ("Patents Patents!", "Reading and understanding patents", "A guide to trademark protection") and addresses current issues ("Software-related patents"). Tips on searching free patent, trademark and design databases help inventors and creative types alike get their intellectual output off to a successful start.

The IP Academy is also expected to start uploading interactive videos on IP protection to its website in June 2020. The explanatory videos are designed to help students in particular gain an insight into the world of IP as early as possible in their degree.

The IP Hub online platform, also devised by the Austrian Patent Office, is the first port of call for anyone looking for specific advice or support on the topic of IP protection in their local area. The platform is enjoying steady growth and now features 23 partners offering a total of 86 services.

Technology transfer and exploitation at universities of applied sciences

Universities of applied sciences take an application-oriented approach to teaching and research, their core areas of expertise. At these institutions, research not only helps to generate knowledge. Instead, right from an early stage – when new insights are being gained – potential tangible applications are also being conceived with the aim of creating innovative products and services too further down the line. And this approach also influences teaching. It is taught to students from day one and is regarded as both a quality criterion and a USP for a university of applied sciences degree.

To exploit their potential for innovation to the full, the universities of applied sciences have been providing active support to students, graduates and employees setting up new ventures for many years now. Many institutions provide office space, infrastructure and services. This creates an innovation-friendly en-

vironment for keen entrepreneurs that has already incubated numerous start-ups now enjoying global success.

Over the past few years, the universities of applied sciences have put numerous measures in place to ensure that the results of their employees' and students' research work are handled professionally. All universities of applied sciences have set out standards governing IP rights and, in particular, service inventions in staff employment contracts and in training contracts with students based on the applicable copyright law. This allows external partners and companies to be dealt with professionally and provides a clear decision-making process for marketing issues.

In their internal process management, the universities of applied sciences rely on research institutes working closely with service facilities (e.g. Finance & Controlling, HR and Legal, Quality Management, Science Mediation and Communication) and external partners such as the Austria Wirtschaftsservice (aws). Since 2019, several universities of applied sciences across Austria have joined universities in getting involved with the knowledge transfer centres in order to make knowledge transfer at Austrian higher education institutions even more professional, expand their networks and develop them further through their joint efforts.

Consulting services offered by the Austria Wirtschaftsservice (aws)

Protecting innovation is a priority for the Austria Wirtschaftsservice (aws) in order to unlock the IP of Austria's small and medium-sized enterprises and support the companies with various funding instruments (such as grants). The Austria Wirtschaftsservice (aws) consolidated its innovation protection portfolio in 2019 and now offers companies the opportunity to bolster their resources with the *aws Innovationsschutz Beratung* advisory services (including *discover.IP* in partnership with the Austrian Patent Office), as well as coaching with *aws Innovationsschutz Coaching* and implementation help with *aws Innovationsschutz Implementierung*.

Also in 2019, the Austria Wirtschaftsservice (aws) contributed its expertise in expanding the dissemination of IP knowledge to the life-long learning seminar ("IP rights knowledge for directors and educators"), which was held at the University College of Teacher Education Vienna. As well as providing an overview of IP protection (patents, trademarks, design), topics such as copyright, data protection and privacy, and software licensing/open source software were covered in particular detail and viewed as valuable support by the participants. The topics of business model development and protection mechanisms were also addressed, with some elements covered interactively.

NCP-IP

The National Contact Point for Knowledge Transfer and Intellectual Property (NCP-IP) continued to focus on awareness in 2019, organising several events including the World IP Day 2019. Three new sample contracts relating to software (software/IT research and development agreement, software evaluation licence agreement and long-form dispute resolution clause) were added to the sample contracts database (IPAG).

Published in October 2019, the Open Innovation Toolkit (www.fair-open-innovation.at) assists people interested in launching Open Innovation processes. The toolkit was devised and made available to support the implementation of Open Innovation processes, particularly at SMEs, in collaboration with external partners such as higher education and research institutions. Users get help with making their Open Innovation process fair and efficient. The NCP-IP is to be positioned even more clearly as a supporting measure in knowledge and technology transfer in the future. Building on what the IPAG and the OI Toolkit have achieved to date, the NCP-IP is to become firmly established and more widely known as an important vehicle for bringing greater professionalism to national and international knowledge and technology transfer. At the same time, the

NCP is also an established service facility for further developing IP rights and exploitation strategies at universities and research institutions (IST Austria, Austrian Academy of Sciences (OeAW)) in accordance with their performance agreements.

Implementation of the "Strategy for the future for Life Sciences and Pharmaceuticals in Austria"

Launched in late 2016, the "Strategy for the future for Life Sciences and Pharmaceuticals in Austria" is geared towards securing and increasing the industrial and scientific competitiveness of the sector, which is important for Austria as a location. As in the previous two years, predefined measures in the nine fields of action (basic research, research infrastructures, big data, personalised medicine, clinical research, partnerships between science and industry, companies, production and market, dialogue between science and society) were continued, implemented and completed in the third year of implementation as well.

One particular priority within the remit of the Federal Ministry of Education, Science and Research (BMBWF) in 2019 was the area of research infrastructures, most notably through its efforts to extend the term of the Vienna BioCenter (VBC) Vision. The VBC Vision is a funding package for high-tech research infrastructure and its operation in order to secure the Vienna BioCenter's position as a centre of excellence for life sciences research. Set up specially for the purpose, Vienna BioCenter Core Facilities GmbH (VBCF GmbH) is a limited-liability company that operates the research infrastructures for the research institutions and biotech firms on campus and in the wider Vienna area. This initiative, which was launched in 2010 and is supported jointly by the Federal Ministry of Education, Science and Research (BMBWF) and the City of Vienna, is due to end in 2020. An evaluation in 2018 by an international committee of experts found that the VBC vision was being implemented in a very positive way and described it as a successful model for harnessing synergy effects between research infrastructures. This prompted a political coordination process between the federal government and the City of Vienna in 2019 regarding extending the VBC Vision to 2030. The necessary groundwork was also laid in terms of actually organising the funding so that an extension could be implemented in good time in the course of 2020.

At European level, the ESFRI research infrastructure "Euro-BioImaging" was set up in November 2019 following a decision from the European Commission. Austria is a founder member of this network for imaging research infrastructure alongside 13 other European countries. Austria's hub for Euro-BioImaging[77] is an "Imaging Facilities" platform run by the Medical University of Vienna, VBCF GmbH, Vienna University of Technology, the University of Veterinary Medicine Vienna, the Austrian Institute of Technology (AIT), the Research Center for Virtual Reality and Visualization (Forschungszentrum für Virtual Reality und Visualisierung – VRVis), the Ludwig Boltzmann Institute for Experimental and Clinical Traumatology and the University of Applied Sciences Upper Austria.

A 2019 highlight in the Big data field of activity was the €50 million call for proposals issued by the Federal Ministry of Education, Science and Research (BMBWF) for "Projects for digital and social transformation in higher education", which is benefiting life sciences, amongst other areas. One noteworthy example from the life sciences field is the "Austrian Neuro Cloud" project, which aims to create a standardised cloud-based system across Austria for storing, managing and evaluating neuro-cognitive research data.

Two flagship projects within the remit of the Federal Ministry for Digital and Economic Affairs (BMDW) were implemented or prepared in 2019.

One involves the Translational Research Center (TRC) for life sciences, which is responsible for creating a national project portfolio based on viable projects from universities and research institutions ac-

77 See https://www.bioimaging-austria.at/web/pages/about.php

tive in the life sciences field, screening this portfolio and selecting and further developing the most promising projects. It is now to be internationalised by setting up an international fund involving the InnovFin Equity Facility for Early-Stage (part of the European Investment Fund EIF), the Austria Wirtschaftsservice (aws) acting on behalf of the Federal Ministry for Digital and Economic Affairs (BMDW) (plus funding from the Austria Fund), and the Max Planck Foundation (MPI). The fund is managed by an experienced team of experts armed with networks of useful contacts. A local office, wings4innovation (w4i), has also been set up in Austria to create a sustainable structure and build up the necessary skills at national level. The fund is endowed with €60 million in venture capital. The full amount of the Austrian contribution (€13 million) goes towards Austrian projects, while there is also the opportunity to supplement these funds by up to €30 million from the fund's assets, which are allocated on a competitive basis.

The call for proposals for a medical engineering networking platform designed with community consensus will be launched in 2020 with the aim of developing an expert/expertise network and/or structured platform to serve as a knowledge pool for medical engineering/products for SMEs, suppliers and researchers. Priority areas include harnessing the available technical expertise and compiling and producing information material/process aids on the topic of regulation/licensing (regulations under the MDR (medical products) and IVDR (in vitro diagnostics), digital applications (AI, e-health) and product profile design as well as market opportunities and market access.

As part of efforts to fund cooperative research and support start-up projects, four new Christian Doppler Laboratories and one Josef Ressel Centre from the "Life sciences and environment" and "Medicine" thematic clusters were opened during the reporting period. In 2019, the LISA (Life Science Austria) initiative handed nine life sciences start-up projects a total of €1.75 million in PreSeed funds and seven firms with €5.2 million in seed financing. The revamped "Best of Biotech 2019" prize for life sciences (BoB, award for the best business plan) also honoured the best business ideas and plans in the three categories of biotech/pharma, digital health and medical engineering. Likewise, the Austrian Society for Molecular Biosciences and Biotechnology (ÖGMBT) presented the "Science2Business Awards" and the "Life Science Research Awards Austria 2019" in the categories of basic research, application-oriented research and outstanding research with social relevance.

Climate and Energy Fund (KLIEN)

The federal government set up the Climate and Energy Fund (KLIEN) as a "one-stop shop" in 2007. It is the only organisation in Austria that supports the entire innovation process in the areas of climate, energy and mobility, from basic research right through to market launch. It is underpinned by the Climate and Energy Fund Act[78] and owned by the Republic of Austria, represented by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK).

A mission-focused programme approach open to all types of technology spans a wide range of options for transformation right through to application. The strategy of the Climate and Energy Fund (KLIEN) is deliberately oriented towards technologies with significant growth potential in Austria and abroad. It produces solutions that have an impact on a broad scale, make the most of Austria as a location and help to protect the climate.

Evaluations

To ensure that funds are used efficiently and areas with the potential for optimisation are identified, the funding allocated must be evaluated regularly and comprehensively. The programmes that form part of the Climate and Energy Fund (KLIEN) boast a high

78 See Federal Act on Establishing the Climate and Energy Fund – Climate and Energy Fund Act (KLI.EN-FondsG), Federal Law Gazette I No. 40/2007.

degree of networking,[79] with findings from research programmes being picked up and progressed further by market programmes, for instance. And, vice versa, insights gained during implementation are fed back into research.

The key role played by the Climate and Energy Fund (KLIEN) in Austria is also becoming clear at international level, as illustrated by mentions by the OECD,[80] UNFCCC[81] and IEA[82] amongst others.

New initiatives and instruments 2019/2020 and outlook

The focus in 2019 was on continuing work on existing initiatives. One highlight during the year was the call for proposals for the "Flagship Region Energy Programme", an RTI initiative, for additional implementation projects in three selected regions: Green Energy Lab, NEFI – New Energy for Industry and WIVA P&G, the Hydrogen Initiative for the Austria Power & Gas Flagship Region. Up to €120 million in funding is set to be invested in these three flagship regions by 2021. "Digitalisation" was included as a new topic area in a call for tenders in the energy research programme (€5 million) for the first time, with the results expected in May 2020.

Outlook

The government programme for 2020–2024 describes the Climate and Energy Fund (KLIEN) as a central instrument for implementing Austria's National Energy and Climate Plan. The strategy plan is being developed further together with the federal ministry that is acting as owner, based on recommendations from national and international evaluations. The objectives are as follows:

- secure multi-year funding for the Climate and Energy Fund (KLIEN) based on the Research Funding Act;
- give greater prominence to cross-sector and cross-system issues relating to the energy and mobility transition such as digitalisation and sector coupling;
- further develop and implement large-scale trials of Austrian-made innovations under real-life conditions. Experimentation spaces[83] will enable technologies that form part of business models to be tested even if the generally applicable legal framework does not yet permit it;
- expand the funding portfolio to accelerate technology and knowledge transfer by increasing networking between research funding, environmental funding and business development as well as innovative public procurement.

International technology transfer

"Technology transfer" means the global marketing of innovative technologies from Austrian companies, especially those technologies that were developed thanks to funding from RTI programmes run by the ministerial department. Within the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), therefore, technology transfer covers all areas of technology specific to the department, such as rail, transport, healthcare, environmental and energy technologies, refuse and waste technologies, smart cities, ICT, etc. Implementing projects in these areas (e.g. renewable energy sources) harbours significant potential for making a major contribution to CO2 reduction and will help developing countries and emerging economies to achieve carbon-neutral economic growth. Large-scale technology projects in partner countries are to be facilitated by government-to-government contacts (bilateral agreements and MoUs). Technology transfer generates added value in that it promotes Austrian industry by supporting the global marketing

79 See Environment Agency Austria (2019).
80 See OECD (2018).
81 See UNFCCC (2019).
82 See IEA (2015).
83 See also Austrian Court of Audit (ACA) (2019).

of Austrian-made technological innovations, magnifies the impact of research funding and has a positive effect through exporting modern technologies to the target countries.

Technology offices as instruments of technology transfer

The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) operates three technology offices to provide local support to the export of Austrian technologies. These are in Beijing in China, Jakarta in Indonesia, and Tel Aviv in Israel.

Types of support available for the successful internationalisation of technology

Before the end of 2020, TECTRANS will be on hand to help Austrian companies become more competitive internationally with three modules: funding for studies (formerly "kit4market"), funding for pilot and demonstration facilities (formerly "tec4market") and "freedom to operate" (FTO) support – a professional analysis of how much commercial scope an exporting company is likely to have. With its established "Austrian Technology Days" format and modern website (www.tecxport.at) showcasing innovative technologies, the TECXPORT programme (Austrian Research Promotion Agency (FFG)) offers additional targeted marketing support abroad.

It is also worth remembering that having positive testimonials from Austria is a decisive factor in successfully marketing innovations abroad. The instruments offered by the Public Procurement Promoting Innovation (PPPI) initiative, for instance, can help companies through what is often a difficult phase up to the launch of their first product.

Bilateral RTI partnerships for focused positioning in selected target countries

Experience shows that bilateral RTI partnerships are a suitable instrument for positioning Austria's technological pioneers on the international stage. Employing a targeted approach, Austrian technology providers are to be given the opportunity to work on an applied research project together with foreign partners. This instrument is set to see greater use in the future in collaborations with countries that also offer significant potential for Austrian exports.

Monitoring implementation of the "Open Innovation Strategy for Austria"

In July 2016, Austria became the first EU member state to put forward a comprehensive national Open Innovation Strategy (OI Strategy).[84] Numerous activities and interventions have already been implemented since then by the ministries entrusted with implementation – the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and the Federal Ministry of Education, Science and Research (BMBWF) – as well as by stakeholders at federal, state and local level. A number of relevant implementation examples are given below:

The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) is focusing on innovation laboratories with different thematic specialisms and on test environments and test regions that provide a broad basis for generating knowledge with the involvement of stakeholders. This goes a long way towards implementing measure 1 of the OI Strategy to set up open innovation and experimentation spaces. At the same time, work is under way to make research results from funded projects available on a large scale as part of the open4innovation platform of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK), thus embed Open Data and Open Access principles in research (measure 12).

The Federal Ministry of Education, Science and Research (BMBWF) is making a key contribution to implementing measure 12 of the OI Strategy, not least with the Austrian Transition to Open Access

84 See http://openinnovation.gv.at/wp-content/uploads/2016/08/Open-Innovation-barrierefrei.pdf

(AT2OA) and e-infrastructure Plus projects, both of which relate to higher education structural funds. In addition, the continuous further development of the research infrastructure database at the Federal Ministry of Education, Science and Research (BMBWF) is producing an important information platform for establishing new partnerships in all areas of science, academia, research, the economy and industry and is thus doing much to implement measure 5, creating and operating an innovation map. This publicly accessible database allows users to find or offer research infrastructures for new cooperation projects and already features over 1,600 research infrastructures from Austria that are ready for a partnership.

The annual Open Innovation stakeholder dialogue, which is organised jointly by the Federal Ministry of Education, Science and Research (BMBWF) and the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) to monitor implementation of the OI Strategy, was given an even more interactive setting in December 2019, with possible applications of Open Innovation being explored and discussed in small groups with the help of relevant success stories. Unveiled there were the new Fair Open Innovation toolbox from the Austria Wirtschaftsservice (aws) as well as the Open Innovation Platform Salzburg together with the first crowdsourcing project launched on it by Salzburg Research and Salzburg's innovation centre ITG. ÖBB presented its group-wide innovation programme and the criteria required for it, while the Public Procurement Promoting Innovation (PPPI) service office discussed its Open Innovation challenges with participants. Finally, the Institute for Public and Nonprofit Management at JKU Linz shared its academic perspective on Open Innovation.

The federal funding agencies are important intermediaries for implementing the Open Innovation strategy through their programmes and funding activities. The Austrian Research Promotion Agency (FFG) anchors OI in existing programme lines and promotes the implementation of the OI strategy through targeted measures, such as projects including "contentXchange" or "Erdbeerwochen" as part of the Impact Innovation Programme.

The Austria Wirtschaftsservice (aws) is providing considerable support to efforts to implement measure 9 of the OI Strategy, which concerns fair sharing and remuneration models for crowdworking. The online guide www.fair-open-innovation.at, which is designed to provide a toolbox for applying fair Open Innovation processes, was completed in autumn 2019.

As a member of the international "cOAlition S" consortium, the Austrian Science Fund (FWF) has committed to publishing all research results from public funding in compliant Open Access journals or on compliant Open Access platforms. This marks a major step towards implementing measure 12 of the OI Strategy, anchoring Open Data and Open Access principles in research.

By establishing the Open Innovation in Science (OIS) Center and continuing to develop it further, the Ludwig Boltzmann Gesellschaft (LBG) has created an important interface for the practical implementation of measure 6 of the OI Strategy (building up research expertise for applying Open Innovation in science and academia).

The Institute for Advanced Studies (IHS) is investigating and supporting the reproduction of stakeholder constellations in innovation processes as part of the EU's "RiConfigure" (Reconfiguring Research and Innovation Constellations)[85] research project. Social labs, which involve stakeholders from industry, research, public institutions and civil society, are geared towards the democratisation of innovation. For instance, the IHS is working together with the ÖBB Open Innovation Lab on a social lab for mobility. Amongst other things, it is lending its support in this regard to the "Community creates mobility" project, where an open mobility ecosystem made up of organisations from industry,

85 See www.riconfigure.eu

science, academia, civil society, the start-up community and many other committed mobility-minded thinkers has been created.

The Austrian Patent Office, which manages data on hundreds of thousands of intellectual property rights such as patents, registered designs and trademarks, has prepared these data in the spirit of an Open Data initiative and made it available to a wide audience. This is another major step towards implementing measure 12 of the OI Strategy, anchoring Open Data and Open Access principles in research.

Universities and universities of applied sciences are also implementing corresponding projects with OI relevance within their field of activity.

Although these examples merely provide a rough overview of ongoing OI initiatives,[86] they illustrate a pleasing willingness amongst all stakeholder types to take action. This can be seen across the board in terms of the content of the measures defined in the OI Strategy for Austria.

Implementing the Creative Industries Strategy for Austria

The 2016 Creative Industries Strategy for Austria has three main objectives: improving the competitiveness of Austria's creative industries; fully exploiting their transformative effect on other economic sub-sectors, public administration and society; and strengthening the innovation system through innovation driven by the creative industries. These objectives are being pursued through a total of 8 fields of activity, 22 measures and 43 implementation initiatives.

Established in 2018, the independent Creative Industries Advisory Board evaluated the implementation of the Creative Industries Strategy to date in its first progress report[87] in 2019, concluding that two thirds of the measures have already been implemented or are currently under way. In the second part of its report, the advisory board suggested injecting new momentum in areas such as impact orientation, funding and mentoring, in order to address relevant issues in Austria's creative industries and guide them in a modern, sustainable and highly innovative direction.

Published in 2019, the Eighth Austrian Creative Industries Report uses relevant data to highlight the sector's increasing importance as a driver of growth and innovation: one in ten companies in Austria belong to the creative industries, which generate annual sales of €22 billion – almost 4% of the country's total economic output (nearly as much as tourism and just under twice as much as the automotive industry). A total of 153,000 people (both those employed by a company and freelancers) work at 42,300 firms. Since 2008, both the sales generated by and the number of people employed in the creative industries have grown nearly twice as fast as in the economy as a whole. The Eighth Austrian Creative Industries Report focuses on the topic of internationalisation and illustrates how Austria's creative industries are extremely successful here too, with 19% of their output exported and nearly 30,000 companies (seven in ten) involved in exports.

Continuing the internationalisation theme, Austria also signed a cooperation agreement with Israel in 2019 to work more closely together in the creative industries. The aim is to accelerate knowledge transfer between the two countries and learn from best practice models in order to strengthen the crossover effects that the creative industries have on the economy as a whole.

Internationalisation is also at the heart of the "Regional Creative Industries Alliance (RCIA)" Interreg Europe project, which is being coordinated by the Austria Wirtschaftsservice (aws) and which involves a consortium of nine European regions. It is geared towards increasing cooperation between creative SMEs and companies from other economic sectors by exchanging examples of good practice between regional strategy-focused stakeholders

86 A tabular overview of the current OI initiatives can be found in Annex I.

87 See https://www.bmdw.gv.at/Themen/Wirtschaftsstandort-Oesterreich/Kreativwirtschaft/Kreativwirtschaftsbeirat.html

and incorporating the lessons learned into regional plans of action.

Within the framework of financial support, another key element of the Creative Industries Strategy was implemented in the form of the "Creat(iv)e Solutions Call" pilot. This allows SMEs to devise new solutions for their business challenges with the help of companies in the creative industries – through process and business model innovations and the use of new methods such as design thinking. This funding is intended to propel targeted crossover innovation and transformation effects from the creative industries to the rest of the economy. In an initial round of funding, seven partnerships were handed support worth some €1.2 million. The existing "impulse XL" and "impulse XS" project funding schemes were continued, although the submission process was overhauled and simplified to reduce the administrative outlay required by companies and ensure shorter time-to-market cycles. Overall, 75 projects received impulse project funding worth nearly €4.9 million in 2019.

The partnerships that the strategy calls for between the creative industries and other industries were instigated by means of crossover workshops, which used a "matchmaking" format to bring creatives and their customers from industry together so that each could learn from the other in a process led by a moderator. Creatives can show companies how they can use the creative industries to grow their business, while designers, advertisers, architects, software developers, musicians and film-makers can get a better idea of their customers' needs and business models.

The potential for the creative industries to transform other sectors of the economy is to be tapped in new "transformation workshops". Selected SMEs from a particular industry use new innovation methods to devise solutions for their specific company with the help of hand-picked professionals from the world of design, marketing, film, photography or digitalisation. The lessons learned during the entire industry's transformation and the results of this transformation process will be edited, prepared and made available to all members of the industry as a set of guidelines.

1.4.3 Current developments in the higher education sector

Higher education institutions are key pillars of knowledge societies and perform a crucial role in the RTI system. The most relevant developments in Austria's higher education system are outlined below.

Austrian Higher Education Plan (HoP)

The Federal Ministry of Education, Science and Research (BMBWF) is currently developing a new governance instrument in order to incorporate the various recommendations by the Austrian Science Board, the Austrian Council for Research and Technology Development and the Austrian Court of Audit (ACA) regarding the comprehensive further development of the higher education system. The objectives of this comprehensive further development are to be presented in the Austrian Higher Education Plan (HoP) and include quantitative targets for the individual sectors and key priorities for all higher education sectors (universities, universities of applied sciences, university colleges of teacher education and private universities) in the years to 2030. An initial prototype is expected in 2020.

Austrian National Development Plan for Public Universities (GUEP)

The Austrian National Development Plan for Public Universities (GUEP)[88] is a strategic planning instrument for developing the public universities and a way of presenting the corresponding aims of the Federal Ministry for Education, Science and Research (BMB-

88 See https://www.bmbwf.gv.at/Themen/Hochschule-und-Universität/Aktuelles/Neuauflage-des-Gesamtösterreichischen-Universitätsentwicklungsplans-GUEP-2022-bis-2027.html

WF) in a transparent manner for a timeframe spanning a total of two performance agreement periods. It serves to provide overall structure and control to Austria's university landscape and forms the basis for university development plans and for the public universities' performance agreements.[89]

Following a consultation process involving 42 higher education institutions, the first-ever Austrian National Development Plan for Public Universities (GUEP) was produced in 2015 with a planning horizon of 2016–2021. The plan was revised in 2017 on a rolling basis for the 2019–2024 planning period in preparation for the negotiations on the performance agreements in 2018 and their conclusion in 2019–2021. The revision of the Austrian National Development Plan for Public Universities (GUEP) for 2022–2027 that is now under way was preceded by a comprehensive consultation process involving the most important stakeholders from science and research.[90] The content of this version focuses more on the Sustainable Development Goals (SDGs), STEM and digitalisation.

As the former system target 4, "Improve relevant teaching performance indicators" has been integrated into system target 3 ("Improve university teaching"), which has been expanded to "Improve the quality and efficiency of university teaching", the revised version now has seven rather than eight system targets. The developments and objectives that the Austrian National Development Plan for Public Universities (GUEP) is targeting at system level for 2022–2027 are thus as follows:

System target 1: strengthen and further develop the higher education system;

System target 2: strengthen basic research;

System target 3: improve the quality and efficiency of university teaching;

System target 4: promote the next generation of scientific and artistic talent;

System target 5: expand knowledge and information transfer and enhance Austria's benefits as a location;

System target 6: increase internationalisation and mobility;

System target 7: the universities' social responsibility – performing a service to society: gender equality, diversity and social inclusion, responsible science, the 2030 Agenda and achieving the SDGs, digital transformation.

Mobility in higher education and the internationalisation of degree studies and teaching

Formulated in 2016, Austria's higher education mobility strategy focuses on promoting high-quality transnational mobility for students, teachers and higher education staff in general. Following the first few years of successful implementation, 2019 was given over to further developing this strategy. Its focus was also expanded to include the internationalisation of degree studies and teaching, of which mobility forms an integral part.

The Federal Ministry of Education, Science and Research (BMBWF) launched a broad-based participatory process. In collaboration with the higher education institutions and all relevant stakeholders, this produced recommendations and measures in the following areas:

- internationalising the curriculum, including addressing the topic of "Joint Programmes" separately;
- promoting mobility for teachers;
- promoting mobility for higher education staff in general;
- non-traditional and innovative forms of mobility;
- promoting mobility for under-represented groups of students;
- quality assurance for mobility measures.

89 See Section 12b of the Universities Act 2002 (UG 2002).

90 A total of 37 statements were submitted on the version of the Austrian National Development Plan for Public Universities (GUEP) presented for consultation.

The higher education mobility strategy is geared towards enabling anyone involved in higher education to gain international and intercultural expertise with a high level of quality. It places particular emphasis on issues including the mobility of students from under-represented groups and complementing traditional, physical mobility with non-traditional and innovative forms.

In terms of its implementation – by the higher education institutions themselves as well as the competent ministerial departments and other stakeholders – the strategy plan must be understood as a framework that enables and encourages the acquisition of international and intercultural expertise for anyone involved in higher education in a quality-assured way, without ignoring the different profiles and needs of the institutions, fields and specialist areas (i.e. the specific context in each case).

OECD Country Review "Supporting Entrepreneurship and Innovation in Austria"

Commissioned by the Federal Ministry of Education, Science and Research (BMBWF), the OECD Country Review "Supporting Entrepreneurship and Innovation in Austria"[91] was presented to the public in November 2019 together with the OECD and the European Commission. With its report, the OECD confirms Austria's policy of driving forward innovation and entrepreneurship at its higher education institutions. During the 2019–2021 performance agreement period and even before that, the universities have been urged to address the topic of entrepreneurship – be this in their teaching, their research or their third mission. Entrepreneurship also forms an integral part of Austria's universities of applied sciences, with the entrepreneurial agenda reflected in their mission statements, diverse ranges of courses and support services.

In its review, the OECD highlights in particular the high quality and breadth of activities targeting an "Entrepreneurial and Innovation Agenda". Indeed, Austria boasts a great many examples of best practices in this regard; those cited in the review include:

- Graz University of Technology: key projects offered in the Entrepreneurial University;
- University of Graz: the "Kompetenzen Lernen Uni Graz" programme;
- NAWI Graz: strategic partnership between the University of Graz and Graz University of Technology;
- University of Innsbruck: service office for all transfer activities, interdisciplinary PhD programme;
- University of Vienna: improving interdisciplinary teaching through complementary courses and interdisciplinary research platforms;
- University of Natural Resources and Life Sciences Vienna: matrix organisation for degrees and research programmes; an "idea hub" run by students;
- University of Applied Arts Vienna: interdisciplinary course in "Cross Disciplinary Strategies";
- Complexity Science Hub set up by Vienna University of Technology, Graz University of Technology, the Medical University of Vienna, the Austrian Institute of Technology (AIT), Vienna University of Economics and Business, IIASA, the University for Continuing Education Krems and the Austrian Economic Chambers (WKO), which encourages researchers to collaborate in interdisciplinary research groups and creates new forms of organisational structure;
- Paracelsus Medical University and the University of Salzburg: as an example of how Salzburg's universities are working together to pool teaching activities;
- Vienna Children's University: cooperation between higher education institutions in the field of scientific communication;
- Vienna University of Economics and Business: NPO SE Competence Centre with a focus on social entrepreneurship;

91 See https://read.oecd-ilibrary.org/industry-and-services/supporting-entrepreneurship-and-innovation-in-higher-education-in-austria_1c45127b-en#page1

- FH Campus Wien: Startup Center, supporting student-driven innovation;
- FH CAMPUS 02 University of Applied Sciences: INNOLAB with a particular focus on SMEs;
- University of Applied Sciences Upper Austria: financing fund for start-ups.

The OECD recommends that awareness of an "Entrepreneurial and Innovation Agenda" be increased further in the future. As well as issues such as enterprise creation and IP rights, this must also focus across the board on encouraging researchers and students to adopt a positive attitude towards entrepreneurial initiatives and innovation. This entrepreneurial agenda also requires those responsible for governance to take a holistic view. Ultimately, the innovative and entrepreneurial universities and universities of applied sciences need to be seen with all their varied characteristics and facets, and this breadth and diversity also needs to be actually taken into account when developing strategies, setting targets and measuring success and impact.

Call for proposals regarding the digital and social transformation at universities

The social dimension and digital transformation are two key priorities in the performance agreements with the 22 public universities in the 2019–2021 performance agreement period. They encompass numerous projects for implementing the national strategy on the social dimension in higher education while also supporting projects and measures that are driving forward the digital transformation at Austrian universities. In particular, universities are being called on to develop and implement an institutional digitalisation strategy. To lend even more effective support in both areas, €50 million was made available explicitly for a call for proposals for cooperative projects on the topic of "digital and social transformation" as part of the university funding package for 2019–2021. Bids were invited in 2019 with the aim of supporting pioneering projects conducive to structural development that would enable new development momentum to be injected into the public university system, the university as a whole or, at the very least, multiple faculties and study programmes in a way that was visible nationwide if not internationally. The fact that preferential treatment would be given at the selection stage to projects that covered both aspects – i.e. both the digital and social dimensions – was highlighted.

The call for proposals was looking for content in the following areas:

- digitalisation in teaching and learning plus learning analytics;
- skills for the digital age – on the path to "Curriculum 4.0";
- harnessing the digital transformation to benefit the social dimension;
- Open Science;
- e-administration – digitalisation in administration.

A total of 71 projects were submitted in response to the call for proposals, with 35 being chosen following an exhaustive selection process. These are projects that will make the Austrian university system fit for the 21st century in a focused manner by opening the door to digital and/or social innovation(s). As well as their potential for innovation, they were also picked for their integration with partnerships and networks facilitating structural change, systemic impact and support for change management processes. International experts were among those who sat on the jury that made the final selection.

Two thirds of the 35 projects deemed worthy of funding (i.e. 23 projects) focused on both digital and the related social transformation, not least as the two areas often overlap closely in terms of their content. For example, digitalisation can help to reach out to those groups of individuals that are currently under-represented at higher education institutions and get them involved. In particular, this includes students with a migration background or a disability.

Just under a third of the projects funded look solely at digitalisation. Many focus on Open Science, which is designed to guarantee as much freedom as possible for accessing scientific publications and research data.

A few projects relate to university administration, often tackling the question of how administrative processes can be made more efficient and more user-friendly at the same time.

At an event held on 20 January 2020, the Federal Ministry of Education, Science and Research (BMBWF) presented the results and details of a few projects by way of examples as well as publishing a corresponding brochure.[92]

The "European Universities" initiative

The "European Universities" initiative is a new form of close partnership between higher education institutions that builds on the complementary strengths of those involved in order to achieve a degree of collaboration that goes well beyond previous forms of cooperation at European level. It is designed to enable students to obtain a degree through structurally integrated study activities conducted in several EU countries and thus boost the international competitiveness of European higher education institutions.

The "European Universities" are pursuing aims including increasing cross-border mobility, promoting top quality and excellence in education and research, linking teaching, research, innovation and knowledge transfer closely together, encouraging multilingual learning and developing joint educational and research programmes and projects. By combining these activities, anchored in a new level of ambition, the aim is to create competitive higher education structures in the European Union that enjoy a high standing internationally and work to tackle the major societal challenges. Implementing the "European Universities" initiative is a forward-looking project with a great deal of potential as it will help to increase competitiveness by bundling the excellence and expertise already present at the individual locations. Austria is actively committed to ensuring the success of this project.

The internationalisation of higher education institutions plays a major role in the (higher) education – research – innovation knowledge triangle. Well educated employees and academics with international experience will secure a key competitive edge for Europe as a centre of science, research and industry.

The first year of the pilot phase for the "European Universities" initiative saw 17 projects selected, which were launched in November 2019. A total budget of some €85 million was available for these projects. The aim is to trial various models for implementing the new concept for European universities and its potential for improving higher education. Austria's participants are the University of Graz and the University of Natural Resources and Life Sciences Vienna.

The European Commission launched the second pilot project phase as part of its call for proposals for 2020. A total of €120 million is to be available to support up to 24 projects. With one eye on the next generation of Erasmus+ programmes, the European Commission is planning to implement the initiative fully as part of Erasmus+.

1.5 Structures and developments in selected institutions

Austria's non-university sector is also continuing to develop further. The following section thus looks first at developments at Austrian Cooperative Research before going on to introduce the reform project involving the Geological Survey of Austria and the Central Institute for Meteorology and Geodynamics.

1.5.1 Austrian Cooperative Research (ACR)

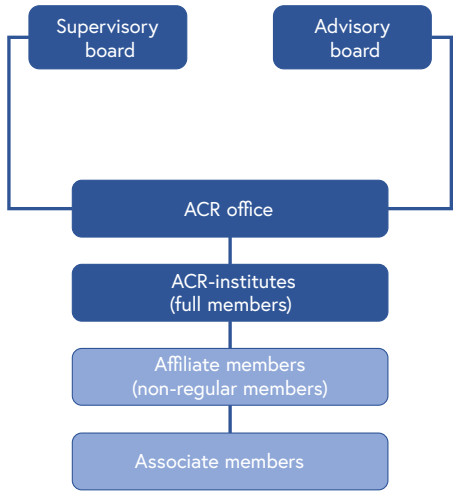
Austrian Cooperative Research (ACR) is the umbrella organisation for Austria's cooperative and non-university research institutions, which primarily support small and medium-sized enterprises with their appli-

92 See https://pubshop.bmbwf.gv.at/index.php?article_id=9&sort=title&search%5Btext%5D=digitale+und+soziale+Transformation&pub=799

cation-oriented research, development and innovation (RDI).

The roots of the network, which was set up in 1954 as an association for cooperative research institutions, stretch back to the very early days of applied research, specifically to the concept of technical experimentation, which was institutionalised as long ago as the early 20th century. One of its key priorities in the first few years was to establish an additional stream of long-term government funding for industry-focused, non-university research. This led Austrian Cooperative Research (ACR) to launch a research promotion fund for industry (now known as the Research Promotion Fund, or FFF), which was set up in 1967. Between then and 2004, the Research Promotion Fund (FFF) supported over 5,000 R&D projects involving cooperative research institutions. Efforts to gradually restructure the umbrella organisation began in 1990, supported by the Austrian Economic Chambers (WKO) and the Federation of Austrian Industries (IV). As well as representing its members' interests and engaging in lobbying activities, since the mid-1990s Austrian Cooperative Research (ACR) has also worked together with the Federal Ministry of Economics and Labour (BMWA; now the Federal Ministry for Digital and Economic Affairs – BMDW) to develop long-term research strategies for applied cooperative research tailored specifically to industry interests.[93]

Fig. 1-35 Structure of Austrian Cooperative Research (ACR)



Source: Austrian Cooperative Research (ACR).

This expansion of its remit also brought about structural changes at Austrian Cooperative Research (ACR) itself. In 1997, it was given its current name: Vereinigung der kooperativen Forschungseinrichtungen der österreichischen Wirtschaft – Austrian Cooperative Research (ACR). The following year, Austrian Cooperative Research (ACR) formulated a strategy document that set out its membership criteria for the first time. This was done in order to guarantee customers reliable standards, show potential members the benefits of joining and set out and communicate the role, responsibilities and objectives of Austrian Cooperative Research (ACR) as an organisation. The association opened itself up more to politicians, industry leaders and the general public and positioned itself as an expert point of contact for the needs and concerns of cooperative research institutions and SMEs. In order to focus more strongly on industry and its customers and raise its profile within the RDI community, Austrian Cooperative Research (ACR) expanded its areas of business and range of services from the 2000s onwards as well as extending and strengthening its network structure (e.g. via topic-based working groups). It also focused on providing quality assurance for services and increasing the institutionalisation of knowledge transfer between research and industry.[94]

Boosting competitiveness and innovative potential among SMEs has been a constant objective ever since Austria took its first steps towards devising a technology policy. This applies more than ever today, in an age of digitalisation and global competition.

93 See Austrian Cooperative Research (ACR) (1994) and (2004).
94 See Austrian Cooperative Research (ACR) (1994) and (2004).

However, only a tiny handful of SMEs have their own RDI departments, enough staff, a network of research partners or access to funding. This is where Austrian Cooperative Research (ACR) comes in – with the overarching aim of bringing SMEs closer to innovation, teaching them the necessary expertise and supporting them in their innovation and digitalisation efforts. In this, the organisation acts as a bridge in three ways:

■ …from science to industry

By running joint research projects with universities and universities of applied sciences and supporting and supervising master's, diploma and doctor's theses, the Austrian Cooperative Research (ACR) institutes gain insights into relevant basic research in their respective areas of expertise, which they pass on to SMEs by means of cooperative research projects, training sessions and specialist events.

■ …from leading firms to SMEs

Austrian Cooperative Research (ACR) institutes work with both leading Austrian firms and SMEs. Cooperative research projects, participation in consortia and sector-specific research activities enable the Austrian Cooperative Research (ACR) institutes to share the very latest technology and industry requirements with SMEs. This in turn allows the SMEs to integrate themselves more effectively into industrial value chains.

■ …from an international to an Austrian innovation system

The Austrian Cooperative Research (ACR) institutes serve numerous foreign-based customers, contribute regularly to international specialist events, work on various international boards, working groups and technical committees, and take part in EU projects on an on-going basis. This gives them international expertise in their relevant industries, bringing them international state-of-the-art knowledge that generates major added value for Austria's SMEs and innovation system.

Austrian Cooperative Research (ACR) is made up of the organisation's management office, the supervisory board and the advisory board as well as ordinary, affiliate and associate members.

Austrian Cooperative Research (ACR) has 26 members at present.[95] In addition to 7 affiliate members[96] and 2 associate members, the following 17 cooperative non-university and non-profit research institutions currently come under the Austrian Cooperative Research (ACR) umbrella:[97]

- AEE – Institute for Sustainable Technologies (AEE INTEC)
- BTI – Bautechnisches Institut (Institute for Building Technology)
- GET – Güssing Energy Technologies
- HFA – Holzforschung Austria (Austrian Forest Products Research Society)
- IBO – Österreichisches Institut für Baubiologie und -ökologie (Austrian Institute for Building Biology and Ecology)
- IBS – Institut für Brandschutztechnik und Sicherheitsforschung (Institute for Fire Protection Technology and Safety Research)
- IWI – Industriewissenschaftliches Institut (Institute of Industrial Science)
- KMFA – KMU Forschung Austria (Austrian Institute for SME Research)
- KOV – Österreichischer Kachelofenverband (Austrian Kachelofen (tile stoves) Association)
- LVA – Lebensmittelversuchsanstalt (Food Testing Agency)
- OFI – Österreichisches Forschungsinstitut für Chemie und Technik (Austrian Research Institute for Chemistry and Engineering)
- ÖGI – Österreichisches Gießerei-Institut (Austrian Foundry and Casting Institute)

95 See https://www.acr.ac.at/ueber-uns/organisation/

96 Affiliate members of Austrian Cooperative Research (ACR) are companies and other RTI institutions that also undertake research and development on behalf of Austrian industry. They are involved, for instance, in the work described above to set and develop RDI priorities.

97 See https://www.acr.ac.at/acr-institute/

- ÖIAT – Österreichisches Institut für angewandte Telekommunikation (Austrian Institute for Applied Telecommunications)
- VG – Versuchsanstalt für Getreideverarbeitung (Cereals Processing Testing Agency)
- VÖZ – Vereinigung der Österreichischen Zementindustrie (Association of the Austrian Cement Industry)
- V-Research – Industrielle Forschung und Entwicklung (Industrial Research and Development)
- ZFE – Austrian Centre for Electron Microscopy & Nanoanalysis.

The Austrian Cooperative Research (ACR) office is mainly involved in managing the association, organising internal networking and training measures, coordinating funding, representing its members' interests in Austria and abroad, and handling press and public relations work. The advisory board is an independent committee that advises Austrian Cooperative Research (ACR) on its strategic development and contributes an "outside perspective" – that of experts from the worlds of industry and innovation – to the association's work.

Services and key indicators of ACR

The Austrian Cooperative Research (ACR) institutes provide a wide range of innovation-focused services and play a major role in the country's innovation system, generating total sales of €64 million. They support SMEs as a form of outsourced RDI department that the company can call on as and when required. There are currently 770 people working in the Austrian Cooperative Research (ACR) network, serving some 10,700 customers every year. More than three quarters of the Austrian Cooperative Research (ACR) institutes' work – some of which is carried out on a non-profit basis – is done for SMEs.[98]

In addition to the Austrian Cooperative Research (ACR) institutes' focus on RDI, the areas of testing, inspection and certification as well as technology and knowledge transfer also feature particularly heavily in Austrian Cooperative Research (ACR)'s portfolio of services in line with the SMEs' requirements. By working together with leading firms and large enterprises on the one hand and with universities, universities of applied sciences and private research institutions on the other, the Austrian Cooperative Research (ACR) institutes generate expertise that they share with the companies and thus also with industry through events, talks, presentations, training sessions, publications and teaching assignments.[99] Measurement, testing and certification assignments for SMEs often form the starting point for both defining and carrying out research projects by the Austrian Cooperative Research (ACR) institutes, frequently in the form of cooperative follow-up projects with industry that introduce SMEs to RDI activities.

In addition, Austrian Cooperative Research (ACR) institutes also play a key role in helping to devise and shape technical standards via various working groups, boards and committees. These standards are just as important as a basis and common framework for innovation and economic development as they are for protecting consumers. Alongside industry representatives, research institutions and, more importantly, many Austrian Cooperative Research (ACR) institutes and their experts are on board, thus making a significant contribution in the interests of industry and society. Standards also play a crucial role in the context of the Austrian Cooperative Research (ACR) institutes' RDI projects. Firstly, standards often provide the impetus for a new cooperative RDI project involving Austrian SMEs, which may be geared towards the joint development of new products or materials that need to comply with revised or more stringent standards, for instance. Secondly, the Austrian Cooperative

98 See Austrian Cooperative Research (ACR) (2019).
99 See Austrian Cooperative Research (ACR) (2019).

Table 1-13: Overview of selected Austrian Cooperative Research (ACR) performance indicators

Funding, including third-party funding	
Federal funding	€3.1 million
...of which from the Federal Ministry for Digital and Economic Affairs (BMDW)	€2.9 million
…of which from the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK, formerly the Federal Ministry for Transport, Innovation and Technology (BMVIT)).	€0.2 million
Third-party funding (international project funding)	€1.6 million
Customers and orders for industry	
Customers	10,700
…of which SMEs	8,200 (77%)
Orders for industry*	18,500
…of which orders with SMEs	13,100 (71%)
Human capital	
FTEs (institutes)	543
…of which RDI employees	213 (40%)
Total employees	770
…of which academic staff	384 (50%)
…of which women	300 (40%)
Internationalisation	
International orders	€9.3 million
International memberships**	58
International RDI projects	40
International project partners	220
Knowledge and technology transfer	
Teaching assignments at universities and higher education institutions	130
Meetings of standardisation and other committees attended	200
Talks and presentations (in Austria and abroad)	700
Publications	190
Training sessions	90 (attended by 3,200 people)

Note: Austrian Cooperative Research (ACR) indicators 2018; * Incl. public sector; ** Memberships of international umbrella organisations
Source: Austrian Cooperative Research (ACR) (2019).

Research (ACR) institutes' RDI projects often form the basis for (further) developing standards. For example, new in vitro test methods based on human cell cultures were developed at the Austrian Research Institute for Chemistry and Engineering (Österreichisches Forschungsinstitut für Chemie und Technik – OFI) as part of a 2019 R&D project. For the first time, these allow the skin compatibility of medical products to be investigated without the need for any animal testing. The Austrian Research Institute for Chemistry and Engineering is currently campaigning for these in vitro test methods to be incorporated into the relevant set of standards so that manufacturers do not need to carry out any tests on animals to get their medical products licensed in the future.

Evaluation, quality assurance and training

Austrian Cooperative Research (ACR) is a member of the Austrian Platform for Research and Technology Policy Evaluation (fteval). The Austrian Cooperative Research (ACR) office views evaluations as an important learning and steering instrument for structuring initiatives and measures on behalf of its

members. The activities of the Austrian Cooperative Research (ACR) are also often the subject of evaluations[100].

Quality management is another significant element, including as part of the networking activities of Austrian Cooperative Research (ACR). For instance, the staff responsible for quality management at the individual Austrian Cooperative Research (ACR) institutes hold regular "ACR QM circles" to discuss relevant matters and questions from their field. To ensure that staff at the Austrian Cooperative Research (ACR) institutes maintain the right level of qualifications over the long term, the topic of continuing education is another focal point. To this end, the various institutes organise individual training measures on a regular basis, while the issue is also pursued at a higher level as part of ACR's qualifications network. For instance, staff at the Austrian Cooperative Research (ACR) institutes are offered general training courses on topics including the GDPR and agile project management.

Internationalisation

Austrian Cooperative Research (ACR) enjoys a high profile on the international stage, thanks to the fact that staff at the institutes sit on international standardisation committees (see above) as well as being involved in numerous other European and international umbrella organisations such as the Association of European Renewable Energy Research Centres (EUREC), the European Society for Automatic Alarm Systems (EUSAS) and the American Society for Materials (ASM). Overall, the Austrian Cooperative Research (ACR) institutes played an active role in nearly 60 international associations and organisations in 2018. In addition, the Austrian Cooperative Research (ACR) office represents the interests of Austrian SMEs and cooperative research at European level via its membership of the European Association of Research and Technology Organisations (EARTO) and its work on EARTO's board. Over the years, this has enabled it to inject significant momentum into efforts to embed cooperative research into the European Research Area as well.

Austrian Cooperative Research (ACR) institutes generate nearly a fifth (19%) of their sales from services outside Austria. In 2018, this figure comprised €9.3 million in orders from abroad and some €1.2 million in return flows from international or EU projects (as part of H2020, CORNET, ERA-Net, etc.) involving a total of 220 international research partners. Since 2011, Austrian Cooperative Research (ACR)'s internationalisation has also been promoted by the Federal Ministry for Transport, Innovation and Technology (BMVIT; now the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)) in the form of support for applications for EU projects, the international exchange of RDI staff and international dissemination, i.e. making an active contribution to international specialist events and conferences.

Current priorities for ACR and outlook

To raise its profile as a service provider and further develop its range of services for SMEs on an on-going basis, the Austrian Cooperative Research (ACR) network is pooling its RDI expertise in interdisciplinary, strategically aligned RDI priorities formed by clustering its institutes' core areas of expertise. The RDI priorities are to be understood as cross-industry, cross-cutting themes headed by the relevant staff responsible at different Austrian Cooperative Research (ACR) institutes. Current **RDI priorities** include:[101]

- sustainable building
- environmental technology and renewable energy
- products, processes and materials
- food quality and safety
- innovation and competitiveness
- digitalisation.

100 These include: Handler et al. (2019), Gruber et al. (2015).
101 See https://www.acr.ac.at/schwerpunkte/

Companies, and particularly SMEs, are seeing their environment being transformed constantly and at an ever faster pace as a result of digitalisation. It is opening up many new paths to innovation, acting as an important driver and increasingly becoming an integral part of RDI projects. Austrian Cooperative Research (ACR) institutes are also increasingly supporting SMEs on their journey into the digital age and are converting the potential offered by digital change into tangible applications for the direct benefit of SMEs and their customers. The following two projects exemplify the 's digitalisation activities of Austrian Cooperative Research (ACR):

■ A virtual glimpse inside materials and components

As well as being a proven tool in medicine, X-ray computer tomography (CT) is also becoming increasingly widespread in industry, such as when performing quality assurance on cast parts. It permits a glimpse "inside" and thus opens up new possibilities in materials research, component development and process optimisation. A research project conducted at the Austrian Foundry Research Institute (Österreichisches Gießerei-Institut – ÖGI) enabled CT data to be experienced in virtual reality for the first time. In other words, users put on data glasses to get a true 3D representation of the interior of an object they are studying. If necessary, they can magnify this view to such an extent that they can even enter the object and walk around inside their virtual space. Borrowed from the gaming industry, the technology offers genuine added value in terms of representation and understanding for the evaluation of 3D data, while interactions between users for the purpose of conducting advanced analysis within the 3D space are also conceivable and feasible.

■ Smart City Sensing

At present, most methods for simulating an urban climate or individual buildings are based on macroscopic data, which are taken either from satellites (or high-altitude aircraft) or from an imprecise network of fixed measuring stations. New kinds of sensor heads for airships, drones and pilotless aircraft enable temperature and air quality to be measured comprehensively and precisely in urban areas and low-altitude aerial photographs to be taken with an unprecedented level of data quality. Together with Austrian and Chinese project partners, the Austrian Cooperative Research (ACR) institute AEE INTEC has studied how these data can be efficiently processed, analysed, evaluated and integrated into 3D microclimate and air quality models in an international project funded by the Austrian Research Promotion Agency (FFG). The investigations are focusing on urban heat island effects and the small-scale recording of pollutant concentrations. This allows potential sources of pollution, interdependencies and improvement measures to be identified and assessed and the information made available to planners and decision-makers by being linked to a 3D model of the town or city.[102]

Experience from previous funding periods and current economic and societal challenges facing Austrian industry and SMEs in particular, such as those caused by digitalisation, have influenced Austrian Cooperative Research (ACR)'s strategic orientation for the next few years (2020–2023). As members of the same Austrian Cooperative Research (ACR) network, the individual institutions are all pursuing the same **strategic objectives**, namely:[103]

- serving as outsourced development departments to support SMEs in their innovation and digitalisation efforts by removing barriers and obstacles preventing SMEs from accessing RDI as well as promoting an innovative mindset amongst them;
- strengthening the competitiveness of Austrian industry, especially SMEs, by acting as a bridge and carrying out joint RDI projects;
- improving Austria's innovative position (output) by expanding technology and knowledge transfer with SMEs and actively helping start-ups to implement new ideas.

102 See https://www.aee-intec.at/smacise-intelligente-stadtvermessung-n-thermografisches-screening-von-gebaeuden-und-luftqualitaet-im-staedtischen-massstab-p230

103 See Austrian Cooperative Research (ACR) (2019b).

1.5.2 The Geological Survey of Austria and the Central Institute for Meteorology and Geodynamics

The Geological Survey of Austria (GBA) and the Central Institute for Meteorology and Geodynamics (ZAMG) serve as the government's meteorological and seismological services respectively. They use research-based methods to systematically collect and interpret basic geological, geophysical, meteorological and climatological data, which they make available to other users, as well as providing innovative products and services with practical relevance. Both agencies are currently subordinate offices of the Federal Ministry of Education, Science and Research (BMBWF) and are governed by the Research Organisation Act.[104] The federal government is planning to merge the two services into a single agency under public law as part of its programme for 2020–2024. The aim is for this new institution to serve as the national centre of expertise for government provision in the areas of natural hazard and climate change management, the supply of raw materials, the protection of groundwater and the potential for harnessing alternative energy sources and to support politicians, administrators, industry leaders and society at large in their efforts to protect people against risks and secure their livelihoods. The reform process was initiated during the previous government[105] and is still under way at the time of going to press. The two institutions are presented below together with the background to and objectives of the reform.

The Geological Survey of Austria[106]

The Geological Survey of Austria (GBA) was set up in 1849. As Austria's state geological service, it is responsible for studying and documenting the country's geology systematically, continuously and comprehensively. As well as geoscientific surveying and producing geological maps, the main areas of its work also include researching the country's raw material reserves, identifying and assessing geological natural hazards, and conducting hydrogeological surveys and analyses of sources of drinking and process water. The agency collates, documents and archives the results of its studies and makes them available to other users: libraries, archives and collections hold the fruit of its research stretching back as far as 1849. It also provides assessments and planning documents to help solve problems in the fields of economic geology, hydrogeology and geological engineering as well as performing crucial duties as part of the government's crisis management.

International cooperation is another important aspect of the agency's role. The GBA is a founder member of the umbrella association of European geological surveys (EuroGeoSurveys, EGS) and is involved in numerous international projects, some of them outside Europe.

As at the end of 2019, the GBA employed 61 civil servants (59.9 FTEs), including 35 researchers and 25 staff performing essential duties in the laboratory, cartography, IT & GIS and administration. The GBA also employed a further 61 people (53 scientific and eight non-scientific staff) at year-end 2019 within the scope of its partial legal capacity.

The Central Institute for Meteorology and Geodynamics (ZAMG)[107]

ZAMG serves as Austria's state meteorological and geophysical service. It was established in 1851 and is thus the oldest government meteorological service in the world. In this role, ZAMG performs the following essential tasks:

- It collates, edits and archives the results of meteorological and geophysical studies and makes these available to other users. To this end, it oper-

104 See Research Organisation Act (FOG), original version: Federal Law Gazette No. 341/1981.
105 See Federal Ministry of Education, Science and Research (BMBWF) (2019).
106 See https://www.geologie.ac.at/
107 See https://www.zamg.ac.at

ates its own measurement networks to monitor, in particular, the weather and climate, natural and human-made earth tremors and the Earth's magnetic and gravitational fields.
- It informs the general public, writes assessments and acts as an advisor as well as providing information, guidance and warnings in the event of crises, accidents and natural or environmental disasters. Besides the information shared with the general public, ZAMG also offers bespoke services, e.g. for disaster response teams.
- It addresses meteorological and geophysical issues relating to environmental protection.
- It produces climatological and geophysical surveys of Austria.
- It conducts application-oriented research across the whole spectrum of meteorology and geophysics, including their related fields.

Collaboration with Austrian, foreign and international institutions and universities in the field of meteorology and geophysics is essential if ZAMG is to perform these duties at a high level. With this in mind, it also takes part in international research projects such as those forming part of Horizon 2020. These wide-ranging partnerships cover topics including: the joint development of meteorological models for weather forecasting; the operation of the Europe-wide weather warning portal METEOALARM,[108] which ZAMG played a large part in developing and now runs; training staff at other meteorological services in order to offer state-of-the-art services; and devising methods for seismic monitoring. Depending on the issue at hand, ZAMG will also cooperate with other scientific disciplines or with users of its services, such as social scientists to improve how warnings and forecasts are communicated or with insurers to assess the impact of damage. ZAMG's measurement networks also make key contributions to the relevant global measurement networks and programmes such as the World Meteorological Organisation (WMO) and monitoring the ban on nuclear weapons testing. It works with the World Bank and other development agencies to help meteorological services in developing countries to grow their capacities and achieve their sustainable development goals.

Headquartered in Vienna, ZAMG also has four customer service offices in Graz, Innsbruck, Klagenfurt and Salzburg. Since 1886, it has also operated a mountaintop observatory on the Hoher Sonnblick in Salzburg in cooperation with the "Sonnblick-Verein". As well as being important for ZAMG's meteorological and climatological work, the data gathered also form the basis for research of many different issues relevant to both science and society as a whole. These include, for instance, the spread of air pollutants, the causes and effects of climate change and health- and safety-related questions such as the impact of UV radiation, aspects of radioactivity and the study of altitude sickness.[109]

In the field of geophysics, since 2002 ZAMG has operated the Conrad Observatory on and inside the Trafelberg mountain in Lower Austria, which focuses on seismological, gravimetric and geomagnetic observations. The observatory is particularly well protected against external influences caused by temperature, vibrations and magnetic fields, enabling extremely precise measurements to be taken.[110]

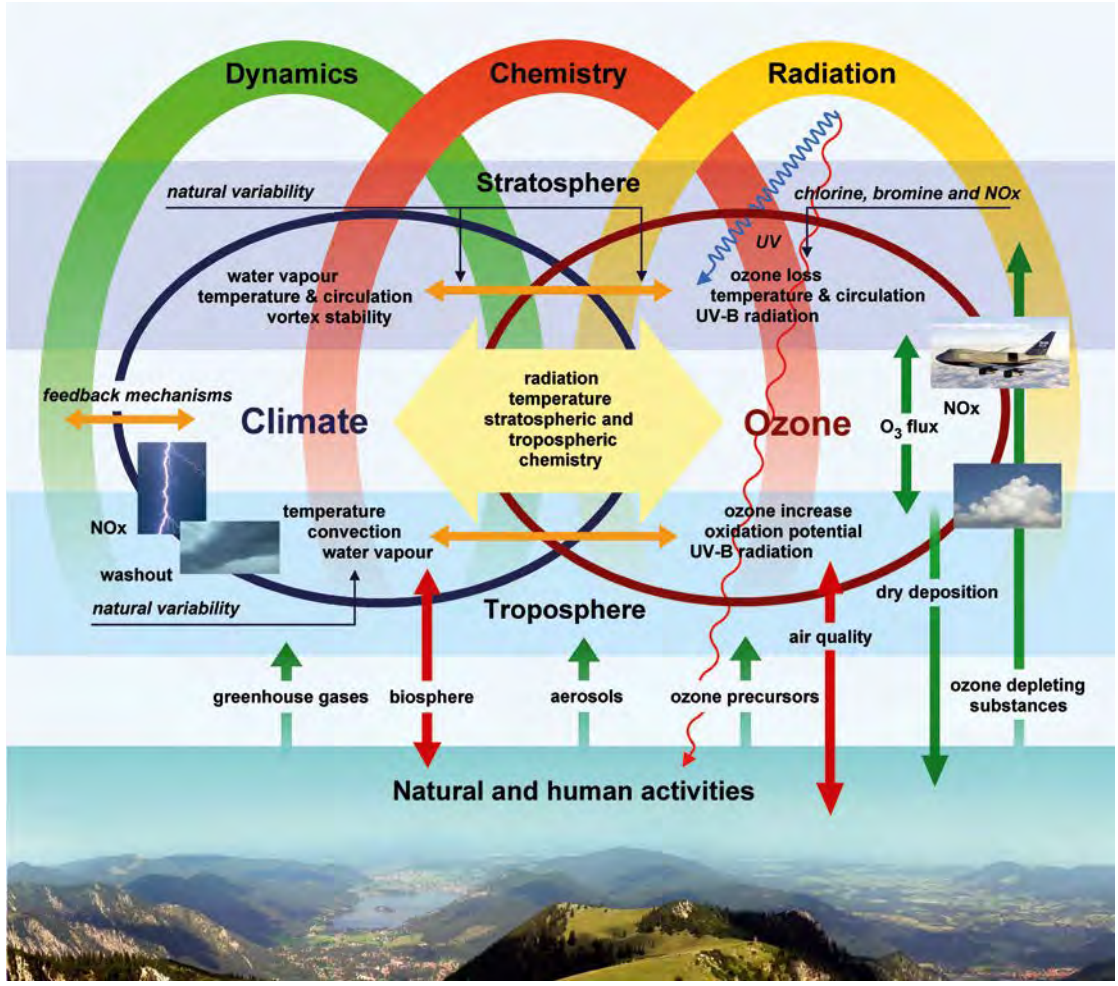
As of 31 December 2019, ZAMG employed 131 civil servants and a further 203 staff within the scope of its partial legal capacity.

Global risks and vulnerable society: background to the planned reform

Our society is facing growing challenges as a result of processes of global change, particularly climate

108 See http://www.meteoalarm.info/
109 See https://www.sonnblick.net/de/
110 See http://www.conrad-observatory.at/

Fig. 1-36: The interactions between human activities, the composition of the atmosphere, chemical and physical processes, and the climate



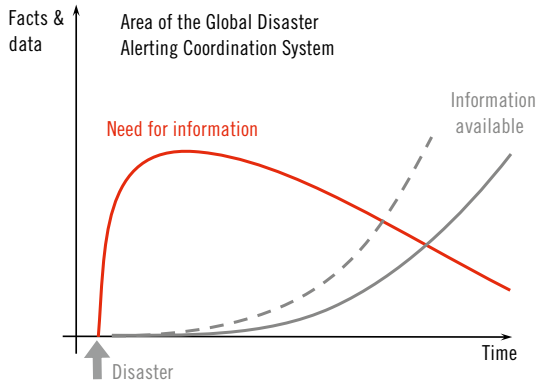
Source: Gottwald and Bovensmann (2011).

change, as well as unsustainable globalisation processes and the dwindling supply of raw materials. The government's duty to ensure people's livelihood is thus becoming a key priority in policy terms, meaning that the challenges in geology, geophysics, meteorology and climatology are growing ever greater. Models for the sustainable development of society and the economy need to be developed and the necessary transformation processes have to be guided by evidence. This will require renewable and non-renewable raw materials and energy sources to be handled carefully. In addition, the regional and global geo-environmental limits on extracting resources and generating emissions will need to be taken into account just as much as the ability of the economy and society to respond efficiently and effectively to unexpected disruptions. All institutions engaged in relevant activities will need quality-assured data and information to overcome these challenges. The only way in which the complexity of an ecosystem's processes, as illustrated in Fig. 1-36, will be able to be grasped and understood is through interdisciplinary research strategies.

The increasing vulnerability of our society and economy to natural disasters calls for a complete rethink in disaster response and, in particular, a preventive approach to dealing with disaster risks that is more broad-based and focused more clearly on

people.[111] When a disaster strikes, both government and civil society stakeholders need a huge amount of information in a short space of time, but the details that they require are often only provided after a certain time lag. Every extra piece of relevant information available at short notice thus helps that little bit more to alleviate human suffering and economic damage. The actual length of this delay in providing information can be determined within a certain range and largely depends on how well prepared the competent government services are for the task at hand. Fig. 1-37 illustrates this relationship and highlights the overriding aim of making the necessary information available faster and in as useful a form as possible.

Fig. 1-37: The time lag between information being needed and made available following a disaster



Source: Federal Ministry of Education, Science and Research (BMBWF) (2019b).

In light of this, there are four key motivations behind the planned reform:

Motivation 1: combat climate change and geo-environmental challenges effectively

Climate change is having far-reaching consequences that are also making their presence felt in Austria. For instance, there has been a change in the range of potential hazards, e.g. those posed by land- and mudslides due to shifting rainfall patterns. At the same time, measures to mitigate and tackle climate change by expanding alternative energy sources and committing to using resources in a climate-neutral and environmentally sustainable way are also producing more and more conflicts of interest. The many various measures for overcoming these challenges that are anchored in the current government programme need to be underpinned by consolidated information.

Motivation 2: optimise data, service and knowledge management

This underlying information is based on high-quality data records. In order to understand the geological subsoil and the atmospheric processes involved, these data have to cover a large enough area and be collected, interpreted and made available over long periods. This work would be nigh on impossible for university research departments to handle as the kind of research projects with which they are familiar have a limited time horizon and involve a high staff turnover. It is therefore important that government services (including the research institutions of the ministerial departments) are structured in such a way that they can tackle long-term topics with practical relevance on an on-going basis while also possessing scientific expertise that can be lent for research and practice at short notice.

Motivation 3: create the necessary institutional and legal framework for government services that are fit for the future

In providing this information and data, both institutions need to keep pace with the state of the art, which is advancing at speed as a result of scientific progress and the opportunities afforded by modern digital technologies and their use. This requires staffing and budget levels commensurate with the problem as well as a flexible structure. The current legal and institutional profile of the subordinate offices is well suited to performing long-term data gathering

111 See United Nations (2015).

and archiving work and retaining relevant specialist expertise over a sustained period. However, it proves to be a stumbling block when there is a need to respond efficiently and flexibly to all manner of different interests amongst users and solutions to problems and to develop innovative services in interdisciplinary, institutional and international partnerships. The partial legal capacity that the two offices were granted in 1992 is not enough to make up for this shortcoming as the corresponding funds are earmarked for the respective projects.

Motivation 4: generate interdisciplinary synergy effects, promote partnerships and bring innovation into the range of services

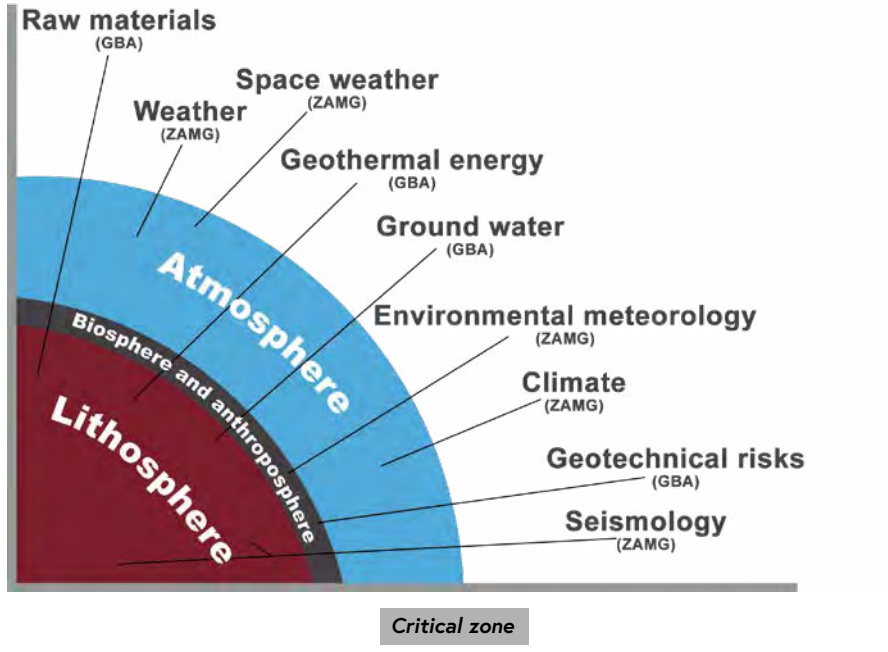
The areas of expertise of the GBA and ZAMG – the atmosphere and lithosphere respectively – complement each other and come together at the Earth's surface (see Fig. 1-38). Both have thus tackled this highly vulnerable "critical zone" of human civilisation as separate institutions up until now.

Combining their expertise and wealth of data offers significant innovative potential that is likely to generate substantial added value for research and practice. Interdisciplinary research and system-oriented data management can form the basis for new, tailored services and, especially, for influencing decisions that will have a direct impact on the action taken. Besides cooperation with universities and research institutions, this will also require close dialogue with those involved on the front line, such as the warning centres operated by the federal and regional governments, the emergency response teams and the hydrographical services. In addition, involving civil society in research and development processes ("citizen science") can generate completely new insights that, amongst other things, can form the basis for policy action.

Current situation and outlook

These technical challenges, institutional limitations and staffing developments mean that the GBA and ZAMG need a comprehensive, root-and-branch reform of their structures and responsibilities. There is also no reason why such a reform of its state

Fig. 1-38: Cross-sphere areas of expertise



Source: Federal Ministry of Education, Science and Research (BMBWF) (2019b).

meteorological, seismological and geological services cannot enable Austria to assume the role of international pioneer. For this to happen, however, the resources needed to perform government-level tasks and the scientific expertise available for this will have to be pooled at national level and harnessed as effectively as possible.

In terms of their content and structure, therefore, the main pillars of the reform project are as follows:

- ensure the performance of the core government-level tasks of a state meteorological, seismological and geological service over the long term and on a sustainable basis in a federal government institution with full legal capacity;
- work closely with universities on research, teaching and the use of infrastructure;
- provide quality assurance for disaster management and the supply of raw materials;
- set up a national core facility for all geological, geophysical, meteorological and climatological data;
- guarantee compliance with international obligations.

The overarching aim of the reform is to optimise a partnership for the future between science and research-based services that are of relevance to society. If this is to be achieved, then, above all, the principles of "responsible science" also need to be reflected at institutional level and – based on facts – help to strengthen societal resilience.

2. Key Players in Research Funding and in Non-university Research

Previously, this chapter of the Austrian Research and Technology Report has always highlighted the federal funding agencies, specifically the Austrian Science Fund (FWF), the Austrian Research Promotion Agency (FFG) and the Austria Wirtschaftsservice (aws), which issue or administrate the majority of federal RTI funding on behalf of the federal government. However, the circumstances surrounding central research and the research funding institutions will change fundamentally once the upcoming Research Funding Act (FoFinaG)[112] has been approved. In addition to establishing planning certainty for a period of three years, the amendment and the subsequent Research Funding Act are intended to give the federal ministries involved more strategic responsibility to steer and control while simultaneously expanding the operational flexibility of the researching and research funding institutions. This includes an annual monitoring in accordance with Section 8 of the amendment: "*In accordance with Section 1(2), the federal ministers must report annually to the National Council within the framework of the Austrian Research and Technology Report as per Section 8(1) of the Research Organisation Act (FOG) (FOG), Federal Law Gazette No. 341/1981.*"[113]

The utilisation of the Austrian Research and Technology Report to this end aims to avoid duplicate structures and processes and enable efficient reporting. The key researching and research funding institutions described in the monitoring in the context of the Austrian Research and Technology Report are listed exhaustively in Section 3 of the amendment. Criteria for listing were research-related federal funds of at least €10 million per year or a research-related funding volume from the federal government of the same amount plus organisation as a stock corporation with a majority stake held by the federal government, as a legal person under public law or as an association with "clear controlling influence by the federal government". Based on these criteria, ten key players in research funding and non-university research are presented in the Austrian Research and Technology Report. These are:

- Austrian Institute of Technology GmbH (AIT);
- Institute of Science and Technology Austria (IST Austria);
- Austrian Academy of Sciences (OeAW);
- Silicon Austria Labs GmbH (SAL);
- Austria Wirtschaftsservice GmbH (aws);
- Christian Doppler Research Association (CDG);
- Austrian Science Fund (FWF);
- OeAD-GmbH (OeAD, the Austrian Exchange Service);
- Austrian Research Promotion Agency (FFG);
- Ludwig Boltzmann Gesellschaft (LBG).

This year's Austrian Research and Technology Report presents the general profiles of the ten institutions along with selected indicators chosen together with the responsible federal ministries and based on a forecast of future developments.

The chapter is intended to be an initial step towards developing a "systemic view" of the entire system (at least at the national level). The goal is to satisfy the monitoring requirement while preserving

112 In autumn 2019, a public review process was initiated for a "federal act under which a federal act will be passed concerning the circumstances involving the funding of research, technology and innovation (Research Framework Act – FRG) and amending the Austria Wirtschaftsservice Act (aws-Gesetz), the Research and Technology Promotion Act, the Austrian Research Promotion Agency Act (FFG-Gesetz), the Research Organisation Act, the IST Austria Act (IST-Austria-Gesetz), the Austrian Exchange Service Act (OeAD-Gesetz) and the Austrian Academy of Sciences Act (OeAW-Gesetz) (Research Framework Amendment 2019)". The Research Funding Amendment 2020 will be based on this public review process.

113 See https://www.parlament.gv.at/PAKT/VHG/XXVI/ME/ME_00165/index.shtml

compatibility with the already existing reporting formats (such as annual reports, quarterly reports and the like). Guidelines were established for all key institutions based on the already available information and data:

- beginning with a profile and the most important key figures on the institution;
- followed by figures from the years 2018 and 2019 (where possible) concerning the following selected indicators i) funding and third-party funding, ii) quality assurance and evaluations, iii) human resources and qualifications, iv) output, innovation and excellence, v) internationalisation, vi) knowledge and technology transfer, and vii) gender and the promotion of gender equality;
- and finally, special events from the year 2019 and a brief outlook of future plans and developments.

This chapter is therefore a first step towards implementing the monitoring called for in the Research Funding Act (FoFinaG) for the ten key institutions of the federal government for funding and performing research. The goal is to depict defined topics and indicators for all the institutions, creating a complete systemic picture, while also respecting the differences between the individual stakeholders in connection with their roles in the system. A number of terms have been defined for this purpose (see the box at the end of the chapter). If institution-specific definitions, deviations, interpretations, etc. apply, these are noted where appropriate.

2.1 Austrian Institute of Technology (AIT)

2.1.1 Profile and key figures

The Austrian Institute of Technology (AIT) is Austria's largest RTO (research and technology organisation) and takes a leading position in innovation. It plays a key role at the European level as the RTO focusing on central infrastructure topics of the future.

Eight specialised Centers conduct research on central infrastructure topics of the future in the areas of Energy, Mobility Systems, Low-Emission Transport, Health & Bioresources, Digital Safety & Security, Vision, Automation & Control and Technology Experience. These research areas are supplemented by competence in the area of Innovation Systems & Policy.

As a national and international hub acting as an interface between scientific research institutions and industry, the Austrian Institute of Technology (AIT) enables innovation through its scientific-technological competence, market experience, tight customer relationships and high-quality research infrastructure.

As an "ingenious partner" to industry and the public sector, the Austrian Institute of Technology (AIT) takes on a central role in advising on future challenges and developing disruptive technologies. The Austrian Institute of Technology (AIT) pursues a research approach based on extensive knowledge at the system level. The goal is not only to understand systems but to actively shape them.

Throughout Austria, numerous employees are working on the development of the tools, technologies and solutions to prepare Austria's economy for its future challenges, according to the motto of "Tomorrow Today".

Key figures 2018 and 2019

	2018	2019
Total income, i.e. sales revenue and other operational income according to investment and financial controlling as per the Austrian Commercial Code (UGB) in €1,000	162,900	167,000

Number of employees at the Austrian Institute of Technology (AIT) (including 100% subsidiaries); data from 31 Dec.[1]	**2018**	**2019**
Employees (=headcount)	1,227	1,278
Full time equivalents, rounded	1,099	1,136

1 These figures do not include employees on temporary contracts. Nor do they include other holdings, such as Profactor.

Source: Austrian Institute of Technology (AIT).

2.1.2 Indicators for 2018 and 2019

Indicator 1: Funding, including third-party funding[114]

	2018 in €1,000	2019 in €1,000
Total operational income	128,007	130,862
of which contributions from partners	48,788	49,779
of which third-party funding	79,219	81,083
of which from non-EU states	1,563	1,584
of which public	125	137
of which private	1,438	1,447
of which from the EU	23,221	27,943
of which public	16,600	18,628
of which private	6,620	9,315
of which national	54,434	51,556
of which public	24,728	21,594
of which private	29,706	29,962

Source: Austrian Institute of Technology (AIT).

Indicator 2: Quality assurance and evaluations

Evaluations of thematic and strategic orientation

The Austrian Institute of Technology (AIT) carries out evaluations for the on-going strategy period in accordance with the articles of partnership and the funding agreement of AIT GmbH. Internationally composed evaluation panels are appointed according to a decision of the Supervisory Board to evaluate and assess the scientific quality and application relevance of the Centers' activities and to issue position statements on the planned strategic orientation of the Centers. The evaluation process and other details are laid down for the evaluation panels in the procedural rules. The evaluation panels report to the Managing Directors, who report to the Supervisory Board. The last evaluation was conducted in 2016, and the current evaluation is scheduled for 2020.

114 Excluding Seibersdorf Labor GmbH and Nuclear Engineering Seibersdorf GmbH.

Institutional quality assurance measures

The Austrian Institute of Technology (AIT) abides by quality management (QM) documents and strives for continuous improvement. Alongside efficient implementation and optimisation, the following aspects are always taken into account:

- statutory requirements;
- QM principles;
- social aspects;
- safety and environmental factors.

The quality management system is certified according to ISO 9001 and some organisational units additionally have ISO 13485 certification for medical products or ISO 17025 accreditation as testing laboratories. All employees are obliged to be familiar with the principles of quality management and to stay abreast of new developments. Compliance with the requirements of the quality management system is monitored through both internal and external audits.

Indicator 3: Human resources and qualifications

Number of employees at the Austrian Institute of Technology (AIT) (including LKR Leichtmetallkompetenzzentrum Ranshofen GmbH); data from 31 Dec.	2018			2019		
	m	f	Total	m	f	Total
Employees (= headcount)	712	315	1,027	742	324	1,066
of which at management level (heads of Centers, heads of competence unit, managing directors, heads of staff units and authorised officers)	33	8	41	32	8	40
Full time equivalents, rounded	651	263	914	670	271	914
of which at the management level	33	8	41	32	8	40

Number of doctoral candidates; data from 31 Dec.	2018	2019
Employees (= headcount)	213	197
of which employed at the Austrian Institute of Technology (AIT)	160	153
of which in a structured training programme (doctoral schools, etc.)	53	44

Source: Austrian Institute of Technology (AIT).

The following measures were implemented in the years 2018 and 2019:

- Applicant management was digitalised and external marketing strengthened as part of the employer branding;
- A work environment survey was done, follow-up measures identified and implemented in the Centers;
- A Gender Equality Office was set up in addition to the GenderTaskforce;
- The scientific careers of female employees were promoted, including by increasing the visibility of their expertise (interviews, podium discussions);
- The third gender is now considered in addition to gender-sensitive structuring of job postings.

Indicator 4: Output, innovation and excellence

Number of scientific publications	2018	2019
Articles/papers in scientific journals, edited collections and proceedings; with peer review	593	537
of which listed in the WoS	363	303

Note: Web of Science (WoS), see explanation in the Chapter "Definitions"

Source: Austrian Institute of Technology (AIT).

The listed publication figures reflect the scientific output of the Austrian Institute of Technology (AIT), which is subject to scientific quality assurance in the form of independent peer review. The figures are based on the annual assessment of the Austrian Institute of Technology (AIT) on the basis of its own publication database. The information for the WoS 2019 is only preliminary since not yet all publications have been included in the WoS at the time of the evaluation (24 February 2020). The journals and document types listed in the WoS encompass only a portion of the media in which the Austrian Institute of Technology (AIT) publishes. For this reason, the WoS values do not completely depict the publication activity of the Austrian Institute of Technology (AIT).

Grants in excellence programmes of the European Research Council (ERC) and Austrian Science Fund (FWF)		2018	2019
European Research Council	**Number**	0	1
	Volume (total funding approved)	-	€1,500,000
Wittgenstein Award of the Austrian Science Fund (FWF)	**Number**	0	0
	Volume (total funding approved)	-	-
Start Programme of the Austrian Science Fund (FWF)	**Number**	0	0
	Volume (total funding approved)	-	-

Source: Austrian Institute of Technology (AIT).

The career model of the Austrian Institute of Technology (AIT) with defined job profiles establishes a Science path as well as a Research Engineering & Expert Adviser path. External hearings ensure the quality of appointments to senior positions. Further development of the principal scientist concept strengthens the Institute's scientific expertise and international networking.

Indicator 5: Internationalisation

	2018	2019
Share of international co-publications among all publications listed in the WoS in the reporting year[1]	54.0%	60.7%
Newly approved participations in H2020 programmes and initiatives		
Number	25	30
Total volume	€13,863,123	€16,893,327

1 The indicated values refer to co-publications with at least one Austrian author, measured against the total number of publications in the WoS. The existing publication database of the Austrian Institute of Technology (AIT) does not currently permit this analysis. The figures for the WoS 2019 consist of preliminary values since not all publications have been included in the WoS at the time of the evaluation (24 February 2020).

Source: Austrian Institute of Technology (AIT).

The Austrian Institute of Technology (AIT) is a member of numerous international umbrella organisations and special interest groups (general as well as topic-specific) and other international initiatives (such as

EIT, EU partnerships). These include: EARTO/EUROTECH including various working groups, European Cyber Security Organisation (ECSO), European Energy Research Alliance (EERA), European Conference of Transport Research Institutes (ECTRI), European Institute of Innovation and Technology (EIT) (CLIMATE, HEALTH, FOOD), etc.

Indicator 6: Knowledge and technology transfer

	2018	2019
Share of co-publications with industry partners among all publications in the WoS[1]	35.9% (12.3%)	34.0% (12.3%)
IPR: Patent and exploitation activities as at 31 Dec.		
Number of patent applications	50	40
of which national	26	11
of which EU/EPC	7	18
of which non-EU states	17	11
Issued patents	35	28
of which national	15	11
of which EU/EPC	15	12
of which non-EU states	5	5
Patents submitted but not yet registered	5	9
Spin-offs (exploitation)	1	1
Licensing agreements	N/A	N/A
Options agreements	N/A	N/A
Sales agreements	N/A	N/A

1 The values indicated refer to publications in the WoS; the existing publication database of the Austrian Institute of Technology (AIT) does not currently permit this analysis. For a more complete picture of the knowledge and technology transfer, other organisation types relevant to implementation and applied research are included as industry partners (service providers, hospitals, industry-related research organisations). The values in parentheses refer to the share of publication partners in the subgroup "company".

Source: Austrian Institute of Technology (AIT).

Indicator 7: Gender and promotion of equality

Share of women in management positions by management level; data from 31 Dec.	2018	2019
General management	0%	0%
Head of competence unit/Center	9%	9%
Principal scientist	25%	33%
Glass ceiling index based on the management levels[1]	1.57	1.52

1 Calculated as the share of women among all employees/share of women in management positions. The following are considered management positions: head of department/division, head of competence unit/Center, managing director and heads of staff units and authorised officers. An explanation of the index can be found in the "Definitions" box at the end of the chapter.

Source: Austrian Institute of Technology (AIT).

2.1.3 Special events in 2019 and outlook

The Flagship Region **New Energy for Industry (NEFI)** was launched in 2019, funded by the Climate and Energy Fund (KLIEN) and under the direction of the Austrian Institute of Technology (AIT) Center for Energy in cooperation with the University of Leoben, the Upper Austrian Energy Conservation Association (OÖ Energiesparverband) and Business Upper Austria (OÖ Wirtschaftsagentur). The innovation network, with over 80 industry, technology and research companies, will spend the next eight years pursuing the goal of demonstrating the path to renewable energy supply and complete decarbonisation of manufactur-

ing and energy-intensive industries on the basis of key technologies Made in Austria. The spectrum of companies participating in NEFI ranges from large industry leaders to innovative SMEs. The governments of the heavily industrialised federal states of Upper Austria and Styria are backing the strategic programme and are prepared to substantially support the development. NEFI is also focused on six fields of innovation at the technological level (e.g. renewable energy, energy storage, processes) and systemic level (infrastructure, business models, policy).

The European Commission has set the goal of achieving strategic autonomy in the critical area of **quantum communication**, basing its new initiative Quantum Communication Infrastructure (QCI) on the capabilities, projects technologies of the Austrian Institute of Technology (AIT). The Austrian Institute of Technology (AIT) is positioned as a key player in the most important initiatives and projects of the EU by managing and participating in two EU Flagship projects for quantum technology development, managing the EU-wide demonstration project for quantum communication and serving as the national representative of Austria in the EU-QCI coordination group.

In cooperation with industrial partners, the Austrian Institute of Technology (AIT) developed alternative concepts for efficient cabin climate control in battery-powered electric vehicles. The heating and cooling demands of conventional heating, ventilation and air-conditioning modules currently restrict the actual **range of battery-powered electric vehicles** under certain weather conditions. Using the driver cab of an electric truck as example, it was possible to reduce the energy demands by implementing intelligent, optimised climate control strategies in a testing facility. By developing and testing intelligent simulation approaches and models in a variety of predefined conditions (temperature, humidity, and sunlight), the concept of the Austrian Institute of Technology (AIT) demonstrated significantly improved efficiency, enabling an increase in range of 6%.

At the Center for **Vision, Automation and Control**, the research on **measurement systems and quality control** has been continuously expanded to new domains of industry. State-of-the-art sensor and camera technology and expertise in the pre-processing of extremely high data rates make it possible to investigate research problems in high-speed applications as well as extremely high image resolutions. The applications range from a road scanner that will map the 3D structure of the road surface with a resolution of 60 µm at a speed of 130 km/h to the analysis of very fine structures in electronics and chip manufacturing. Extremely high data rates are processed by intelligent algorithms – generally in real-time. Computational imaging and AI technologies are used to inspect surface properties that are practically impossible to specify as well as flaw sizes that are difficult to quantify. These technologies are essential for enabling the analysis of certain glossy, metallic, reflective or black surfaces using camera systems.

Outlook for the coming years

In accordance with the **AIT Shareholder Vision 2025**, the Austrian Institute of Technology (AIT) is positioned as the main Austrian technology development research institute working on the "grand challenges" with a focus on infrastructure topics of the future, and the Institute supports industry and the society as a whole in addressing the challenges of decarbonisation and digitalisation in particular.

As an international player, the Austrian Institute of Technology (AIT) acts as a partner to industry in the following ways:

- it plays an important role at the interface of applied research and practical implementation, thereby expanding its position as a system-focused partner to industry;
- it serves as a "door-opener" for Austrian companies thanks to its strong affiliation with European institutions and its international activities;
- it pursues an active IPR strategy and implements this strategy in cooperative projects with companies and other partners.

By **continuously developing its portfolio**, the Austrian Institute of Technology (AIT) helps generate a critical mass of know-how in the selected fields of activity, giving a boost to contract research and market focus. It also creates added value for Austria by founding start-ups and spin-offs and maintains participations in companies that support its agenda.

The Institute capitalises on the development and growth potential in the areas of cyber-physical systems (CPS) and complex dynamical systems as well as the digitalisation of production. With regard to scientific performance, the Austrian Institute of Technology (AIT) compares well with its international peers.

2.2 Institute of Science and Technology Austria (IST Austria)

2.2.1 Profile and key figures

The Institute of Science and Technology Austria (IST Austria), founded in 2006 and opened in 2009, serves as a centre for top-level basic research in the natural sciences. As a PhD-granting research institution, it is dedicated to exploring new fields of research and offering high-quality post-graduate instruction in the form of interdisciplinary PhD and postdoc programmes. IST Austria is located in Klosterneuburg near Vienna. The research, education and staff are of international character; English is used as the language for work and instruction.

The founding principles of the Institute continue to serve as guidelines for the growth and further development of IST Austria as it pursues its core missions:

- to perform world-class basic research;
- to train the next generation of scientific leaders;
- to implement best practices in science management;
- to support science education and technology transfer.

IST Austria raises Austria's visibility in the area of excellent basic research and is on its way to becoming a world-class research institute in physics, chemistry, the life sciences, mathematics and computer science. The research fields of the Institute are determined primarily by the availability of internationally leading researchers. The strategy is: "people over topics". Since its opening in 2009, the Institute has grown continuously and is expected to encompass roughly 90 research groups and over 1,000 employees on campus by 2026.

Key figures 2018 and 2019

	2018	2019[1]
Total income, i.e. sales revenue and other operational income in €1,000	68,013	76,272

Number of employees; data from 31 Dec.	**2018**	**2019[1]**
Employees (= headcount)	693	777
Full time equivalents, rounded	664	752

1 All figures for 2019 are provisional, pending final analysis and approval by the Board of Trustees.

Source: IST Austria.

2.2.2 Indicators for 2018 and 2019

Indicator 1: Funding, including third-party funding

	2018 in €1,000	2019 in €1,000
Total operational income	68,013	76,272
of which basic public funding	50,337	55,426
of which third-party funding	16,345	19,218
of which from non-EU countries and global organisations	844	1,009
of which from the EU and European countries or organisations	10,984	12,862
of which from national organisations	4,518	5,347

Source: IST Austria.

Indicator 2: Quality assurance and evaluations

Evaluations of thematic and strategic orientation

The Institute's development is evaluated regularly. One economic evaluation was done in 2014–2015 in addition to two scientific evaluations in 2011 and 2015. In accordance with the IST Austria Act, (ISTAG), the Institute must be evaluated every four years. The third Institute evaluation took place in December 2019. The seven-person evaluation panel composed of high-ranking international experts emphasised the remarkable accomplishments of IST Austria and confirmed that the founding vision of IST Austria has proven correct. The Institute can serve as an example to other countries seeking to engage in excellence-based science.[115]

Indicator 3: Human resources and qualifications

Number of employees; data from 31 Dec.	**2018**			**2019**		
	m	**f**	**Total**	**m**	**f**	**Total**
Employees (= headcount)	376	317	693	436	341	777
of which at the management level (faculty – professors and assistant professors, general management, division heads, unit heads)	54	17	71	59	18	77
Full time equivalents, rounded	368	296	664	429	323	752

Source: IST Austria.

115 See also Chapter 4.2.8.

Number of doctoral candidates; data from 31 Dec.	2018	2019
Employees (= headcount)	185	223
of which employed by IST Austria	185	223
of which in a structured training programme (doctoral schools, etc.)	185	223

Source: IST Austria.

The Institute implements a staff development and career development plan, which has been continuously improved and updated from 2018 to 2020 within the framework of the performance agreement.

Indicator 4: Output, innovation and excellence

Number of scientific publications	2018	2019
Articles/papers in scientific journals, edited collections and proceedings; with peer review	359	388
of which listed in Scopus	297	341

Source: IST Austria.

Grants in excellence programmes of the European Research Council (ERC) and Austrian Science Fund (FWF)		2018	2019
European Research Council	Number	4	3
	Volume (total funding approved)	€4,822,000	€4,949,000
Wittgenstein Award of the Austrian Science Fund (FWF)	Number	1	0
	Volume (total funding approved)	€1,400,000	-
Start Programme of the Austrian Science Fund (FWF)	Number	0	0
	Volume (total funding approved)	-	-

Source: IST Austria.

Indicator 5: Internationalisation

	2018	2019
Share of international co-publications among all publications in the reporting year	74.1%	66.5%
Newly approved participations in H2020 programmes and initiatives (including ERC grants)		
Number	6	10
Total volume (total funding approved)	€5,166,000	€6,724,000

Source: IST Austria.

IST Austria takes part in the Erasmus+ Staff Mobility programme both as a host and a source of participants.

Indicator 6: Knowledge and technology transfer

	2018	2019
Share of co-publications with industry partners among all publications	4.7%	7.0%
IPR: Patent and exploitation activities as at 31 Dec.		
Number of patent applications	6	4
Issued patents	2	1
Exploitation spin-offs	0	0
Licensing agreements	0	0
Options agreements	0	0
Sales agreements	0	0

Source: IST Austria.

Indicator 7: Gender and promotion of equality

Share of women in management positions by management level; data from 31 Dec.	2018	2019
General management	0%	0%
Division heads/unit heads	38.1%	39.1%
Faculty (professors and assistant professors)	18.4%	17.0%
Glass ceiling index based on the management levels[1]	1.91	1.88

1 Calculated as the share of women among all employees/share of women in management positions. The following are considered management positions: Faculty (professors and assistant professors), general management, division heads and unit heads. An explanation of the index can be found in the "Definitions" box at the end of the chapter.

Source: IST Austria.

The increase in the share of women represents a key strategic focus. Various measures exist for this purpose, such as targeted scouting of female postdocs in top institutions and a separate recruiting committee that specifically searches for appropriate female candidates and actively invites them to apply. In addition, a number of regular training sessions and workshops are offered to strengthen diversity and career development on the campus.

2.2.3 Special events in 2019 and outlook

10 years of IST Austria

In June 2019, the Institute of Science and Technology Austria celebrated its tenth anniversary. Since the opening of the campus in June 2009, IST Austria has now grown to over 50 research groups and more than 700 employees. A number of anniversary events to celebrate this occasion offered the opportunity to join with high-ranking guests to look back on the successful history of the Institute and gain insights into the preparations for the coming decade.

Scientific successes

- In 2019 *Nature Index* published the results of the annual evaluation of publication data of 82 scientific journals. For the first time, this evaluation took into account the sizes of the institutions where the publishing researchers were employed. IST Austria was ranked globally in third place within this size-weighted evaluation. First place went to the Cold Spring Harbor Laboratory in New York, USA. Second place was held by the Weizmann Institute of Science in Rehovot, Israel. The normalised ranking permits a comparison of institutions of differing sizes on the same basis, making even smaller institutions visible in the ranking.
- Another sign of excellence is the continued success of researchers in acquiring funding from the European Research Council (ERC). Of 53 IST Austria professors under contract (about 2/3), 36 received funds from the ERC. A total of 43 ERC grantees (25 starting, 7 consolidator, 11 advanced grantees) work at IST Austria. Furthermore, two ERC Proof of Concept Grants (top-up funding) have been obtained to date. In the first ten years, 36 professors at IST Austria received 45 ERC grants, each with a total volume exceeding €1.5 million.

BRIDGE Network

The "BRIDGE Network" *(Basic Research Institutions Delivering Graduate Education)* was established in 2019 with the Rockefeller University (USA), the Francis Crick Institute (UK), the Weizmann Institute of Science (Israel), the Okinawa Institute of Science and Technology (Japan) and IST Austria as founding partners. The BRIDGE Network is an informal platform of the aforementioned academic institutions that pursues two goals: to perform top research and train doctoral candidates.

Outlook for the coming years

The current planning horizon for IST Austria calls for the Institute to grow to 90 research groups by 2026. Construction of a new laboratory building for chemistry research is in full swing. The planned campus visitor centre will eventually be home to the increasing activities of IST Austria in the area of scientific outreach. Further development of the graduate school will introduce a combined master's/PhD programme.

2.3 Austrian Academy of Sciences (OeAW)

2.3.1 Profile and key figures

"Promote science in every way" – that is the statutory mission of the Austrian Academy of Sciences (OeAW). Succeeding in this ambition demands flexibility and innovation capability. In other words: space for new ideas. Austria's largest non-university institution for basic research has offered this space since the year 1847, when the academy was founded as a learned society.

In short, the Austrian Academy of Sciences (OeAW) stands for:

- expertise and excellence:
  bringing experts together, advancing research, discovering new insights;
- curiosity and openness:
  asking new questions, overcoming disciplinary boundaries, exploring the unknown;
- attractiveness and diversity:
  promoting exceptional talent, fostering opportunities, advocating plurality in discourse;
- autonomy and integrity:
  guaranteeing scientific freedom, ensuring traceability, exemplifying responsibility;
- cooperation and competition:
  working with the best, expanding the exchange of ideas, being a pioneer;
- fascination and vision:
  exciting young people, strengthening critical thinking, fostering engagement;
- transfer and innovation:
  sharing insights, exploiting results, supporting entrepreneurship.

As a national institution, the Austrian Academy of Sciences (OeAW) is a learned society, a dispenser of knowledge and a research performer and promoter. By embracing the interplay between these areas, the academy is able to capitalise on synergies and innovation potential in dynamic ways.

The Austrian Academy of Sciences (OeAW) is dedicating to disseminating scientific achievements and

insights. Members, employees and guests at the academy exchange ideas on important questions across disciplinary boundaries, advise policymakers and society and inform the public about major scientific insights. With the Young Academy, the Austrian Academy of Sciences (OeAW) brings together outstanding young research talent from across Austria. Through a diverse range of events, publications and, increasingly, digital content directed expressly towards young people, the Austrian Academy of Sciences (OeAW) shares its love of research with the next generation.

The Austrian Academy of Sciences (OeAW) operates 27 research institutes in the humanities, cultural studies and social sciences, in the natural sciences and life sciences and in technological fields. It sets trends by remaining application-agnostic, taking responsibility for protecting our cultural inheritance and engaging in forward-looking research topics, frequently via interdisciplinary approaches. Within Austria and beyond, the Austrian Academy of Sciences (OeAW) cooperates with numerous academic and research-oriented institutions to actively contribute to shaping the research landscape.

The sustainable development of promising academic talent is a central goal of the Austrian Academy of Sciences (OeAW). At its research institutions, the Academy creates numerous opportunities for up-and-coming researchers. Even outside of its institutes, the Austrian Academy of Sciences (OeAW) fosters the early stage researchers by awarding grants and prizes to individual researchers and interdisciplinary teams.

Key figures 2018 and 2019

	2018 in €1,000	2019 in €1,000
Total income, i.e. sales revenue and other operational income according to investment and financial controlling as per the Austrian Commercial Code (UGB)	183,222	196,891

Number of employees at the Austrian Academy of Sciences (OeAW) (including 100% subsidiaries); data from 31 Dec.	**2018**	**2019**
Employees (= headcount)	1,781	1,820
Full time equivalents, rounded	1,490	1,515

Source: Austrian Academy of Sciences (OeAW) Note: The numbers for 2019 are preliminary figures.

2.3.2 Indicators for 2018 and 2019[116]

Indicator 1: Funding, including third-party funding

Austrian Academy of Sciences (OeAW) research performing organisation	2018 in €1,000	2019 in €1,000
Income, i.e. sales revenue and other operational income according to investment and financial controlling as per the Austrian Commercial Code (UGB)	158,935	169,119
of which federal funds based on the OeAW-BMBWF performance agreement	102,865	102,662
of which third-party funding[1]	42,262	47,614
Global organisations and non-European countries or organisations	423	399
EU and European countries or organisations (public/private)	16,029	17,607
National organisations (public/private)	23,451	24,414
of which NTFE	3,089	7,676
Regional organisations (public/private)	2,359	5,194

1 Third-party funding income and other operational income according to investment and financial controlling. Other income from forwarding of costs by invoicing services, funding from the Public Employment Service Austria (AMS) and research premiums are not classified as third-party funding.

Source: Austrian Academy of Sciences (OeAW) Note: The numbers for 2019 are preliminary figures.

Indicator 2: Quality assurance and evaluations

	2018	2019
Evaluations conducted at the Austrian Academy of Sciences (OeAW) at the institute and programme level	4	3

Source: Austrian Academy of Sciences (OeAW)

2018:

- Evaluation of the Programme for Promotion of Long-Term Research;
- Evaluation of the Stefan Meyer Institute for Subatomic Physics (SMI);
- Evaluation of the Institute for Modern and Contemporary Historical Research (INZ);
- Evaluation of the Institute of Technology Assessment (ITA).

2019:

- Evaluation of the Austrian Archaeological Institute (OeAI);
- Evaluation of the Institute for Comparative Media and Communication Studies (CMC);
- Evaluation of the Institute for Quantum Optics and Quantum Information Innsbruck (IQOQI).

Regular or specially prompted evaluations are key elements of self-assessment and drive the further development of the Austrian Academy of Sciences (OeAW) institutes and the academy's portfolio as a research performing organisation. These evaluations are structured in strict accordance with international standards and conducted exclusively by international teams of high-ranking scientists. The internationally renowned members of the Austrian Academy of Sciences (OeAW) Research Board are responsible for ensuring the independence and quality of these teams by overseeing the selection process. The Academy Council and the Research Committee participate alongside the Presiding Committee in deciding on measures to be introduced based on the results of the evaluations. The results of this process enter into the

116 In contrast to the "central figures", all indicators in section 2.3.2 refer only to the research performing organisation, in other words excluding the learned society, grants and contracting area.

multi-year development planning of the Austrian Academy of Sciences (OeAW) as well as into the target agreements established with the institutes.

In addition to evaluations of research institutes, other measures according to international standards ensure transparency and quality in the appointment of academic (leadership) positions, in ex-ante and ex-post project evaluations as well as on the internationally composed Scientific Advisory Boards of the institutes. All quality assurance processes at the Austrian Academy of Sciences (OeAW) take into account special aspects and developments of the respective research fields as well as special institute missions, such as protecting our cultural inheritance or projects in the area of policy advising.

Indicator 3: Human resources and qualifications

Number of employees of the Austrian Academy of Sciences (OeAW) research performing organisation (including 100% subsidiaries); data from 31 Dec.	2018			2019		
	m	f	Total	m	f	Total
Employees (= headcount)	968	703	1,671	998	719	1,717
of which at the management level	130	55	185	128	56	184
Full time equivalents, rounded	834	565	1,399	835	574	1,427
of which at the management level	123	52	175	118	51	169

Source: Austrian Academy of Sciences (OeAW)

Number of doctoral candidates employed at the Austrian Academy of Sciences (OeAW) research institutions; data from 31 Dec.	2018	2019
Employees (= headcount)	293	289

Source: Austrian Academy of Sciences (OeAW)

The high quality of basic research and academic cooperation at the Austrian Academy of Sciences (OeAW) is based on a carefully designed policy for selections and appointments. The OeAW also strives to increase the underrepresented share of women in its managing bodies as well as in research.

At the institutes of the Austrian Academy of Sciences (OeAW), the research work is generally organised into research groups, in which the participants at various career levels engage as equals in the process of creativity and criticism, much to the benefit of younger researchers. The employees of the OeAW represent as a whole the international character of successful science, with people from 77 nations working at the OeAW in 2019.

Indicator 4: Output, innovation and excellence

Number of scientific publications from projects of the Austrian Academy of Sciences (OeAW) research performing organisation	2018	2019
Monographs and editions	55	57
Articles/papers in scientific journals, edited collections and proceedings; with peer review	1,687	1,702
of which listed in WoS or Scopus	1,281	1,282
of which published in other outstanding journals or by specialised publishers	137	119

Source: Austrian Academy of Sciences (OeAW)

The publication figures shown here reflect the output of the Austrian Academy of Sciences (OeAW) that is subject to scientific quality assurance in the form of independent peer review. Web of Science (WoS) and Scopus indices do not fully reflect the significant portion of publications in the humanities, social sciences and cultural studies (GSK). In order to appropriately present the publications in the humanities,

social sciences and cultural studies (GSK), a number of additional indices and other outstanding publication bodies were selected on the basis of accepted international practices and with external, international assistance. These are considered to be on par with the journals indexed in WoS/Scopus and were included in the publication figures of the Austrian Academy of Sciences (OeAW).

Projects acquired by Austrian Academy of Sciences (OeAW) research institutions in excellence programmes of the European Research Council (ERC) and Austrian Science Fund (FWF)		2018	2019
European Research Council	Number	5	8
	Volume (total funding approved)	€7,371,941	€12,247,456
Wittgenstein Award of the Austrian Science Fund (FWF)	Number	0	0
	Volume (total funding approved)	-	-
Start Programme of the Austrian Science Fund (FWF)	Number	0	3
	Volume (total funding approved)	-	€3,416,518

Source: Austrian Academy of Sciences (OeAW)

The Austrian Academy of Sciences (OeAW) is one of the top two most successful institutions in Austria when it comes to the number of ERC grants. The ERC grant approval rates show that the OeAW is among the top research institutions at the European level and among the associated countries of the EU, even exceeding the German Max Planck Society in this regard.

Indicator 5: Internationalisation

	2018	2019
Share of international co-publications among all publications listed in the WoS in the reporting year[1]	80.1%	79.0%

1 The following citable publication types are taken into account: articles, proceedings, papers, reviews, letters.

Newly approved participations by Austrian Academy of Sciences (OeAW) research institutions in H2020 programmes and initiatives	2018	2019
Number	22	21
Total volume of approvals	€19,170,721	€20,838,210

Source: Austrian Academy of Sciences (OeAW)

The Austrian Academy of Sciences (OeAW) initiates and maintains academic partnerships around the world in all of its fields of activity. The entire Austrian scientific community benefits from this work. The OeAW mobility programme Joint Excellence in Science and Humanities (JESH) offers young researchers in Austria and many other countries around the world the opportunity to establish contacts at the highest academic level on a diverse range of topics. In this way, the OeAW makes an important contribution to counteracting "brain drain" and promoting a "brain circulation" of benefit to everyone involved.

Cooperative projects with over 60 scientific academies in 50 countries allow the Austrian Academy of Sciences (OeAW) to implement promising joint research activities with minimal bureaucracy and enable scientific guest visits at short notice as well as the opportunity to act as a bridge builder in the area of science diplomacy. The intensive contact with Chinese, Iranian and Turkish institutions as well as the Western Balkans region is worth particular mention.

Since 2018, the Austrian Academy of Sciences (OeAW) has held the annual Joint Academy Days, where their researchers meet in Vienna with representatives of other academies. This initiative makes Austria an

important hub for international exchange between scientific academies and opens up opportunities for jointly addressing specific transnational challenges faced in research and research funding. In 2019, five academies were hosted as guests: from Slovenia, Czechia, Slovakia, Hungary and Poland.

The Joint Academy Days are complemented by engagement in multilateral academy alliances (e.g. All European Academies – ALLEA, European Academies Science Advisory Council – EASAC) and other relevant organisations (e.g. International Science Council – ISC).

Memberships of the Austrian Academy of Sciences (OeAW) in international research alliances and infrastructures on behalf of the Republic of Austria are open to the entire domestic scientific community and stand alongside a variety of autonomously initiated research cooperations with key international players. Examples include: European Synchrotron Radiation Facility (ESRF), European Organisation for Nuclear Research (CERN), Japan Proton Accelerator Complex (J-PARC), European Southern Observatory (ESO), Digital Research Infrastructure for the Arts and Humanities (DARIAH).

Indicator 6: Knowledge and technology transfer

IPR: Patent and exploitation activities as at 31 Dec.	2018	2019
Number of patent applications	46	68
of which national	0	0
of which EU/EPC	11	16
of which non-EU states	35	52
Issued patents	12	9
of which national	0	0
of which EU/EPC	3	4
of which non-EU states	9	5
Current patents	42	53
Exploitation spin-offs	2	3
Licensing agreements	3	4
Options agreements	0	1
Sales agreements	0	1
Exploitation partners	3	6
of which companies	3	6
of which (non-)university research institutions	0	0

Source: Austrian Academy of Sciences (OeAW)

Indicator 7: Gender and promotion of equality

Share of women in management positions by management level; data from 31 Dec.	2018	2019
Institute directors	21%	29%
Scientific directors	20%	20%
(Senior) group leaders	27%	23%
Junior group leaders	24%	24%
Administrative and technical management personnel	44%	45%
Glass ceiling index based on the management levels[1]	1.42	1.38

1 Calculated as the share of women among all employees/share of women in management positions. An explanation of the index can be found in the "Definitions" box at the end of the chapter.

Source: Austrian Academy of Sciences (OeAW)

The Austrian Academy of Sciences (OeAW) supports gender equality and equal opportunities at the structural level and through specific measures. With its broad, diverse membership, the Academy's Working Group on Non-Discrimination (AKG) coordinates a number of important tasks: it creates the plan for the Academy of Sciences to promote women, it supports the Equal Opportunities Commissioner and it is included in staff-related decisions. Because gender and diversity must also be reflected in language, the Working Group on Non-Discrimination (AKG) adapted the guidelines for gender equality in language in 2019 in accordance with current developments in language use. Regular lectures on gender equality and diversity directed at a general public help raise awareness of these issues.

To promote harmony between work and family, the Austrian Academy of Sciences (OeAW) established the programme "Akademie und Kind" (Academy and Child) in 2019, which offers researchers financial assistance in childcare, such as for participation in conferences away from home. In 2019, women represented a greater proportion (66%) of new members of the Austrian Academy of Sciences (OeAW) than men.

2.3.3 Special events in 2019 and outlook

Examples of research results from 2019

- Quantum physicists at the Austrian Academy of Sciences (OeAW) are helping shape the future of communication. Previous experiments teleported binary states, known as qubits. An Austrian-Chinese team has now succeeded in sending three-dimensional quantum states for the first time. One of the potential benefits of these qutrits: they could help connect quantum computers together at higher information rates.
- Organoids enable research on models that are very similar to real tissue in order to investigate the causes of illness in detail. Molecular biologists at the OeAW's Institute of Molecular Biotechnology (IMBA) have succeeded in developing human blood cells from stem cells. With tissue engineering in the lab, it is possible to directly use human tissue to reproduce and observe the production of illness in the vascular system, e.g. as a consequence of diabetes. This opens up new opportunities for understanding the causes of these illnesses and eventually developing therapies.
- Religion increasingly stands at the centre of global controversies surrounding societal values. A study of history is essential to understand today's positions. The Austrian Science Fund (FWF) Specific Research Area "Visions of Community", which was located at the Austrian Academy of Sciences (OeAW) and brought to a successful completion in 2019 after an eight-year run, took a multidisciplinary approach to the question of how religion and politics influenced each other during the Middle Ages not only in Europe but in the Arabic world and Asia as well. This global historical approach was able to unlock many new insights, which can be found in the roughly 60 books and hundreds of other publications that have resulted from the programme.

With the 2015 founding of the Austrian Center for Digital Humanities (ACDH), the presentation of the Digital Humanities strategy and the development and implementation of the funding programmes go!digital and Digital Humanities: "Langzeitprojekte zum kulturellen Erbe" (Long-Term Projects on Our Cultural Inheritance), the Austrian Academy of Sciences (OeAW) has helped establish Austria as an active home to research in the digital humanities. In 2019, the Austrian Academy of Sciences (OeAW) concluded a consortium agreement with a number of universities within the framework of CLARIAH-AT.

Good governance and administrative streamlining remain in the focus of improvement measures. An increasing number of processes are being standardised, especially in the context of the monthly and quarterly reporting.

Two **new, competitive programmes** seek to raise scientific understanding within society at large:

- The grants for science journalists specifically strengthen the media representation of basic research conducted in Austria.
- The "Österreichische Studienstiftung" (Austrian Academic Studies Foundation) supports particularly motivated and engaged young people during their studies. The work of the foundation is primarily conceptual in nature, assisting funded parties with mentoring and seminar offerings over the course of their studies.

New formats for communicating and disseminating knowledge:

- For the first time, the Academy has published science comics to generate enthusiasm for the fascinating world of basic research among eight- to twelve-year-olds. Four winning comics were selected from the submissions to a public competition.
- The lives of 16 researchers who were persecuted in childhood by the National Socialist party and driven out of Austria are illuminated in personal interviews by the film "The Class of '38. Exile & Excellence", which was conceived and commissioned by the Austrian Academy of Sciences (OeAW). A specially adapted grade school version is available online for free.
- Urgent challenges, such as climate change and poverty, were the focus of an international conference on the UN goals for sustainable development, accompanied by a specially planned art exhibition.
- The event series "Wissenschaft und Politik im Gespräch" (Science and Politics in Conversation), established by the President of the National Council and the Austrian Academy of Sciences (OeAW), offers legislators the opportunity to discuss important future topics directly with scientists in a casual atmosphere.

Outlook for the coming years

Forward-looking and competitive science and research remains the top priority of the Austrian Academy of Sciences (OeAW) for the coming years. The continued development of the academy is in accordance with the established agenda of the federal government. In 2020, a new three-year performance agreement will be negotiated for the years 2021 to 2023. A corresponding development plan was already adopted by the Austrian Academy of Sciences (OeAW) at the end of 2019 and submitted to the Federal Ministry of Education, Science and Research (BMBWF).

In the future, the Austrian Academy of Sciences (OeAW) will focus in particular on topics of critical importance for science and society in Austria and Europe, not only with the goal of popularising these topics but also to take a holistic approach to research in the interests of conducting responsible science. The research institutes of the OeAW will also foster an emphasis on insight and an application-agnostic approach to their work. The Austrian Academy of Sciences will continue to pursue its strategy for excellence, which demands the courage to take risks and an openness (within budgetary constraints) to new, internationally competitive research activities, such as in the field of Computational Sciences. The Austrian Center for Digital Humanities (ACDH) will be expanded in 2020 by a focus on cultural heritage, which will considerably strengthen the synergies between long-term research and the digital humanities.

As of 2020, the Austrian Academy of Sciences (OeAW) will be implementing a comprehensive career model based on international standards that has been updated in the course of collective agreement negotiations. This offers top researchers attractive incentives with a tenure option and promises early stage researchers a transparent development path that can serve as an internationally competitive springboard for their further careers. The OeAW's efforts at promoting early stage researchers will be continued, directed toward researchers at all research institutions in Austria since OeAW grants are awarded independent of location and institution, taking solely criteria of scientific quality and originality into account.

The consolidation of the Vienna locations of the Austrian Academy of Sciences (OeAW) will be continued, and a new location concept should be in operation by 2025. The OeAW campus remains the core of this strategy, not only offering research jobs in the heart of Vienna but also an attractive venue for encounters with the public.

To improve cost efficiency and minimise risks, the administrative streamlining will be continued within the entire Austrian Academy of Sciences (OeAW) group, such as via digital workflows.

2.4 Silicon Austria Labs (SAL)

2.4.1 Profile and key figures

Silicon Austria Labs (SAL) is a European research centre for electronics-based systems (EBS). At the three locations of Graz, Linz and Villach, SAL conducts research along the entire EBS value chain, from basic to application-oriented research, from microelectronic components to intelligent systems. Thanks to innovations that add value at every stage, participating companies can secure unique competitive advantages on the world market.

The cooperation model of Silicon Austria Labs (SAL) brings together key players from different areas to work on research projects in the areas of sensor systems, radio frequency systems, power electronics, system integration technologies and embedded intelligence. SAL offers various models customised to the specific research requirements and the technology readiness level (TRL). The cooperation model makes it easier for partners conducting research along the EBS value chain to pool their expertise and know-how in order to realise projects that would not be possible without such pooling.

Because Silicon Austria Labs (SAL) is a newly established research centre that is still in the early stages, data are only available for 2019.

Key figures for 2019

	2019 in €1,000
Total operational income	14,838[1]

1 Note: Figures are preliminary and have not yet been audited.

Source: SAL.

Employees	Headcount	FTE
Total	146	131.32
Women	41	35.2
Men	105	96.1
Total at management level	21	20

Source: SAL.

2.4.2 Indicators for 2019

Indicator 1: Funding, including third-party funding[117]

	2019 in €1,000
Total operational income	14,838
of which contributions from partners	7,400
of which third-party funding	7,496
Global organisations and non-European countries or organisations	0
Public	0
Private	0
EU and European countries or organisations	608
Public	479
Private	129
National organisations	6,055
Public	2,970
Private	3,085
Regional organisations	832
Public	832
Private	0

Source: SAL.

Indicator 2: Quality assurance and evaluations

Evaluations of thematic and strategic orientation (research fields):

The strategic orientation of Silicon Austria Labs (SAL) is regularly subjected to an international evaluation by the Austrian Research Promotion Agency (FFG). This evaluation covers the following aspects of the multi-annual strategic plan (MASP):

- quality of the project (including research programme);
- suitability of the project partners;
- utilisation;
- internationalisation and human resources.

In June 2019, the Austrian Research Promotion Agency (FFG) presented the results of the evaluation and discussed them with SAL management as well as the international evaluators.

SAL management then developed an action list for implementation of the improvements and corrections. A large portion of the measures have already been implemented and integrated into the strategy plan, the research programme and the quality management practices. A status report on the implementation has been submitted to the Austrian Research Promotion Agency (FFG). In addition, the revised research programme was discussed in the Programme Advisory Board of Silicon Austria Labs (SAL) and presented to the Scientific Advisory Board. The Scientific Advisory Board will then submit a list of recommendations to the SAL Supervisory Board.

117 Note: Figures are preliminary and have not yet been audited.

Indicator 3: Human resources and qualifications

Qualifications level	Headcount	m	f	Full time equivalents, rounded	m	f
Dr	62	48	14	58	46	12
DI and Mag/MSc	54	42	12	51	37	14
BA/BSc	15	11	4	14	10	4
No academic title	15	9	6	13	8	5
Doctorate candidates (current thesis project)	21	19	2			
of which employed at SAL	10	9	1			
of which in a structured training programme (doctoral schools, etc.)	11	10	1			
Ratio of completed to current theses	2:19					

Source: SAL.

Special measures

Areas of core competence required at the company now and in the future are derived from a comprehensive overview of the existing technical and social competences of the employees. A staff development plan defines which competences are built up internally, which are retained, which are no longer needed, and which should be procured externally. Binding goals, measures and resources are defined as a result. The staff development concept accordingly contains statements about fields of learning, forms of learning and learning goals (knowledge management per strategic business area, customer category, etc.), know-how transfer, ways of assessing existing potential and needs, instruments and methods of qualification, systems for monitoring success. The needs of the employees are taken into account in the planning of staff development activities. This concerns in particular the career goals, perspectives, talents, preferences and personal aspects of the employees.

Employees at Silicon Austria Labs (SAL) are actively involved in their professional development. The focus lies on career planning and advising as well as consistent employee development. Employees are supported by management and the HR department with suitable training offerings and development perspectives. In all activities, Silicon Austria Labs (SAL) places great value on a systematic and objective measurement of success. This is also the basis for the optimisation and correction of staff development measures and for keeping the current needs of employees and the company in mind.

It is equally important to promote and develop both technical and social competences in a balanced way, especially among managers. In the case of managers, the focus must lie not only on social competences but also an understanding of personal development, communication skills and a partnership-based management style. Professional evaluation of training and education is therefore an important instrument for evaluating the quality and success of the measures. Cost controlling and the evaluation of learning success and final results must be based on informative data from the evaluation of staff development measures within a systematic and holistic perspective, together with broad-based success assessment and cost-benefit analysis.

Key figures are tracked to demonstrate legal compliance and continuous improvement of company and department results. This includes tracking staff fluctuation and the ratio of applicants to hires.

Indicator 4: Output, innovation and excellence

Scientific publications	Number
Articles in scientific journals, peer-reviewed	35
of which listed in Scopus	35
Edited collections (books)	1
of which listed in Scopus	1
Proceedings articles, peer-reviewed	40
of which listed in Scopus	30
Monographs (book chapters)	2
of which listed in Scopus	2
Grants in excellence programmes[1]	
ERC grants	0
FWF Wittgenstein Award, FWF Start Programme	0

1 Note: The focus of Silicon Austria Labs (SAL) is not on basic research but rather constant and direct co-operation with scientific and industrial partners along the EBS value chain in the area of TRL 2 to TRL 6 (see the "Definitions" at the end of the chapter for an explanation of TRL). Nevertheless, both the Austrian Science Fund (FWF) and the European Research Council (ERC) are of interest since basic research should serve as preparation for projects in the SAL research programme. At the current time, there are no ERC grants, FWF Wittgenstein or FWF Start projects, but Silicon Austria Labs (SAL) is working on making better use of funding opportunities for basic research by its researchers.

Source: SAL.

Indicator 5: Internationalisation

	Number
Co-publications with industry partners	35
of which international	13
Participations in H2020	8
EUREKA, COSME	0

Source: SAL.

Special measures

- The employed international researchers expand the international network of Silicon Austria Labs (SAL). The researchers employed at the centre come from 26 nations (Algeria, Austria, Bangladesh, Bosnia and Herzegovina, Brazil, Canada, Ecuador, Egypt, France, Germany, Great Britain, Hungary, India, Iran, Italy, Kosovo, Macedonia, Pakistan, Poland, Russia, Switzerland, Slovenia, Sri Lanka, Tunisia, USA, Vietnam). Alongside the permanent staff, 2019 once again saw the international hosting and completion of many masters' projects.
- Researchers at Silicon Austria Labs (SAL) are active in the following international boards and working groups:
  - *ASCOS Series, H2020-ICT project AQUARIUS*
  - *International Electrotechnical Commission (IEC), TC 82*
  - *ASCOS Series, SPIE Next-Generation Spectroscopic Technologies XI*
  - *Session Chair: IDTechEx 2018, ACMA 2018*
  - *H2020-TEC and Marie Skłodowska-Curie Actions (MSCA)*

- The researchers also produce expert analyses for international technical journals and conferences, such as the Journal of Physical Chemistry, Composite Interfaces, Microelectronics Reliability, IEEE Transactions on Mechatronics, IEEE Transactions on Magnetics, Microelectronic Engineering, Applied Surface Science, Eurosensors XXIII, etc.
- The COMET Austrian Smart Systems Integration Research Center (ASSIC), which is being continued by Silicon Austria Labs (SAL) as a supporting organisation in 2019 for the second funding period (as of 11 July 2019), has welcomed five international industry partners. In the area of scientific partners, the consortium consists of four international partners.
- Silicon Labs Austria (SAL) also supports the internationalisation of the research centre in all other areas of research. In 2019, for example, SAL participated in ten internationally funded projects with a total project volume of approximately €3.86 million.
- In the area of contract research, Silicon Austria Labs (SAL) successfully completed a number of international projects during the reporting period. (The largest orders come from DLR, AIRBUS Group, Baumer Identec.)
- The support organisation also participates in numerous internationally active clusters and associations. This includes continued participation in the European initiatives Electronic Components and Systems for European Leadership (ECSEL, EU Joint Undertaking) and European Technology Platform on Smart Systems Integration (EPoSS), the AMA Association for Sensors and Measurement, the Institute of Electrical and Electronics Engineers (IEEE), the International Society of Optics and Photonics (SPIE) and the Silicon Alps Cluster.

Indicator 6: Knowledge and technology transfer

	Number of patent applications	Granted patents	Patents submitted but not yet registered
National	0	6	0
EPC and EU	2	1	20
PCT	4	0	7
Non-EU countries	3	8	17
Share of co-publications with industry partners among all publications: 45%			

Source: SAL.

Indicator 7: Gender and promotion of equality

	Women	Men	Share of women
Management level 1 (general management)	0	1	0%
Management level 2	3	4	42.8%
Management level 3	3	13	23.5%
Glass ceiling index based on the management levels[1]		1.18	

1 Calculated as the share of women among all employees/share of women in all management positions at all three management levels. An explanation of the index can be found in the "Definitions" box at the end of the chapter.

Source: SAL.

Gender equality plans and measures

The central goals of the gender equality policy are to achieve a balanced ratio of women to men in the research teams and enterprise functions as well as integration of gender equality and gender analysis in the research content. One challenge in improving the share of women within Silicon Austria Labs (SAL) lies in the limited number of female graduates from national and international technical universities. Measures are being undertaken to address young people and in particular women in order to ensure a satisfactory number of female applicants in the future. These include activities like visits from pupils who are at the vocational and general secondary education level to position Silicon Austria Labs (SAL) as an attractive employer. Existing department heads and researchers present their careers at such events to serve as examples for young women interested in careers in research. In the recruiting process and selection process for new employees, all texts and conversations are formulated in a gender-neutral fashion.

Women are underrepresented in the technical-scientific area of Silicon Austria Labs (SAL). Because SAL strives to obtain female candidates in particular and also gives them preference in cases of equivalent qualifications, the share of women is now higher than typical in the technical-scientific sector of the labour market. SAL has an internal Gender Equality Officer, who is responsible for consistently evaluating and developing gender mainstreaming measures. Another gender mainstreaming activity aims to achieve the best possible work and family balance for employees. Flexible rules concerning working hours, the option to work from home and mutually agreed-upon part-time work are measures that serve this end.

2.4.3 Special events in 2019 and outlook

On 26 February 2019, the shares of Carinthian Tech Research (CTR) were transferred from the federal state of Carinthia to Silicon Austria Labs (SAL). This was also the kick-off for the organisational and staff merger between SAL and CTR, which was presented to the media on 25 June 2019.

The first projects in 2019 already made it clear that Silicon Austria Labs (SAL) conducts both basic and application-oriented research along the entire value chain. The cooperative SAL model for research cooperation brings together players from various sectors of science and industry focused on a variety of applications and united by a drive to innovate.

In the **Radar Tomography** project, the project partners are exploring the use of intelligent radar sensors for industrial applications that are already common in the automotive sector. In this cooperation project, Silicon Austria Labs (SAL) brings together two partners from very different industries, resulting in brand new conceptual approaches and solutions. Launched in July 2019, the project is a perfect example of research that extends from components to industrial use.

The **Tiny Power Box** project is all about optimisation of the power density of built-in battery chargers in electric cars, known as onboard chargers. The result: Lower weight, fewer components and smaller space requirements coupled with high efficiency for fast charging and lower environmental impact. This cooperation between the research centre and the five participating international companies is a model project in the area of power electronics. At the same time, the broad industry participation shows that jointly achieved research results can be utilised in a variety of applications all along the value chain, strengthening Austria's long-term innovation potential. These projects highlight SAL's function as a networker and research partner with a focus on the entire system.

In the area of basic research, Silicon Austria Labs (SAL) works with universities and universities of applied sciences to conduct joint research in Uni-SAL Research Labs. At the Carinthia University of Applied

Sciences Villach, the Graz University of Technology and the Johannes Kepler University Linz, employees of SAL are already collaborating with the universities to research a variety of technologies. These Uni-SAL Labs establish the scientific foundation for subsequent application-oriented research carried out in cooperative projects with industry partners.

In the Linz, Graz, Villach research triangle and through cooperation with (inter)national partners from science and industry, Silicon Austria Labs (SAL) is raising Austria's profile in the field of electronics-based systems. By 2023, the staffing at all three locations should be increased to a total of 360 employees and roughly €23 million will be invested in systems and laboratory equipment.

2.5 Austria Wirtschaftsservice (aws)[118]

2.5.1 Profile and key figures

As the federal promotional bank and central point of contact for the promotion of entrepreneurial growth and innovation, the Austria Wirtschaftsservice (aws) is charged with meeting the challenge of keeping pace with entrepreneurial trends, staying attentive to change and innovating within its own services and offerings. To fulfil this duty in the best possible way and actively contribute to strengthening Austria's competitiveness on the international stage, the Austria Wirtschaftsservice (aws) regularly defines its strategic orientation. The strategic focal points of digitalisation, innovative transformation, scalable new enterprises, sustainable growth and internationalisation reflect the current environment, circumstances and future challenges.

Making access to the services of the Austria Wirtschaftsservice (aws) as simple and efficient as possible for companies is a key goal for the coming years, as laid out in the ninth multiannual programme for 2020–2022. The programme structure of the Austria Wirtschaftsservice (aws) has been simplified, and the most relevant programmes that directly address companies have been merged from 44 down to 18. 18 special programmes are additionally directed at specific target groups such as universities and incubators. This new structure is intended to considerably improve the transparency for companies, make the most commonly used offerings more visible and put customer needs in the foreground.

The relaunch of the website of the Austria Wirtschaftsservice (aws) reveals a clear, comprehensible programme architecture for customers with four clusters. At the same time, the contents of the offer are not restricted by this. The "Developing ideas" cluster contains all programmes focussed on the pre-formation phase – with the goal of strengthening entrepreneurship as a career option in Austria. In the "Setting up a business" cluster, the Austria Wirtschaftsservice (aws) supports new enterprises with loans, guarantees, equity, grants and coaching. Established firms are supported by the "Sustainable expansion" cluster in developing new products and production methods, scaling business models and internationalising technologies. With the "Connecting services" cluster, the Austria Wirtschaftsservice (aws) acts as a neutral intermediary to offer companies a number of networking services where solutions may be lacking on the market.

Measures have also been taken to reduce the complexity of the processes for monitoring and controlling the activities of the Austria Wirtschaftsservice (aws), and the system has been focussed on three impact goals. Alongside the assessment of economic effects gained from the monitoring indicators, the

118 Performance figures for 2019 are provisional, pending submission of the performance report to the Supervisory Board of the Austria Wirtschaftsservice (aws) (26 March 2020).

controlling indicators provide information about the successful implementation of the promotional activities in accordance with the impact goals.

Key figures 2018 and 2019

	2018	2019
Projects[1]	3,700	4,770
Total funding [in € millions]	1,100	1,120
Present value (in € millions)	189	135

1 All data exclude any employment bonus.

Employees	**2018**	**2019**
Headcount	278	255
Full time equivalents, rounded	245	227

Source: Austria Wirtschaftsservice (aws).

2.5.2 Indicators for 2018 and 2019

Indicator 1: Funding, including third-party funding

Funding volume (in € millions)[1]	**2018**	**2019**
ERP Fund	600	600
Federal Ministry of Finance (BMF)	187	262
Federal Ministry for Digital and Economic Affairs (BMDW)	243	200
Federal Ministry for Sustainability and Tourism (BMNT)	35	17
Federal Ministry for Transport, Innovation and Technology (BMVIT)	5	6
Federal Ministry of Education, Science and Research (BMWF)	1	0
National Foundation for Research, Technology and Development (NFTE)	7	16
European Commission	15	12
Federal state of Tyrol	4	7
Federal state of Salzburg	4	3
Total	**1,100**	**1,120**

1 The funding volume is calculated as accepted commitments, volume of the issued credit or loan, amount of the awarded grant or established value of a consulting service.

Source: Austria Wirtschaftsservice (aws).

Indicator 2: Quality assurance and evaluations

Surveys of (potential) applicants and assisted companies:

A systematic study of customer satisfaction and service quality continually supplies valuable information on ways to improve the promotion provided by the Austria Wirtschaftsservice (aws) through organisational, technical and thematic refinements. A feedback system for funded companies was developed in 2012 on the basis of internal evaluations. This system is evaluated every six months by the Strategy/Evaluation team (aws-K-Feedback) as an integral component of the monitoring activities aimed at quality assurance. Random samples encompassing an average of 300 funded companies and 25 companies that were not funded are available for the semi-annual assessments.

Evaluations of the programmes and the portfolio:

The quality assurance measures naturally include evaluations. Evaluations are typically conducted by external teams in coordination with the programme owners and are often directly commissioned by them. The timing of these evaluations is based on the term of the programme, typically from two to five years, and is defined upon commissioning of the evaluation, within the assistance guidelines or in the programme documents. The programme documents contain detailed provisions on the type of evaluation, questions studied, indicators and methodology.

To supplement external evaluations, the Austria Wirtschaftsservice (aws) also conducts internal evaluations, where specific needs of the entities commissioning the programmes are taken into account – particularly with regard to the design or redesign of guidelines and programme documents. If evaluations are carried out internally, they serve primarily to improve the internal information base concerning the programme portfolio as well as current evaluation questions and therefore function largely as supplements to external programme evaluations as well as to monitoring activities based on assessments of application data. The following evaluations have been conducted recently:

- Wagner, K. and Pöchhacker-Tröscher, G. (2018): aws Industry 4.0 programme, interim evaluation, commissioned by the Austria Wirtschaftsservice (aws);
- Ecker, B., Gassler, H., Gogola, G. and Sardadvar, S. (2019): Evaluation of "i2 Business Angels" and "aws Business Angel Fund", commissioned by the Austria Wirtschaftsservice (aws);
- Enenkel, K., Merkl, F., Dudenbostel, T., Berger, F. and Vivanco, J. (2019): Evaluation of Industry Startup. Net, commissioned by the Austria Wirtschaftsservice (aws);
- Warta, K., Dudenbostel, T., Gassler, H., Rammer, C. and Köhler, M. (2019): Evaluation of the Frontrunner Initiative, commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT);
- Wagner, K. und Pöchhacker-Tröscher, G (2019): Technology internationalisation programme "aws tec-4market" – final report for programme evaluation, commissioned by the Austria Wirtschaftsservice (aws);
- Sardadvar, S. (2019): Risk Capital in Austria: Venture Capital, Business Angels and Data Validity, commissioned by the Austria Wirtschaftsservice (aws);
- Ecker, B. and Gogola, G. (2019): aws IP Coaching: Satisfaction and needs analysis based on a customer and stakeholder survey, commissioned by the Austria Wirtschaftsservice (aws).

Impact analysis

The internal evaluations also include an impact monitoring assessment conducted every three years by the Austria Wirtschaftsservice (aws); the last was done in 2019). The analysis relates to the funding periods and is largely representative with respect to the monetary funding of the Austria Wirtschaftsservice (aws). The uniform and central approach that spans the various guarantee, loan and grant programmes is based on a survey of assisted companies. This enables a comparative analysis that contributes to improved understanding of the functioning and impact potential of the various instruments of the assistance portfolio. In the 2019 impact monitoring, roughly 1,500 surveys were sent out with 361 responses, distributed among four guarantee programmes, two loan programmes and five grant programmes.

Indicator 3: Human resources and qualifications

	2018	2019
Staff		
Staff (headcount)	278	255
Staff (full time equivalents, rounded)	245	227
Staff structure		
Share of academics	60%	62%
Share of women		
Share of women	57%	58%
Share of women in management	35%	39%
Share of women in project management positions	53%	52%

Source: Austria Wirtschaftsservice (aws).

Indicator 4: Output, innovation and excellence

	2018		2019	
	Number	Share	Number	Share
Funded projects	3,700		4,770	
of which SMEs	3,250	88%	4,630	97%
of which enterprise formations	2,155	58%	1,570	33%
Time to contract[1]	~33 days		~32 days (average)	
Number of consulting sessions for (potential) funding recipients	~25,000		~10,200	

1 Time period between receipt of the application at the Austria Wirtschaftsservice (aws) and finalisation (sending) of the contract to the funding recipient.

Source: Austria Wirtschaftsservice (aws).

Indicator 5: Internationalisation

Memberships in international networks

- European Association of Guarantee Institutions (AECM);
- Network of European Financial Institutions for SMEs (NEFI);
- European Business Angel Network (EBAN);
- European Venture Fund Investors Network (EVFIN);
- Invest Europe.

Indicator 6: Knowledge and technology transfer

Cooperation projects science/industry

	2018		2019	
	Number	Volume in €1,000	Number	Volume in €1,000
Digital Innovation Call*	-	-	15	2,500
Impulse Programme for Transferring Knowledge and Technology in Austria*	-	-	3	2,700
Innovative Youth	431	41	470	52
Creat(iv)e Solutions Call*	-		10	1,200
aws First	12	400	12	400
Austrian Phoenix Founders Award	47	20	103	20

Source: Austria Wirtschaftsservice (aws). Note: * There were no calls for proposals in 2018 for the call programmes.

Indicator 7: Gender and promotion of equality

	2018		2019	
	Number	Share	Number	Share
Number of project managers and share of women in project management of all funded projects	740	20%	1,100	23%
Number of female founders and share of women in all funded enterprise creations	390	25%	240	20%
Evaluating bodies				
aws Supervisory Board	5	33%	5	33%
ERP Credit Committee	2	20%	2	20%
ERP Expert Committee on Tourism Industry	3	43%	3	43%
ERP Expert Committee on Agriculture and Forestry	3	43%	3	43%
ERP Committee on Transport	3	43%	3	43%
Processing, Marketing and Development	3	27%	4	36%
Digital Innovation Call	-	-	3	30%
Film Industry Support Austria (FISA)	7	78%	7	78%
"Impulse" (Stimuli)	11	52%	11	52%
Seed	6	29%	6	29%
"Gründung am Land" (Rural Enterprise Formation)	2	33%	2	33%
kit4Market	5	60%	5	40%

Source: Austria Wirtschaftsservice (aws).

2.5.3 New initiatives and instruments 2019 and outlook

New instruments and highlights 2019

Once again in 2019, the Austria Wirtschaftsservice (aws), acting as the promotional bank of the Republic of Austria, provided loans, guarantees, grants and investments as well as services and consulting to establish a solid foundation for many successful projects and provide valuable stimulus for Austria as a location for doing business, especially in the areas of digitalisation, growth and innovation.

Outlook for the coming years

In response to the COVID-19 crisis, the Austria Wirtschaftsservice (aws) is awarding fixed cost grants[119] and stop-gap guarantees[120] within the framework of the COVID-19 aid fund in order to secure the liquidity of companies. Because innovation activities in particular are financed with liquid resources, these supporting measures benefit research and development work.

On the basis of a comprehensive analysis of economic policy objectives and strategies, socio-economic and technological developments as well as trends among the entities addressed by the promotional efforts, the Austria Wirtschaftsservice (aws) worked with owners, clients and stakeholders within the context of its multiannual programme for 2020-2022 to define three impact goals for the coming programme period:

1. Impact goal: facilitate enterprise creation;
2. Impact goal: support innovation;
3. Impact goal: finance investments in growth.

119 See https://www.aws.at/fixkostenzuschuss-1/

120 See https://www.aws.at/aws-ueberbrueckungsgarantien/

Because technological and economic opportunities emerge in particular from young companies and these structural changes impact the business landscape, it is the declared goal of the Austria Wirtschaftsservice (aws), in accordance with impact goal 1, to continue providing sufficient financial resources for enterprise creations in the future and to support companies beyond the early stages in making large investments. In accordance with impact goal 2, the Austria Wirtschaftsservice (aws) plans to utilise its instruments to raise awareness among companies concerning innovation topics, provide financial resources for the implementation of innovation projects and develop strategies for the protection and exploitation of intellectual property. This should take place so that companies can undertake innovation activities in order to actively capitalise on opportunities to remain competitive despite structural change and continuously adapt to new requirements. With its monetary promotional instruments in particular, the Austria Wirtschaftsservice (aws) shall, in accordance with impact goal 3, continue to support large investments in order to enable growth prospects.

Based on the circumstances, challenges and opportunities encountered by the Austria Wirtschaftsservice (aws), five strategic focal points for strategically and sustainably addressing customer needs and changes during the coming years have been defined in addition to the three described impact goals. With these five strategic focal points as guides, the Austria Wirtschaftsservice (aws) modifies the orientation of its agenda and its support programmes. The following **strategic focal points** were defined in the new multiannual programme for 2020–2022:

1. Digitalisation

The process of digitalisation will bring fundamental changes to the economy and society, placing new requirements on workers. Digital skills are in increasing demand and give rise to the need for lifelong learning. Appropriate qualifications and an enabling mindset support the achievement of social inclusion and a high level of employment even in a digitalised society. Moreover, digitalisation offers new opportunities for the Austrian economy by means of new technologies such as artificial intelligence, big data and 5G applications. Austria wishes to play a pioneering role in this area, in part through an ambitious 5G build-out, which is also substantively supported by the Austria Wirtschaftsservice (aws).

2. Innovative transformation

Innovative transformation, whether due to new customer expectations or the impacts of digital technologies, leads to the development of new (digital) business models, value chains and networks by means of innovative start-ups, existing companies and research institutions, making it an important focal point of the Austria Wirtschaftsservice (aws). Company acquisitions and spin-offs frequently offer opportunities for transformation and reinvention. Best practices can lead the way to new methods that engender innovative transformation and inspire all parts of the ecosystem by example, a dynamic that is supported by the Austria Wirtschaftsservice (aws) through its programmes.

3. Internationalisation

The continuing process of internationalisation (every second job in Austria is directly or indirectly dependent on export) harbours tremendous opportunities as well as potential threats. The Austria Wirtschaftsservice (aws) therefore strives to strengthen Austria within the field of international competition, make companies better aware of new markets and professionally preparing them for an international market presence. This facilitates integration into international value chains and enables SMEs to expand their roles as suppliers and/or exporters.

4. Sustainable growth

Austria has committed to implementing the Sustainable Development Goals of the United Nations and to support them through environmentally oriented industry policy. To live up to this responsibility, the Austria Wirtschaftsservice (aws) has selected sustainable growth as one of its strategic focal points. Compliance with the climate goals will require companies to adapt in extensive and fundamental ways in the coming years and should be supported by the Austria Wirtschaftsservice (aws) through environmental innovations and sustainable financing. The promotion of diversity should also boost the innovative potential, success and productivity of companies.

5. Innovative, scalable new enterprises

Innovative and scalable business start-ups play an important role in the development of Austria as a business location as they contribute significantly to structural change. However, fewer individuals are planning to form new enterprises in Austria over the coming years than in other countries, making it necessary to prioritise a strengthening of entrepreneurial spirit both in education and in public relations work. In addition, various options for early stage financing via the Austria Wirtschaftsservice (aws) should motivate the formation of new enterprises and encourage venture capitalists and business angels to contribute to the long-term success of young companies.

2.6 Christian Doppler Research Association (CDG)[121]

2.6.1 Profile and key figures

The Christian Doppler Research Association (CDG) supports the establishment and operation of the Christian Doppler Laboratories (CD Laboratories) at universities and non-university research institutions and of Josef Ressel Centres (JR Centres) at universities of applied sciences.

These efforts are aimed at promoting application-oriented basic research: This includes application-oriented research activity as well as the necessary further development of the associated foundational scientific knowledge. The participating researchers are granted scientific autonomy within this process. The guiding research question comes from the companies, with no restrictions on the potential topics. Cooperation with companies generates new avenues of research and advances the state of knowledge in the respective research fields. The research results then strengthen the innovative potential and competitiveness of the participating companies.

The promotional programmes of the Christian Doppler Research Association (CDG) are founded on the basic assumption that companies actively participate over the entire term of the programme, in other words seven years for CD Laboratories and five years for JR Centres. The research budget of a CD laboratory is up to €5.25 million, with an annual budget of up to €750,000. This is covered 50% by public funds, or 60% in the case of SME participation. The public funds are provided by the Federal Ministry for Digital and Economic Affairs (BMDW) and the National Foundation for Research, Technology and Development

121 The deadline for report submission by funding recipients for the year 2019 is 31 January 2020. As a result, up-to-date statistical data and accounting data for 2019 are currently not available in full (i.e. January 2020). The listed budgetary data for 2019 therefore correspond to the maximum available budgetary framework and not the accounting data. Figures for the year 2019 that have been approved and released by the CDG general meeting will be available after holding of the general meeting in October 2020.

(NFTE). The remainder of the budget is contributed by the participating companies within the framework of their membership in the Christian Doppler Research Association (CDG). Contract research is not supported. The awarding of funding is subject to a competitive, international public review process, and the CD Laboratories and JR Centres must subject themselves to interim evaluations during the term of their existence.

The funding models of the Christian Doppler Research Association (CDG) strengthen Austria as a place of doing business as well as a place of doing science. Due to this essential bridging function between basic research and innovation, the CDG is internationally considered a best practice model. The work of the CDG also produces great societal benefits since the majority of CDG research units contribute to implementation of the UN Agenda 2030 for sustainable development and achievement of the established *Sustainable Development Goals*.

Key figures for 2018 and 2019

	2018	2019
Funding budget in €1,000	30,609	34,981

Employees	2018	2019
Headcount	14	17
Full time equivalents, rounded	12	14

Source: CDG. Note: Budgetary data for 2019 corresponds to the maximum budgetary framework since accounting data are not yet available. The number of employees refers to the business office of the Christian Doppler Research Association (CDG).

2.6.2 Indicators for 2018 and 2019

Indicator 1: Funding, including third-party funding

	2018 €1,000	2019 €1,000
Funding budget (public)	15,561	18,009
of which federal funds from BMDW	10,501	11,647
of which federal funds from NFTE	5,060	6,362
Total organisation costs in relation to the total funding budget[1]	5.51%	5.98%

1 By internal definition and as reflected in the annual report, the organisation costs include the production costs for intangible investments (e.g. development of new funding processing software) in the full amount as incurred in the year of procurement/programming. Under tax law, however, these are capitalised only after the software is put into use and depreciated over the period of use. Other funding providers represent the annual depreciation costs in their organisation costs, which complicates comparisons.

Source: CDG. Note: Budgetary data for 2019 corresponds to the maximum budgetary framework since accounting data are not yet available. Organisation costs for 2019 based on preliminary actual values (data from 01/2020) and including intangible investments.

Indicator 2: Quality assurance and evaluations

Surveys of (potential) applicants and funded projects

Surveys of the funded CD Laboratories/JR Centres are conducted roughly every five years in the framework of the programme evaluations. The last programme evaluation took place in 2016.

Evaluations of the programmes and the portfolio

- Alt, R., Berrer, H., Borrmann, J., Brunner, Ph., Dolle, B., Helmenstein, C., Jöchle, J., Pirker, J., Pohl, P., Popko, J., Schmidl M. and Schneider H. (2017): Combined programme evaluation of the Christian Doppler Laboratories and Josef Ressel Centres 2016, commissioned by the Federal Ministry of Science, Research and Economy (BMWFW)

Impact analysis

Impact analyses are conducted within the framework of the programme evaluations roughly every five years (see above).

Evaluation and quality assurance concept; institutional quality assurance measures

The evaluation and quality assurance concept for the funding measures of the Christian Doppler Research Association (CDG) is defined in the programme documents and evaluation manuals:

- Programme document 2019 for funding the establishment and operation of Christian Doppler Laboratories, reference no.: BMDW-97.430/0018-C1/9/2018, 16 April 2019;
- Programme document 2019 for funding the establishment and operation of Josef Ressel Centres, reference no.: BMDW-97.700/0009-C1/9/2018, 26 April 2019;
- Evaluation manual for the programme for funding the establishment and operation of Christian Doppler Laboratories, reference no.: BMWFJ-97.430/0021-C1/9/2013, 12 August 2013;
- Evaluation manual for the programme for funding the establishment and operation of Josef Ressel Centres, reference no.: BMWFJ-97.700/0001-C1/9/2012, 13 January 2012.

Ensuring excellent scientific quality is the responsibility of the roughly 45 renowned researchers on the Scientific Board of the Christian Doppler Research Association (CDG). This is based on a multi-stage, international peer review process for the funding decision as well as interim evaluations during the term of the CD Laboratories and JR Centres.

The Christian Doppler Research Association (CDG) is a member of the Austrian Agency for Research Integrity (ÖAWI) and the Austrian Platform for Research and Technology Policy Evaluation (fteval).

Indicator 3: Human capital and qualifications[122]

Funded staff (headcount)	2017					2018				
	Total	Women		Men		Total	Women		Men	
Head of CD Laboratory/JR Centre	95	16	17%	79	83%	103	18	17%	85	83%
Senior postdoc	43	11	26%	32	74%	45	12	27%	33	73%
Postdoc	120	31	26%	89	74%	116	33	28%	83	72%
PhD students	346	111	32%	235	68%	383	114	30%	269	70%
Student employees	173	54	31%	119	69%	231	71	31%	160	69%
Technical specialists	80	33	41%	47	59%	92	49	53%	43	47%
Assistance staff	72	71	99%	1	1%	75	72	96%	3	4%
Other	40	22	55%	18	45%	46	27	59%	19	41%
Total	**969**	**349**	**36%**	**620**	**64%**	**1091**	**396**	**36%**	**695**	**64%**

Source: CDG.

122 No figures from 2019 are available yet for this indicator.

Full time equivalents (rounded) Funded staff	2017					2018				
	Total	Women		Men		Total	Women		Men	
Senior postdoc	17	6	33%	13	67%	20	6	29%	14	71%
Postdoc	60	17	29%	43	71%	65	19	29%	47	71%
PhD students	192	60	31%	132	69%	220	62	28%	158	72%
Student employees	31	9	29%	22	71%	40	12	29%	28	71%
Technical specialists	37	17	46%	20	54%	40	23	57%	17	43%
Assistance staff	13	12	97%	0	3%	14	13	94%	1	6%
Other	12	8	71%	3	29%	14	8	57%	6	43%
Total	**362**	**129**	**36%**	**233**	**64%**	**413**	**143**	**35%**	**271**	**65%**

Source: CDG.

Indicator 4: Output, innovation and excellence

	2018 in €1,000	2019 in €1,000
Funding volume CD Laboratories	27,460	30,471
Laboratories	85	91
Funding volume JR Centres	2,777	4,064
Centres	12	15
Participating companies	158	173
of which SMEs	37	38
Universities (public)	15	15
Non-university research institutes	1	2
Universities of applied sciences	7	7
Foreign universities	1	1
Foreign non-university research institutes	1	1

Source: CDG. Note: Budgetary data for 2019 corresponds to the maximum budgetary framework since accounting data are not yet available.

Time to contract

The evaluation process of the Christian Doppler Research Association (CDG) allows applications to be revised before further processing or for the conditions for further processing of an application to be established (neither case constitutes a rejection of the application). Longer times to contract can arise in such cases. These applications make up 18% of the examined applications and are specially indicated. The average time to contract from submission to approval is given for the years 2017–2019.

- Application processing time: 153 days;
- Processing time for applications with revision: 317 days.

Number of consulting sessions for (potential) funding recipients

Information events and scheduled consulting sessions in the General Secretariat are documented (unscheduled telephone consults are not included). In addition, consulting sessions are occasionally conducted by the Scientific Board if applicants wish this after a deferral for revision or a rejection.

	2018	2019
Scheduled consulting sessions – General Secretariat	36	40
Consulting sessions by the Scientific Board after deferral or rejection	6	7
Information events	4	1

Source: CDG.

Scientific publications from the funded projects[123]

Publications	2017	2018
Journal publications with peer review	390	438
Conference publications with peer review (proceedings)	189	214
Monographs	12	9
Publications in edited collections	22	41
Total	**613**	**702**

Source: CDG.

Indicator 5: Internationalisation

	2018	2019
International CD Laboratories	2	2
Participating companies registered abroad	45	52

Source: CDG.

Possibilities for international cooperation

CD Laboratories can also be established at foreign universities/research institutions. In addition, CD Laboratories offer the option of operating one or more of their modules at a foreign location. A domestic CD Laboratory may also engage foreign company partners.

Indicator 6: Knowledge and technology transfer

	2018	2019
Total funding volume in €1,000	30,609	34,981
of which science/industry cooperation	30,609	34,981
Share in %	100%	100%

Source: CDG. Note: Budgetary data for 2019 corresponds to the maximum budgetary framework since accounting data are not yet available.

	2017	2018
Granted patents	4	16
Records of invention submitted to the university (of applied science)/research institution	27	38

Source: CDG.

123 The publishing activities are evaluated within the framework of interim evaluations. Publication costs are subsidised. A list of publications in Scopus or WoS is not available.

Indicator 7: Gender and promotion of equality

	2018		2019	
Women on permanent evaluation committees and advisory councils	13	28%	12	26%
Assessments conducted by women	14	14%	9	9%
Female heads of CD Laboratories and JR Centres	18	17%	17	15%

Source: CDG.

Programmes with gender equality as a funding criterion

As a measure to strengthen the representation of women among the leadership of CD Laboratories, the staff costs for a female laboratory head can be funded as project costs in special cases (if non-hiring is the sole reason speaking against a positive funding decision). During the term of the CD Laboratory, the university/research institution must establish a way for this hiring and funding to take place.

Beginning in 2020, a number of initiatives are being introduced (see below under "New initiatives and instruments 2019 and outlook").

2.6.3 New initiatives and instruments 2019 and outlook

New instruments and highlights 2019

- After many years of successfully holding the office, Prof. Reinhart Kögerler stepped down from the position of President of the Christian Doppler Research Association (CDG) in 2019, and Prof. Martin Gerzabek was named as the new President of the CDG on 1 July 2019 by Federal Minister Dr Margarete Schramböck. In the course of this transition, new measures for promoting early stage researchers and fostering gender equality were initiated. These were announced in 2019 and will be implemented as of 2020 (see the Chapter "Outlook for the coming years").
- Roughly 250 news items in the year 2019 demonstrate the far-reaching interest of the public in the activities of the Christian Doppler Research Association (CDG). One highlight of these reports is the extensive media coverage of a press conference held in conjunction with the Federal Ministry for Digital and Economic Affairs (BMDW) concerning the Alpbach Technology Symposium.
- Over 100 research units (91 CD Laboratories and 15 JR Centres) were administered by the Christian Doppler Research Association (CDG) in 2019. The funding models of the CDG are still in high demand within science and business: The highest number of new applications for CD Laboratories/JR Centres to date was received in 2018 and 2019.

Outlook for the coming years

Special programme elements at CD Laboratories will be established to pursue the goal of fostering the early stage researchers, especially in STEM fields (science, technology, engineering and mathematics) as well as the more general goal of promoting women in research.

CDG Girls Day

Young female pupils of the lower cycle (about 10–14 years old) have the opportunity to spend a day at a CD Laboratory to learn about research work at universities/research institutions in order to inspire them to pursue careers in research.

CDG Insight Days

Young female pupils of the upper cycle (roughly 15–19 years old) are given the opportunity to spend three days at a CD Laboratory and/or with a company partner of a CD Laboratory to gain insight into the research activities at universities/research institution or companies. This is intended to strengthen their interest in technical and scientific fields of study and in research.

CDG internship

Students in a masters' programme have the opportunity to spend three months working at a CD Laboratory, including potentially one month at a company partner of the CD Laboratories, to encourage them to enter into research. The focus here lies on providing learning opportunities.

2.7 Austrian Science Fund (FWF)

2.7.1 Profile and key figures

The Austrian Science Fund (FWF) is Austria's central institution for the promotion of basic research as well as artistic-scientific research. It supports outstanding research projects in accordance with international quality standards, as well as excellent researchers who are dedicated to the acquisition, expansion and consolidation of scientific knowledge.

Its funding activities in all disciplines focus on cutting edge scientific research, and the quality of this is ensured by international peer review. The Austrian Science Fund's objectives are to strengthen Austria's scientific and economic performance in international comparisons and to increase the country's attractiveness as a location for research and science. In this context, the Austrian Science Fund (FWF) seeks to increase the quantity and quality of research potential according to the principle of "education through research" and promotes dialogue between science and cultural, economic and social life.

Key figures 2018 and 2019

	2018	2019
Total funding budget in € millions	240.	251.6
of which new or extended projects in € millions (amount of new approvals)	230.8	237.4
Staff FWF office		
Headcount	118	121
FTE	101.13	102.24
Number of approved research projects	684	707
Number of individuals funded via funds from FWF (as of 31 Dec.)	4,155	4,175

Source: Austrian Science Fund (FWF).

2.7.2 Indicators for 2018 and 2019

Indicator 1: Funding, including third-party funding

	2018	2019
Total funding budget (research funding) in € millions	240.5	251.6
of which federal funds	233.8	247.5
of which basic budget	215.2	221.3
of which from NFTE and Austria Fund	18.6	26.1
of which BMVIT	<0.1	<0.1
of which funds from the regional governments	4.1	3.2
of which funds from private individuals and donors	1.3	0.9
of which funds from international institutions (including third-party funding acquired)	1.3	<0.1
Processing costs in relation to the funding budget	3.79%	4.02%
Processing costs in relation to funding applied for from FWF	0.87%	0.98%

Source: Austrian Science Fund (FWF).

Indicator 2: Quality assurance and evaluations

Surveys of (potential) applicants and funded individuals

The scientific community is surveyed on various aspects of the Austrian Science Fund (FWF) procedure, funding programmes and research agendas every ten years. These surveys are carried out based on calls for proposals by international institutions. The last survey was conducted in 2013 by the (former) Institute for Research Information and Quality Assurance (Berlin) (now the German Centre for Higher Education Research and Science Studies – DZHW).[124] The survey prior to this was conducted in 2002.[125]

Surveys among project managers are conducted on an on-going basis as part of the final project report aimed at evaluating various aspects of application submission, project management and support and supervision from the Austrian Science Fund (FWF).

Evaluations of funding programmes

Evaluations of funding programmes are assigned by default to independent and proven experts based on transparent selection procedures and defined criteria. They follow the Austrian Science Fund (FWF) rules on the quality and transparency of evaluations, studies and research policy services as well as the standards of the Austrian Platform for Research and Technology Policy Evaluation (fteval) for this process. Evaluations are scheduled at appropriate intervals after the programmes have started and are done for the duration of these (5-10 years). The following programmes have been evaluated in recent years:

- Meyer, N. and Bührer, S. (2014): Erwin Schrödinger Fellowships;
- Ecker, B., Kottmann, A., Meyer, S. and Brandl, B. (2014): Doctoral Programmes;
- Seus, S., Heckl, E. und Bührer, S. (2016): START Programme and Wittgenstein Award;
- Degelsegger-Marquéz, A., Wagner, I., Kroop, S. et al. (2017): International programmes;
- Currently not yet published: Specific research areas;
- Currently open for tender: Programme for Advancement and Appreciation of the Arts (2021);
- Scheduled: Clinical research (2023).

124 See Neufeld, J. (2014).
125 See SPECTRA (2002).

Impact analysis

The programme evaluations (see above) are central impact analyses. In addition to these, higher-level comprehensive impact analyses are carried out by international institutions approximately every ten years. The last analysis was the "Bibliometric Study of FWF Austrian Science Fund" in 2012[126].

An international study "International differences in basic research grant funding – a systematic comparison" was carried out in 2019 in which the Austrian Science Fund (FWF) was evaluated as one of seven funding organisations[127].

Evaluation and quality assurance concept; institutional quality assurance measures

The Austrian Science Fund (FWF) has a systematic internal quality assurance system (IQS) enshrined within the institution. It defines the responsibilities and powers of the employees and ensures that the resources are available. Management assessments are regularly performed on suitability, standards, appropriateness and effectiveness.

The internal quality assurance system of the Austrian Science Fund (FWF) is designed as a combination of elements involving risk management, process management, internal control system, compliance management and internal auditing with the goal of managing and monitoring the company. The expansion and further development of this overarching holistic system takes place in compliance with the requirements of the Research and Technology Promotion Act (FTFG) and the Federal Public Corporate Governance Code.

Indicator 3: Human resources and qualifications

Human resources (as at 31 Dec.)	2018		2019	
	Headcount	FTE	Headcount	FTE
Executive Board (full-time)	2	2.0	2	2.0
of which women	1	1.0	1	1.0
of which men	1	1.0	1	1.0
Executive Board (in an honorary capacity)	3	n.a.	3	n.a.
of which women	2	n.a.	2	n.a.
of which men	1	n.a.	1	n.a.
Heads of department	12	12.0	12	12.00
of which women	6	6.0	6	6.00
of which men	6	6.0	6	6.00
FWF total*	118	101.13	121	102.24
of which women	77	66.18	82	66.73
of which men	41	34.95	39	35.51

Source: Austrian Science Fund (FWF). Note: * including President, Executive Vice President and individuals in marginal employment, not including Vice Presidents or individuals on leave of absence.

126 See van Wijk, E. and Costas-Comesaña, R. (2012).

127 See Janger, J., Schmidt, N. and Strauss, A. (2019).

Special measures

As an expert organisation and because of its funding activities, the Austrian Science Fund (FWF) is very aware of the importance of having well-qualified employees. The Austrian Science Fund (FWF) invests in training and continuing education for its employees in order to ensure that its employees support the quality standards, implement them in real life and continuously improve them. An annual budget is available to the departments for this purpose.

Indicator 4: Output, innovation and excellence

Funded projects (new approvals)	2018		2019	
	Number	€ millions	Number	€ millions
Total	684	230.8	707	237.4
of which universities	556	192.3	574	193.3
of which universities of applied sciences	3	0.9	1	0.2
of which private universities	11	2.6	10	3.1
of which non-university research facilities*	114	35.0	122	40.8

Source: Austrian Science Fund (FWF). Note: * Including research facilities abroad.

Individuals receiving funding (project managers)	2018	2019
Total	665	667
of which women	239	237
of which men	426	429
of which third gender	-	1

Source: Austrian Science Fund (FWF).

Processing time in months *	2018	2019
Programme of stand-alone projects	5.0	5.4
International mobility (Schrödinger and Meitner programmes)	4.1	4.1

Source: Austrian Science Fund (FWF). Note: * Period between receipt of the application by the Austrian Science Fund (FWF) and the decision on funding. It generally only takes a few days until the funding agreement is issued.

Number of consulting events for (potential) funding applicants	2018	2019
Total	32	40
of which coaching workshops	14	17
of which information events	14	13
of which Proposers' Days	4	10

Source: Austrian Science Fund (FWF).

Scientific publications from the funded projects with the peer review procedure*	2018	2019
Total no.	7,701	7,320
of which scientific journals	6,915	6,654
of which collected volumes	245	208
of which proceedings	478	397
of which monographs	21	23
of which editions	42	38
Percentage of open access	92%	89%

Source: Austrian Science Fund (FWF). Note: * Information from final project reports received in the relevant year.

Indicator 5: Internationalisation

Share of projects with international partners as % of all projects (share of projects in progress at 31 Dec. of the relevant year)	2018	2019
Number of ongoing projects	2,354	2,378
Percentage with international partners	75.3%	74.9%

Source: Austrian Science Fund (FWF).

Bilateral and multilateral agreements with foreign research funding institutions (these are existing agreements; it does not mean that there is an option for submitting projects or that projects receive funding every year)

		2018	2019
Within Europe	**Multilateral**	• 13 ERA-NET participations • Cooperation in the DACH region (Germany, Austria, Switzerland)	• 14 ERA net participations • Cooperation in the DACH region (Germany, Austria, Switzerland) • CEUS – Central European Science Partnership (Austria, Poland, Slovenia, Czechia)
	Bilateral	• Belgium/Flanders • Czechia • France • Germany • Hungary • Italy/South Tyrol • Luxembourg • Poland • Russia • Slovenia • Switzerland	• Belgium/Flanders • Czechia • France • Germany • Hungary • Italy/South Tyrol • Luxembourg • Poland • Russia • Slovenia • Switzerland
Beyond Europe	**Multilateral**	---	---
	Bilateral	• Argentina • China • India • Israel • Japan • South Korea • Taiwan • USA	• Argentina • China • India • Israel • Japan • South Korea • Taiwan • USA

Source: Austrian Science Fund (FWF).

Special measures

The Austrian Science Fund (FWF) is involved in a number of international networks and activities and plays a leading role in some of these. The following current memberships and shareholdings should be mentioned first and foremost:

- Science Europe (www.scienceeurope.org);
  - High-level Policy Network on Cross-border Collaboration
  - Task Force on Multilateral Lead Agency Procedure
  - Working Group on Open Access
  - Working Group on Research Data
  - Task Force on Research Assessment
- Global Research Council (www.globalresearchcouncil.org);
- Belmont Forum (belmontforum.org);
- ERC Programme Committee (national expert);
- Georgian National Science Foundation Twinning Project;

- Research on Research Institute (www.researchonresearch.org);
- Cooperation with ETH Zurich on analysis of the Austrian Science Fund (FWF) decision-making process;
- GRANteD (www.granted-project.eu);
- Research Integrity (www.sops4ri.eu);
- cOAlition S (www.coalition-s.org);
- OA2020 (www.oa2020.org).

Indicator 6: Knowledge and technology transfer

In addition to traditional knowledge transfer formats (including the "Am Puls" events and the online platform "scilog"), a number of funding programmes, projects funded via topic-based foundations, and the PEARL network initiative are used to promote knowledge and technology transfer:

"Ideen umsetzen – Wechselwirkung Wissenschaft – Gesellschaft" (Realising Ideas - Scientific – Societal Interplay) funding programmes	Foundations/initiative
• Clinical Research programme (KLIF) • Quantum Research and Technology programme (QFTE) • Programme for Arts-based Research (PEEK) • #ConnectingMinds programme • Stand-Alone Publications promotion programme • Additional funding for peer-reviewed publications • Science Communication Programme (WissKomm) • Top Citizen Science (TCS) Funding Initiative	**Foundations** • Weiss Prize • ASMET Research Award • netidee SCIENCE • Projects of the Herzfelder Foundation **Network Initiative** • PEARL – Prospects in Entrepreneurship and Research Leadership

Source: Austrian Science Fund (FWF).

Indicator 7: Gender and promotion of equality

Percentage of women on permanent committees and advisory boards	2018	2019
Executive Board	60%	60%
Supervisory Board	60%	70%
Assembly of Delegates	34%	39%
Board of Trustees	34%	34%
Scientific Advisory Board	-	50%
START Programme and Wittgenstein Award jury	27%	33%
Programme for Arts-based Research (PEEK) jury	50%	50%
Science Communication Programme jury	-	50%
Total	37%	41%
Percentage of (written) reviews carried out by women	24.1%	26.1%

Source: Austrian Science Fund (FWF).

Number and volume of programmes with gender or equality as a project description criterion or funding criterion

Gender-relevant aspects must be included in the project description for all programmes except in a few cases (extract from the application guidelines): *"All potential gender and gender-related aspects in the planned project and the planned implementation of these research questions must be described in a separate section. This point should still be briefly addressed in the text even if the applicant is of the opinion that a project does not raise these types of issues."* There are a few exceptions, including the Wittgenstein Award, as there is no need to submit a project description here and nominations are instead submitted by third parties.

2.7.3 New initiatives and instruments 2019 and outlook

New instruments and highlights 2019

For the first time in 2019, researchers were able to apply for funding for new, courageous or particularly original research ideas as part of the **1000 Ideas Programme** offered by the Austrian Science Fund (FWF). The programme aims to support new and forward-looking topics with high relevance for science and research, even if this requires the "courage to fail". Over 400 proposals submitted from all scientific disciplines provided evidence of the high demand for this new format. The new programme has also expanded the circle of those submitting applications for the first time and obviously also appealed to new research facilities. The Austrian Science Fund (FWF) is also breaking new ground in the evaluation of project applications for the 1000 Ideas Programme. The applications are evaluated anonymously and partly randomised by an international jury with broad expertise.

With the new **#ConnectingMinds** programme, the Austrian Science Fund (FWF) is adding a transdisciplinary component to its portfolio. The aim is to support joint searches for solutions to complex current issues and to promote social engagement and collective learning. The special feature here is the fact that stakeholders from civil society are involved from the very beginning. The research questions and objectives of the relevant project are therefore already being developed jointly. The experiences, perspectives and proposals of the stakeholders in practice should increase the relevance and ultimately also the knowledge gained. These include representatives of NPOs/NGOs, associations, public administration, companies, health and educational institutions as well as stakeholders who generally have little to do with science and research. Funding is provided for teams that combine scientific and societal knowledge in order to meet the upcoming social, technological, ecological and economic challenges. The first call for proposals was issued in the spring of 2020.

International comparison clearly shows the major potential that philanthropy offers for science and research. Successful initiatives at universities and research facilities have also instigated a welcome cultural change in Austria in recent years which the Austrian Science Fund (FWF) wishes to further by establishing the non-profit **alpha+-Foundation**. The objective is to provide additional support for those researchers who are able to succeed at the Austrian Science Fund (FWF) with the help of new private sponsors. The Foundation began its fundraising activities as of late 2019. In terms of existing Austrian Science Fund (FWF) collaborations with private partners, funds amounting to approximately €1 million were also awarded from the Dr Gottfried and Dr Vera Weiss Science Foundation, the Internet Private Foundation Austria and the Herzfelder'sche Familienstiftung (Herzfelder Family Foundation) to excellent researchers in 2019.

Outlook for the coming years

One essential component of the gradual reforms of the Austrian Science Fund (FWF) portfolio is to advance career programmes that aim to consolidate more female researchers at research institutions and create fair conditions for all applicants. The Austrian Science Fund (FWF) organised an intensive consultation process in order to ensure that the views, expert opinions and recommendations of relevant stakeholders were taken into account in subsequent planning stages. Rounds of consultations were launched with several stakeholder groups in the spring of 2019. A total of four groups were involved: the representatives of the Assembly of Delegates, the Board of Trustees, the Richter Network and the Young Academy, as well as a group of experts on gender equality issues. The results and recommendations for the realign-

ment of future Austrian Science Fund (FWF) career programmes were submitted to the FWF Executive Board in mid-December.

Realignment of the career programmes provides for the following two measures: on the one hand, the plan is to merge the Lise Meitner Programme with the Hertha Firnberg Programme to create a new early stage programme. There are also plans to harmonise the Elise Richter and the START Programme as part of a new Advanced Stage Programme. The reduction of the programmes to the two levels Early Stage and Advanced Stage is intended to ensure equal opportunities and equal prestige for excellent women researchers over the long term at different stages of their careers.

After the consultations were completed the basic principles of the new Early Stage Programme were endorsed in full. The key points include the option for ongoing submissions, needs-based funding amounts, the expansion of mentoring for women and equal allocation of funds (50% of the funds are reserved for women). The new programme and the accompanying measures are intended to give women researchers a fixed and sustainable place in cutting edge research. The discussion process also showed that the next major step towards the sustainable advancement of women must be taken under the joint responsibility of the Ministry, research facilities and the Austrian Science Fund (FWF).

The Executive Board of the Austrian Science Fund (FWF) extended the planning stage and consultation process for reforming the Advanced Stage Programme. The aim remains the same: to take specific steps to retain more women researchers even more effectively and more sustainably in cutting edge research.

Annual increases in the funding budget of the Austrian Science Fund (FWF) (in 2020: €270 million) will ensure planning certainty, increase the efficiency of investments and enhance confidence in Austria as a location, therefore helping it to remain competitive internationally. Outstanding basic research is only possible on a long-term basis and requires sustainable funding, which is reflected in a guarantee covering multiple years. This is particularly important against the background of the consistently high number of projects in recent years that could not receive funding despite excellent ratings by international experts (approved but not funded, funding volume lacking in 2019: approx. €60 million).

One excellence initiative in accordance with international standards is to further intensify cutting edge research and cooperation between fields and institutions, bringing Austria noticeably closer to the world's best science and innovation nations. Such an excellence initiative would invigorate the competitive culture, promote cooperation and create a dynamic research environment for all fields which would also attract top international researchers and offer long-term career prospects to early stage researchers.

Since April 2020 the Austrian Science Fund (FWF) has also been supporting "urgent funding for research into humanitarian crises such as epidemics and pandemics" and "Urgent Funding SARS-CoV-2" (see https://www.fwf.ac.at/en/news-and-media-relations/news/detail/nid/20200316-2495/).

2.8. Austrian Agency for International Cooperation in Education and Research (OeAD-GmbH)

2.8.1 Profile and key figures

The OeAD-GmbH, is the Austrian agency for international mobility and cooperation in education, science and research. Since it was founded in 2009, the OeAD-GmbH has established itself as the central agency for organising national and international mobility, funding and innovation programmes in the Austrian education system. Initially founded in 1961 as an association, the "Austrian Exchange Service" is now a broad-based agency which also stimulates and promotes innovations in education, teaching and research through targeted interventions, in addition to its core mission of supporting the internationalisation of educational institutions through mobility and project funding.

The head office of OeAD-GmbH is located in Vienna, and there are also seven regional offices in Austrian university towns, partner offices in Lviv and Shanghai, and an OeAD Info Point in Baku. OeAD-Wohnraumverwaltungs-GmbH is a subsidiary of OeAD-GmbH that provides accommodation in student dormitories and OeAD guest houses for approximately 12,000 international students, researchers and professors each year.

Key figures for 2018 and 2019

	2018	2019
Total funding budget, disbursements in €1,000	€52,380	€54,390

Employees	**2018**	**2019**
Headcount	214	217
Full time equivalents, rounded	161	164

Source: OeAD-GmbH.

2.8.2 Indicators for 2018 and 2019

Only those research-related activities that are funded from the federal budget under Section 31 of the Universities Act (UG) are included in the following indicators. These are primarily incoming and outgoing grant programmes, activities with our neighbouring countries of Hungary, Czechia and Slovakia, scientific and technical cooperative projects, development research, support for university networks with South East Asia, China and African countries, and the Sparkling Science programme. The OeAD-GmbH's activities cover all phases of the project cycle, such as providing information, advertising, the application phase, evaluation of applications, selection, events forming part of the programme, support during the implementation phase, support and supervision of grant recipients and project implementers, receipt and review of interim and final reports as well as reporting, financial processing and accounting.

Indicator 1: Funding, including third-party funding

Total funding budget (commitments of BMBWF in € millions)	**2018**	**2019**
Federal funding	13.57	12.36

Source: OeAD-GmbH.

The processing costs range from 10% to 20% of the funding budget in accordance with the approvals by the Federal Ministry of Education, Science and Research (BMBWF) to OeAD-GmbH.

Indicator 2: Quality assurance and evaluations

Surveys of (potential) applicants and subsidised companies:

Grant recipients are surveyed regularly on the progress of their study or research activities and on OeAD-GmbH services. Among other things, these surveys provide information on levels of satisfaction with the way the OeAD-GmbH is implementing the programme.

Evaluations of the programmes and the portfolio

The external evaluation of a development cooperation programme as well as the interim evaluation of the Erasmus+ programme at European level over the last two years should be mentioned at the overall OeAD-GmbH level.

Impact analyses and institutional quality assurance measures

OeAD-GmbH prepares an annual report on effectiveness, performance and costs; the 2019 report is not yet available.

The quality management system at OeAD-GmbH has been certified in accordance with ISO 9001 since 2006. Compliance with the requirements of the quality management system is monitored through both internal and external audits.

Indicator 3: Human resources and qualifications

The headcount stated relates solely to those research-related activities that are funded from the federal budget under Section 31 of the Universities Act (UG).

	2018	2019
Staff		
Staff (headcount)	27	27
Staff (FTEs, rounded)	21	21
Management levels as full time equivalents		
Management level	2.5	2.5
Programme coordination and assistance	19	19
Percentage of women as full time equivalents		
Percentage of women overall	67%	69%
Share of women in management	84%	84%

Source: OeAD-GmbH.

Employees at OeAD-GmbH have access to an extensive range of continuing education courses.

Indicator 4: Output, innovation and excellence

Only those projects and individuals funded from the federal budget under Section 31 of the Universities Act (UG) are shown here.

	2018		2019[1]	
	Number	Share	Number	Share
Funded projects	**678**		**634**	
of which at universities	477	70.3%	468	73.8%
of which at universities of applied sciences	22	3.3%	24	3.8%
of which at other institutions	179	26.4%	142	22.4%
Funded individuals	**2,767**		**2,896**	
of which for a bachelor's degree		8.4%		8.4%
of which for a master's degree		33.3%		31.6%
of which for a PhD		34.3%		33.9%
of which postdocs		21.1%		23.4%
of which others		2.9%		2.7%
of which men		50.6%		50.5%
of which women		49.4%		49.5%

1 Note: The 2019 figures are provisional.

Source: OeAD-GmbH.

Indicator 5: Internationalisation

OeAD-GmbH is involved in the European EURAXESS initiative and is a member of the Academic Cooperation Association, the European umbrella organisation for education and science agencies.

Indicator 6: Knowledge and technology transfer

OeAD-GmbH's grant and cooperation programmes involve a knowledge and technology transfer, even though this is not stated as an explicit funding programme objective for many of the programmes.

Indicator 7: Gender and promotion of equality

OeAD-GmbH's evaluation committees are formed on an ad-hoc basis according to the relevant programme and efforts are made to ensure a balanced percentage of women and men.

2.8.3 New initiatives and instruments 2019 and outlook

New instruments and highlights 2019

The grant programmes, actions, support for university networks and the Cooperation Development Research programme all funded by the Federal Ministry of Education, Science and Research (BMBWF) were continued in 2019 based on the usual quality levels. OeAD-GmbH's activities include providing information on and advertising the programme, support during the application phase, organisation of the external evaluation of applications, preparation and implementation of selection meetings, events forming part the programme, support during the implementation phase, support and supervision of grant recipients and project implementers, receipt and review of interim and final reports, reporting and end-to-end administrative and financial processing and accounting.

A new university network known as the Austrian-African Research Network "Africa-UniNet" was established in 2019 in cooperation between the Federal Ministry of Education, Science and Research (BMBWF), the University of Natural Resources and Life Sciences and OeAD-GmbH. Significant interest has been shown in this network from both the Austrian and the African sides. Following the constituent General Assembly in January 2020, the Africa-UniNet will promote networking and cooperation projects between 63 African and 19 Austrian universities, thereby supplementing the existing Austrian university networks for the Southeast Asian region and China for the African continent.

Outlook for the coming years

OeAD-GmbH is moving from being an agency focused on mobility and internationalisation into a more broad-based agency in the fields of education, science and research. The integration of KulturKontakt Austria with a focus on schools opens up new opportunities to promote the dialogue between science and society, particularly in the area of young people and children. The plan is for the different formats and methods from Citizen Science and communication between research and society to be expanded for this purpose.

2.9 Austrian Research Promotion Agency (FFG)

2.9.1 Profile and key figures

The Austrian Research Promotion Agency (FFG) sees itself as the central agency for the promotion of research, development and innovation in Austria. It is the implementation partner of the Austrian federal government in its strategies to strengthen Austria's position as a research and innovation location in global competition and in coordinating the specific strategies needed to achieve this, e.g. in the context of digitalisation, climate and energy, intellectual property rights and open innovation.

As a service provider, the Austrian Research Promotion Agency (FFG) also supports the Climate and Energy Fund (KLIEN) in its efforts to implement its funding programmes and assists the majority of Austrian regional governments in processing their services aimed at promoting research and development.

In addition to implementing funding programmes, the Austrian Research Promotion Agency (FFG) also offers an extensive range of information and consulting services for Austrian research institutions and companies in connection with participating in European programmes.

Based on its expertise in implementation and comprehensive access to the Austrian and European RTI community, the Austrian Research Promotion Agency (FFG) supports RTI policy through its extensive monitoring activities, as well as through activities such as evaluating research premium applications on behalf of the Federal Ministry of Finance (BMF).

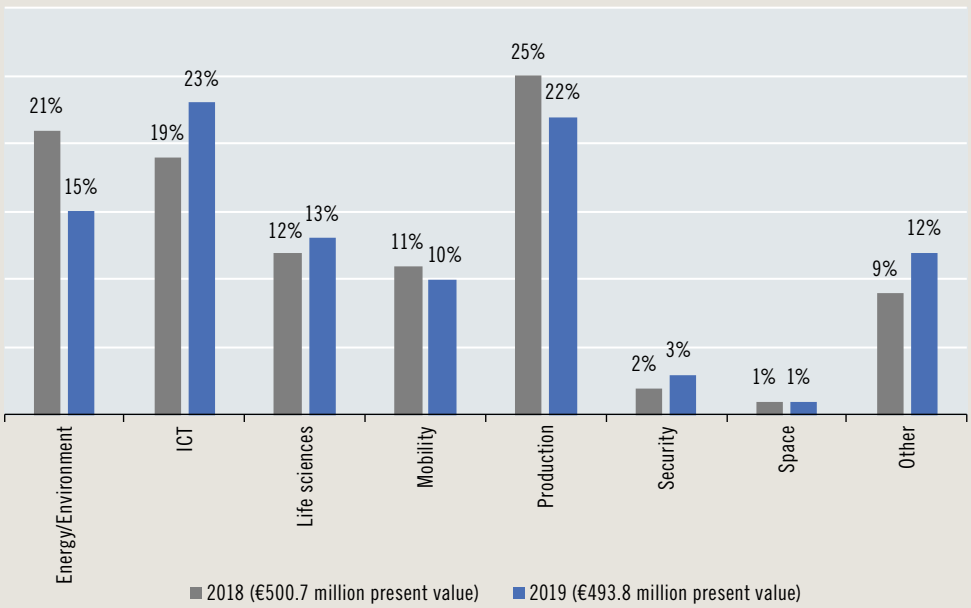
Against this background, the Austrian Research Promotion Agency (FFG) sees itself as a one-stop shop both for Austrian research institutions and companies as well as for owners and clients.

The funding portfolio: the intervention logic behind the funding portfolio of the Austrian Research Promotion Agency (FFG) is based on a broad understanding of research and innovation, and attempts to generate effective added value, on the one hand wherever bottlenecks become evident and on the other

where promising topics and societal challenges need to be addressed. Against this background, the Austrian Research Promotion Agency (FFG) uses the following instruments:

- low-threshold, project-based support for innovation activities for small enterprises and newcomers in an attempt to broaden the innovation base;
- R&D project funding with no topic-based restrictions and predominantly via opportunities for submission that are constantly open in order to pick up companies' specific innovation strategies where they stand and to stabilise innovation processes and promote radical innovations;
- highly competitive R&D project funding geared towards specific topics that sends a strong signal as a contribution towards solving societal challenges and entering new markets;
- promotion of efficient research infrastructures and cooperation platforms in order to increase the performance of the innovation system through efficient cooperation structures;
- promotion of the development of young talents into innovative and expert R&D employees in research institutions and companies. Qualification of established employees in the context of more critical qualification requirements, such as in the context of digitalisation.

Fig. 2-1: Austrian Research Promotion Agency (FFG): Share of funding volume (commitments, present value) as a % in 2018 and 2019



Source: Austrian Research Promotion Agency (FFG).

The Austrian Research Promotion Agency (FFG) actively addresses key innovation topics. The distribution of funds (see Figure 2-1) illustrates the range and underlines in particular the FFG's contribution in safeguarding Austria as a production location, which is subject to particular pressure in terms of transformation and therefore innovation in the balancing act required as a result of the challenges posed by digitalisation and climate protection.

Key figures for 2018 and 2019

	2018			2019		
	FFG not including BB*	BB*	FFG including BB*	FFG not including BB*	BB*	FFG including BB*
Number of projects	3,855	502	4,357	3,545	308	3,853
Participations	6,623	502	7,125	5,910	308	6,218
Players	3,897	179	4,070	3,536	160	3,692
Total costs in €1,000	1,246,895	422,824	1,669,719	1,237,137	252,198	1,489,335
Funding including liabilities in €1,000	617,565	214,931	832,496	618,301	155,257	773,557
Present value in €1,000	500,737	214,931	715,668	493,799	155,257	649,055
Disbursements in €1,000	505,089	27,815	532,903	523,822	85,593	609,415

Source: Austrian Research Promotion Agency (FFG). Note: * BB = broadband

Employees	2018	2019
Headcount	334	356
Full time equivalents, rounded	285	308

Source: Austrian Research Promotion Agency (FFG).

2.9.2 Indicators for 2018 and 2019

Indicator 1: Funding, including third-party funding

Source of funds (not including commissioned projects or broadband)	Present values within the scope of contractual commitments in €1,000	
	2018	2019
Federal ministries acting as owners	381,874	376,191
of which from BMVIT	302,671	323,229
of which from BMDW	79,203	52,961
BMBWF	6,058	3,963
BMNT	0	137
NTFE/Austria Fund	10,321	46,742
Climate and Energy Fund (KLIEN)	62,982	32,337
Regional governments	12,117	11,154
EU	21,373	23,275
Other	6,121	
Total	500,845	493,799

Source: Austrian Research Promotion Agency (FFG). Note: Annual values may be strongly impacted by the timing of the proposals.

Indicator 2: Quality assurance and evaluations

Surveys of (potential) applicants and funded projects

- annual telephone survey on overall satisfaction with all services provided by the Austrian Research Promotion Agency (FFG) (procedures, familiarity with services, support provided by the FFG in the course of its services, etc.);
- online survey reviewing satisfaction with the reporting/project management or with the application process soon after submission (satisfaction with the application, effort, clarity of reporting requirements, etc.);
- focus groups are frequently set up during projects in order to ensure that customers are properly involved, particularly when it comes to further developing applications or handling processes;
- suggestions can be made at any time at anregungen@ffg.at.

Evaluations of the programmes and the portfolio:[128]

- Geyer, A. and Good, B. (2020): Begleitende Evaluierung des Formats Ideen Lab (Supporting evaluation of the Ideas Lab format), study commissioned by the FFG;
- Ploder, M., Sauer, A., Wagner-Schuster, D. and Schön, L. (2019): Strategische Beurteilung der FFG - Förderkooperation des Landes Oberösterreich (Strategic assessment of the FFG - Funding cooperation of the federal state of Upper Austria), study commissioned by Upper Austria;
- Warta, K., Gassler, H., Rammler, C. and Köhler, M. (2019): Evaluierung der Frontrunner Initiative (Evaluation of the Frontrunner Initiative), study commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT);
- Jud, T., Geyer, A. and Good, B. (2019): PdZ Evaluierung Endbericht (Production for the Future evaluation, final report), study commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT);
- Tiefenthaler, B. (2019): Assessment Quantenbericht (Quantum report assessment), study commissioned by the Austrian Research Promotion Agency (FFG);
- Sturn, D., Glinsner, B. and Schuch, K. (2019): Assessment Impact Innovation, study commissioned by the Austrian Research Promotion Agency (FFG);
- Gruber, B. and Schmid, K. (2018): Review Talente regional (Regional talents), study commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT);
- Dall, E., Degelsegger, A., Lampert, D., Schuch, K. and Sturn, D. (2018): Zwischenevaluierung Beyond Europe (Interim evaluation of Beyond Europe), study commissioned by the Federal Ministry for Digital and Economic Affairs (BMDW);
- Handler, R., Jud, Th. und Kupsa, St. (2018) Global Incubator Network – GIN Bericht zur Zwischenevaluierung (GIN interim evaluation report), study commissioned by the Austrian Research Promotion Agency (FFG);
- Biegelbauer, P., Dinges, M., Wang, A., Weber, M., Ploder, M., Polt, W., Streicher, J., Unger, M., Fischl, I., Kaufmann, P., Gassler, H., Konzett-Smoliner, St. and Schuch, K. (2018): Evaluierung der Umsetzung von H2020, EUREKA, COSME, EEN and ERA in Österreich (Evaluation of the implementation of H2020, EUREKA, COSME, EEN and ERA in Austria), study commissioned by the Federal Ministry of Science, Research and Economy (BMWFW);
- Jud, Th., Pohn-Weidinger, S., Kupsa, Heyskamo. C., Schnabel, F. and Rosegger, R. (2018): Ergebnisbericht Smart Cities Demo (SCD) Evaluierung (Report on results of Smart Cities Demo (SCD) evaluation), study commissioned by the Climate and Energy Fund (KLIEN);
- Bührer, S., Daimler, St., Koschatzky, K., Sheikh, S., Kaufmann, P., Ruhland, S., Schmedes, C. and Berghäuser, H. (2018): Evaluierung der Förderungsorganisationen aws und FFG (Evaluation of the funding organisations Austria Wirtschaftsservice (aws) and Austrian Research Promotion Agency (FFG), study commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry of Science, Research and Economy (BMWFW);
- Astor, M. (2018): e-Mobilität Evaluierung Endbericht (E-mobility evaluation, final report), study commissioned by the Climate and Energy Fund (KLIEN);

128 The Austrian Research Promotion Agency (FFG) funding is subject to regular evaluations in accordance with the evaluation plan defined in the relevant programme document. The relevant programme owners are the clients here, although the final reports are not submitted to Austrian Research Promotion Agency (FFG) on a systematic basis, meaning that the list may be incomplete. The Austrian Research Promotion Agency (FFG) only commissions its own evaluations in its own funding areas (e.g. in the case of funding offers financed by the National Foundation for Research, Technology and Development or the Austria Fund).

- Kaufmann, P., Geyer, A. and Nindl, E. (2018): Evaluierung des BRIDGE Programms 2009-2016 (Evaluation of the BRIDGE programme 2009-2016), study commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and Austrian Research Promotion Agency (FFG).

Impact analysis

The Austrian Research Promotion Agency (FFG) commissions an annual survey of the recipients of funding (companies and research institutions) regarding the impact of the funded projects, with each survey commissioned four years after the relevant funded RTI projects have been completed. The survey covers funded RTI projects from the various programmes and areas (General Programmes – GP, Thematic Programmes – TP, Structural Programmes – SP and Aeronautics and Space Agency – ALR) and is therefore not programme-specific. The results are published on a regular basis at: https: //www.ffg.at/content/evaluierung-der-foerderung.

Evaluation and quality assurance concept; institutional quality assurance measures

The Austrian Research Promotion Agency (FFG) has formulated and documented its procedures in defined processes. The evaluation of funding programmes is covered by one of these processes, even though the FFG's services are often themselves subject to evaluations. The process governs the steps in an evaluation process that affect the Austrian Research Promotion Agency (FFG), such as data transfers; however, the main focus of the evaluation is the exploitation of the knowledge generated. Evaluation results are therefore presented and discussed across departments in order to support learning throughout the entire organisation. The steps implemented based on the evaluation are set out below.

Indicator 3: Human resources and qualifications

	Headcount as of 31 Dec. in each case									
	Total		Women				Men			
	2018	2019	2018		2019		2018		2019	
Assistance staff	63	71	51	81%	54	76%	12	19%	17	24%
Experts	246	258	138	56%	151	59%	108	44%	107	41%
General management and other managers	25	27	11	44%	12	44%	14	56%	15	56%
Total	334	356	200	60%	217	61%	134	40%	139	39%
Full time equivalents, rounded	285	308								

Source: Austrian Research Promotion Agency (FFG).

Special measures

- An online employee satisfaction survey was conducted in 2019. A total of 84% of employees took part in this survey. The high levels of satisfaction recorded in previous surveys were confirmed once again: employees at the Austrian Research Promotion Agency (FFG) agreed with the question "All in all, I am satisfied at FFG" with a score of 84 out of 100 points.
- The software in the HR department was migrated in April 2019, with implementation of a new system for recording hours and for HR administration and of a learning management system.

Indicator 4: Output, innovation and excellence

	Research institutions	Higher education institutions	Intermediaries	Other	Companies	of which SMEs	Total
	Participation in projects						
2018	974	1,208	46	633	3,762	2,403	6,623
2019	908	984	52	695	3,271	2,151	5,910
	Present value in €1,000						
2018	135,777	88,106	3,434	12,998	260,423	139,420	500,737
2019	137,103	74,875	3,855	8,732	269,233	127,109	493,799
	Number of projects						
2018	841	822	43	562	2,748	1,912	3,855*
2019	767	665	51	636	2,415	1,639	3,545*

Source: Austrian Research Promotion Agency (FFG). Note: * The question regarding the number of funded projects per organisational type results in projects being counted multiple times when totals are calculated for the organisational types. This has been adjusted, i.e. the totals shown do not correspond with the total project numbers per organisational type.

Time to contract,[129] median values

Funding offer	2018	2019
FFG total	54 days	50 days
of which as examples		
Bottom-up programmes*	69 days	62 days
Small-scale programmes**	12 days	8 days
Research premium	42 days	43 days

Source: Austrian Research Promotion Agency (FFG). Note: * Includes all funding offers that are implemented within the scope of the General Programme document: General Programme Classic, Early Stage, Impact Innovation; ** Mainly includes the internships and the Innovation Voucher.

Number of consulting sessions for (potential) funding recipients

- Funded nationally by the Austrian Research Promotion Agency (FFG): data from 2019[130]
  - 9,109 consultations completed (includes: guideline consultations, questions on the FFG portfolio in general, questions on specific funding, support in connection with the submission tool (eCall).
  - Of which: 588 guideline consultations based on the initial question: "What types of funding are available for my project idea?"
- Consultations within the scope of the EIP mandate
  - 7,100 individual consultations in 2019 and 6,220 in 2018: approx. 75% for the EU Framework Programme; remainder: COSME, Eureka, others.
  - 95 events with approx. 3,700 participants in 2019 and 100 events with approx. 4,900 participants in 2018.
  - Of these: 29 webinars with 1,670 participants in 2019 and 28 webinars with 1,420 participants in 2018.

Special measures

- The funding service set up in 2018 is now fully operational. It provides potential funding applicants with an access portal for their initial consultation as well as *first-level support*.

129 Period from receipt of the application to the signing of the contract (by the FFG).

130 The funding service of the Austrian Research Promotion Agency (FFG) was set up in 2018, although it only started operating fully as of 2019. Therefore no data is available for 2018.

Indicator 5: Internationalisation

Projects with international partners	as % of all projects
2018	16%
2019	17%

Source: Austrian Research Promotion Agency (FFG).

	Commitments	
	Present value 2018 in €1,000	Present value 2019 in €1,000
Article 185: Aal	5,890	1,306
Article 185: Eurostars	3,896	5,953
Eranet EU co-funded	5,759	5,997
Eranet not EU co-funded	3,052	5,015
Eureka	3,964	2,961
Joint Programming Initiatives	4,872	1,413
Joint Technology Initiatives	8,822	10,223
Other transnational projects	6,241	1,996
Total	42,496	34,864

Source: Austrian Research Promotion Agency (FFG).

Participations of FFG in Horizon 2020

The Austrian Research Promotion Agency (FFG) is a partner in 59 H2020 projects. The following table illustrates the portfolio of projects along the H2020 pillars and their instruments.

Pillar	Instrument	Number of projects
Excellent Science	CSA	3
Excellent Science	ERA-NET-Cofund	2
Industrial Leadership	CSA	8
Industrial Leadership	ERA-NET-Cofund	2
Industrial Leadership	H2020-EEN-SGA	3
Industrial Leadership	LS-CSA	1
Societal Challenges	CSA	15
Societal Challenges	ERA-NET-Cofund	16
Spreading excellence and widening participation	CSA	2
Science with and for society	CSA	7
Total		59

Source: Austrian Research Promotion Agency (FFG).

Special measures

The Austrian Research Promotion Agency (FFG) is a member of numerous international networks and initiatives. The most important memberships are as follows:

- Member of TAFTIE, the European Network of Innovation Agencies.[131] TAFTIE's objective is to ensure that its members (currently 31 agencies) exchange their experiences on an ongoing basis and learn from each other. The Austrian Research Promotion Agency (FFG) runs the TAFTIE Academy on TAFTIE's behalf and has led a working group on the topic of "experimental approaches" since 2019.
- Partner in the Innovation Growth Lab (IGL)[132]

131 See www.taftie.org
132 See https://www.innovationgrowthlab.org/

- Member of the evaluation society DeGEval-Gesellschaft für Evaluation e.V.[133]
- With regard to Horizon 2020, the Austrian Research Promotion Agency (FFG) is working closely with the European Commission on the NCP (National Contact Points) Network and the NCPs act as experts in the programme committees. Within the NCP network, knowledge is shared, joint events are held and project partners are found and placed.
- Partner in the Enterprise Europe Network[134]
- Partner in the Science Center Network, an association currently made up of 175 partners from the fields of education, science and research, exhibition design, art, media and industry, which aims to make it possible for people to experience and comprehend science directly and in an easily accessible way.[135]
- In the context of the Aeronautics and Space Agency: Partner in UNO COPOUS (UN Committee on the Peaceful Uses of Outer Space), the IAA (International Academy of Astronautics), associate member of NEREUS (Network of European Regions using Space Technologies) and COSPAR (Committee on Space Research).
- Member of the International Astronautical Federation (IAF)[136]
- Founding member of the think tank ESPI (European Space Policy Institute) with its head office in Vienna[137]

Indicator 6: Knowledge and technology transfer

	Total funding volume (present value)	*Of which cooperation between science/industry*	*Proportion as a %*
2018	500,736,700	297,762,063	59%
2019	493,798,793	284,942,061	58%

Source: Austrian Research Promotion Agency (FFG).

Intellectual assets

- A total of 28% of funded projects report one or more patent applications as part of their output. The observation period for IPR activity is four years after the end of the project. The number of patent applications can vary considerably per project, depending on the subject area and the IPR strategy pursued. The regular impact monitoring for SME research has recorded a total of 396 patent applications from funded projects completed in 2014.
- This survey does not take into account the intellectual property right applications initiated in the course of the Patent Voucher. Internal monitoring by the Austrian Research Promotion Agency (FFG) has so far documented approximately 100 patent applications out of 248 Patent Vouchers concluded in 2019.

133 See https://www.degeval.org/home/
134 See https://www.enterpriseeuropenetwork.at/
135 See https://www.science-center-net.at/
136 See http://www.iafastro.org/
137 See https://espi.or.at/

Indicator 7: Gender and promotion of equality

	Percent in 2018	Percent in 2019
Women on permanent evaluation committees and advisory councils		
Bridge Advisory Board	28%	29%
General Programme Advisory Board	19%	19%
Evaluations carried out by women (not including BB)	28%	31%

Source: Austrian Research Promotion Agency (FFG).

Programmes that include gender or gender equality in their funding criteria

- 100% of the funding at the Austrian Research Promotion Agency (FFG):

Criteria aimed at achieving a gender balance among project teams are now enshrined within all programmes administered by the FFG. In addition, gender-specific topics are expected to be embedded in R&D projects whenever individuals are the subject of the research, and this expectation is addressed as part of the funding criteria.

	2018	2019
Participations with named individuals*	6,386	5,672
Women in a project management role**	1,364	1,273
Share in %	21%	22%

Source: Austrian Research Promotion Agency (FFG). Note: * Not all participations include named individuals but rather organisations ** Project management refers to the management of the participating organisation's project team. If no project management function is recorded, the evaluation is based on the gender of the technical contact person.

2.9.3 New initiatives and instruments 2019 and outlook

In terms of programmes, there were no decidedly new initiatives or instruments in 2019. The focus was on ensuring the continuation of the initiatives launched in 2018. This has been achieved primarily via funding from the National Foundation for Research, Technology and Development and the Austria Fund. The funds were allocated mainly to:

- what was now the third R&D infrastructure proposal (€20 million);
- the continuation of Impact Innovation (€5 million);
- the second proposal for Digital Innovation Hubs (€5 million);
- the continuation of the priority funding for quantum research and quantum technology (€7 million);
- a new focus within the scope of Production for the Future: big data in production (€3.75 million).

Outlook

The government programme sets clear priorities. In addition to digitalisation, climate protection is put forward as a second issue that has a transformative character and that challenges the innovation system as a whole. Research and innovation will play an important role in this. Against this background, the Austrian Research Promotion Agency (FFG) is called upon to develop its promotion and support services further in view of the challenges presented by digitalisation and climate change.

The federal government made an additional €26 million available in the short term in 2020 for researching medicine to combat the coronavirus (as of April 2020). Funding is primarily directed at projects that aim to investigate the effectiveness of existing drugs in the fight against coronavirus.

The Research Funding Act will substantially change the framework conditions for the Agency to be able to act more quickly and more effectively, also in light of the challenges outlined above. In this context, the Austrian Research Promotion Agency (FFG) is working with the federal ministries acting as owners on a new governance policy. The objectives are to:

- clarify and untangle the responsibilities between the ministerial departments and the Agency;
- substantially simplify the funding offer and make it clearer and more accessible for Austrian companies and research institutions;
- promote a concerted focus on the major challenges by breaking up small-scale programme structures;
- improve planning certainty by extending the funding periods, with a switch to 3-year funding agreements.

The launch of Horizon Europe (1 January 2021) marks the start of a new framework programme at the international level. Accordingly, careful attention will be paid to preparation and consultation with respect to the new programme structure. Finally, the Austrian Research Promotion Agency (FFG) will take over as chair of EUREKA from July 2020. With its 47 partner countries and well-established instruments, EUREKA offers companies and research institutions a unique and flexible framework for international cooperation.

2.10 Ludwig Boltzmann Gesellschaft (LBG)

The Ludwig Boltzmann Gesellschaft (LBG) is a research performing organisation that has so far focused on the topics of medicine, life sciences, humanities, and social and cultural sciences. The current government programme provides for the Ludwig Boltzmann Gesellschaft (LBG) to transform from a research performing organisation into a research promotion agency and to add a focus on the topic of health. The new programme includes a clear commitment to the Ludwig Boltzmann Gesellschaft (LBG). The Ludwig Boltzmann Gesellschaft (LBG) is seen as one of the key institutions in the Austrian research area, and it will be given several years of financial and planning security when the Research Funding Act comes into force, thereby providing a solid basis for funding and promoting outstanding and innovative research.

Founded in the 1960s, a far-reaching structural and substantive transformation of the Ludwig Boltzmann Gesellschaft (LBG) was implemented from 2000. Since then, Ludwig Boltzmann Institutes have been founded through highly competitive calls for tender, most recently in conjunction with Open Innovation in Science methods, equipped with a critical core of staff and set up with fixed-term contracts. In contrast with other cooperative programmes geared towards economic concerns under Austrian research agendas, the Ludwig Boltzmann Gesellschaft (LBG) started at an early stage to establish a presence in topic areas that follow other logics than boosting industrial competitiveness. They identified and addressed early on challenges of relevance to society which could be overcome through research. In the past, new sources of funding were also used to expand the LBG Open Innovation in Science Center and the LBG Career Center for junior researchers.

2.10.1 Profile and key figures

The Ludwig Boltzmann Gesellschaft (LBG) currently pursues three strategic objectives:

- finding solutions for complex societal problems;
- implementing and testing open innovation methods in science;
- training and further development of scientists, including for the non-academic labour market.

In order to implement these goals, Ludwig Boltzmann Institutes are founded forming a neutral platform for cooperation between national and international partner organisations from science, industry and civil society. The interdisciplinary research programme is defined by all partners and is also jointly funded by all partners. Funding is provided as both cash and in-kind contributions.

Key figures for 2018 and 2019[138]

Budget by organisational unit in €1,000	2018	2019
Institutes	26,660	26,970
Research groups	1,220	1,320
Center	1,950	2,320
Administrative office*	2,780	2,950
Total LBG budget**	**32,610**	**33,560**

Source: Ludwig Boltzmann Gesellschaft (LBG). Note: * Includes one-off effect due to higher investments; ** 2018: audited amounts in acc. with annual financial statements; 2019: amounts in acc. with budget

Staff working in the administrative office	2018	2019
Staff expenses in €1,000	1,460	1,460
Full time equivalents*	19.7	20.5
Headcount*	22	23
of which women	18	19
of which men	4	4

Source: Ludwig Boltzmann Gesellschaft (LBG). Note: * Full time equivalents and headcount: annual average

2.10.2 Indicators for 2018 and 2019

Indicator 1: Funding, including third-party funding

Funding and third-party funding (in €1,000)	2018	2019
Total budget for the research units*	29,830	30,610
of which federal funds**	15,860	17,120
of which funds from the regional governments	460	700
of which funds from private individuals and donors	3,280	3,510
of which funds from international organisations	200	220
of which third-party funding raised	3,430	3,940
of which other sources	6,600	5,120
Processing costs in relation to the research units' budget* **	**4.9%**	**4.8%**

Source: Ludwig Boltzmann Gesellschaft (LBG). Note: * Amounts rounded to the nearest €1,000; ** Federal funds also include funds for universities (incl. in-kind); *** Processing costs = staff costs for the administrative office

138 Note: The figures for the 2019 reporting year are provisional and subject to approval by the Board of Management of the Ludwig Boltzmann Gesellschaft (LBG).

Indicator 2: Quality assurance and evaluations

Surveys of (potential) applicants and of funded projects

In the course of an Open Innovation in Science enterprise-creation process for two new Ludwig Boltzmann Institutes in the field of digital health, potential stakeholders (federal states, health insurance companies, hospitals, patient advocates, university clinics, NGOs etc.) were consulted concerning promising topics and possible consortia.

Evaluation of the Ludwig Boltzmann Institutes

The Ludwig Boltzmann Gesellschaft (LBG) has two established measures aimed at ensuring the high quality of its research. The Ludwig Boltzmann Gesellschaft (LBG) is the client for the evaluations and puts together an internationally renowned team for interim evaluations. This team consists of three subject experts and one expert in scientific evaluation and research management.

There are essentially two evaluation formats used in the Ludwig Boltzmann Gesellschaft (LBG):

- Ex-ante evaluations: used when new ventures are set up (two new ventures in 2018/19);
- Interim evaluation: every four years.

The evaluation results and recommendations are implemented consistently and monitored by the Scientific Advisory Board and the experts from the administrative office. Institutions may also be closed down in the event of poor performance.

Impact analysis

The Ludwig Boltzmann Gesellschaft (LBG) intensively analyses the impact of its research and uses appropriate instruments for the different purposes:

- Impact-oriented indicators provide an overview of the human, relational and structural capital as well as of the sponsor, bridge and incubator function.
- Narrative Impact Case Studies illustrate the economic and social effects of the research. They also provide important information on the impact of research in different disciplines and sectors, and on which methods generate which short-term impacts and long-term effects.
- A Science Impact Model, based on the theory of change, is used for strategic planning of the economic and social effects of the research.

Evaluation and quality assurance concept; institutional quality assurance measures

- A Scientific Advisory Board (SAB) composed exclusively of international experts (generally with five people) has been established for external quality assurance purposes for each Ludwig Boltzmann Institute (LBI). This Advisory Board meets once a year at each LBI and submits written recommendations. There were 66 international experts working in 14 SABs in 2018 and 72 experts working in 16 SABs in 2019.
- There is also an internal quality assurance procedure in place with representatives from the partner organisations.

Indicator 3: Human resources and qualifications

Human Resources	2018
Total staff *	627
of which women	369
of which men	258
Full time equivalents, rounded	326
of which women	192
of which men	135
Work and service contracts	172

Note: * This includes genuine employees and freelancers, as well as employees on temporary contracts.

Source: Ludwig Boltzmann Gesellschaft (LBG).

Special measures

The following continuing education measures are offered by the LBG Career Center:

Pre- and post-docs: individual offers (such as the career chat, potential analysis, coaching, career advice, career budget, etc.) and institutional offers, i.e. career events (expert talks, skills training, career workshops) as well as special programmes (expert internships, 4 fellowships 4 entrepreneurs, summer school LEAD_able) have all been available to the pre- and post-doc students at the LBI free of charge since 2017. There were 280 pre- and post-docs in 2019 who took advantage of these services, with significantly more women (56%) using them than men (44%). This year, 60 people used their career budget (for individual training and continuing education) and 90 people took part in career events. In addition, all the places were fully booked in the "Special Programs 4 Fellowships 4 Entrepreneurs" (6 individuals) and at the Summer School LEAD_able (16 individuals) and there were also 7 expert internships in 2019.

Managers or heads of the Institute and their deputies (approx. 40 individuals): since 2019 there have been collective offers within the framework of the LAB - Leadership Academy Boltzmann (leadership circle, leadership and management training, LAB modules with partners) and individual offers (executive coaching, leadership profile, executive education budget) for the heads of the LBI institutes, which are implemented on a step-by-step basis and are becoming increasingly popular.

Indicator 4: Output, innovation and excellence

Scientific publications

Total LBG scientific publications	2018		
	Med./LS	GSK	Total
Articles in scientific journals	449	81	530
First editions of scientific reference books (monographs)	0	8	8
Collected works			
Editorships	2	19	21
Articles	18	106	124
Policy papers	1	15	16
Other publications	3	93	96
Popular scientific literature	11	12	23
Total	484	334	818

Source: Ludwig Boltzmann Gesellschaft (LBG).

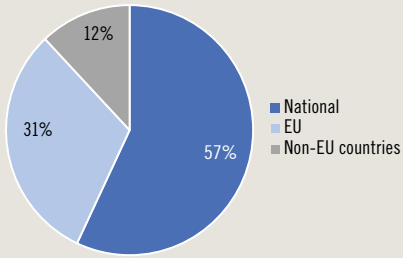
Aside from recording the publication output, the Ludwig Boltzmann research units' scientific output is also recorded in other categories. These include:

- creation of guidelines and reference works;
- development of technologies (patents);
- development of therapy and treatment approaches;
- implementation of preclinic proof of concept studies;
- implementation of clinical studies.

Indicator 5: Internationalisation

The Ludwig Boltzmann Gesellschaft (LBG) cooperated with 162 partners in 2018, most of which are located in Austria and in the EU.

Fig. 2-2: Proportion of international cooperation partners at the Ludwig Boltzmann Gesellschaft (LBG) in 2018



Source: Ludwig Boltzmann Gesellschaft (LBG).

The Ludwig Boltzmann Gesellschaft (LBG) was involved in a total of 19 EU projects in 2019 (compared with 15 projects in 2018). Five of these projects were coordinated by the Ludwig Boltzmann Gesellschaft (LBG). Examples include the ALKATRAS project in the area of cancer research, EUNetHTA in health technology assessments, TRAIN-ERS, ARREST BLINDNESS and THIRST in experimental and clinical traumatology, iDysChart (ERC CoG) in rare and undiagnosed diseases as well asIMediaCities and Visual History of the Holocaust in digital history.

Indicator 6: Knowledge and technology transfer

	2018	2019
Share of co-publications with industry partners among all publications:	9.5%	-
Number of patent applications	0	1
Exploitation partners (companies, university/non-university research institutions)	0	1

Source: Ludwig Boltzmann Gesellschaft (LBG). Note: There were no patents, licence, option or sales agreements or spin-offs in either year.

Indicator 7: Gender and promotion of equality

Percentage of women on permanent evaluation committees and advisory boards		
Year	**Number of people**	**Percentage of women**
2018	66 (44 men, 22 women)	33%
2019	72 (48 men, 24 women)	33%

Source: Ludwig Boltzmann Gesellschaft (LBG).

Proportion of evaluations carried out by women		
Year	**Number of people**	**Percentage of women**
2018	24 (15 men, 9 women)	37.5%
2019	34 (18 men, 16 women)	47%

Source: Ludwig Boltzmann Gesellschaft (LBG).

At both of the two new digital health institutes established in the reporting period 2018 and 2019 in Salzburg (Digital Health and Prevention) and Vienna (Digital Health and Patient Safety) three juries, each of which was specially set up and comprised of different members, were active:

- Selection of topics: 8-member jury with 3 women (proportion 37.5%);
- Definition of guiding questions: 16-member panel of experts with 6 women (proportion 37.5%);
- Selection of the Principal Investigator and Co-Investigator Teams in an Ideas Lab by a 7-member panel of mentors with 3 women (proportion 43%).

As such, the selection and evaluation committees for establishing LBI Digital Health reveal a proportion of women averaging 37%.

Number and percentage of women in management positions* (research)		
Year	**Number of people**	**Percentage of women**
2018	27 (18 men, 9 women)	33%
2019	37 (23 men, 14 women)	38%

Source: Ludwig Boltzmann Gesellschaft (LBG). Note: * Heads and deputy heads

Gender equality plans and measures

The Ludwig Boltzmann Gesellschaft (LBG) is aiming to achieve certification as a "family-friendly employer" in 2020 (via the career and family audit berufundfamilie, see https://www.familieundberuf.at/audits/audit-berufundfamilie) in order to highlight previous measures and to develop new ones. These should also include gender equality measures aimed at improving reconciliation of work and family life, as well as special measures aimed at promoting women, particularly in management positions.

2.10.3 Outlook

The Ludwig Boltzmann Gesellschaft (LBG) is celebrating its 60th anniversary in 2020. A total of 20 Ludwig Boltzmann Institutes are currently conducting research with partners from science, industry, politics and society in the fields of medicine and life sciences as well as in the social and cultural sciences and humanities. The plan under the current government programme is to transform the Ludwig Boltzmann Gesellschaft (LBG) from a research performing organisation into a research funding agency and for it to focus on medical topics in the future.

COVID-19 supporting measures: the OIS (Open Innovation in Science) Research Enrichment Fund supports activities of Ludwig Boltzmann Institutes which are dealing with the challenges of the current "coronavirus crisis" and therefore helping to create a greater impact from their work. Support is offered for the application of open innovation within science in the broader sense.

Definitions

Global budget: The Austrian "global budget" or the basic funding of the research institutions refers to all grants from the owners/ shareholders/supervisors that have not already been earmarked (frequently based on a performance agreement). The institutions allocate the basic funding themselves.

Third-party funding: The third-party funding of the research institutions includes both customer revenues (private and public) and funding raised. Funds of the National Foundation for Research, Technology and Development and the Austria Fund are also included in third-party funding, but other income from the onward charging of costs by charging for services, or funding from the Public Employment Service Austria (AMS) and research premiums is not.

Publications: The publications only include scientific publications (not project reports, etc.) that have undergone a quality assurance procedure (peer review). All publications have a "persistent identifier" such as a DOI or ISSN and have been published in scientific journals, collected works, proceedings or monographs. Publications with multiple authors are evaluated as "whole counts" (i.e. the publication as a whole is attributed to each author).

WoS and Scopus: The Web of Science (formerly ISI, Web of Knowledge) is a multidisciplinary database run by Clarivate Analytics which lists scientific publications with their citations. Scopus is a similar database from Elsevier with bibliographic references to scientific literature. Scopus contains more entries and also covers non-natural science disciplines on a broader basis. Nevertheless, research organisations were given the option of presenting their publications in accordance with Scopus or WoS.

Funding budget: The research funding agencies use various terms to describe their funding or financing activities. For the purposes of the Research and Technology Report, approvals or commitments are reported as present values. The Austria Wirtschaftsservice (aws) presents items in a different manner, a footnote explains the correlation.

Time to Contract: The Time to Contract is the period between the receipt of an application by the research funding organisation and the finalisation (sending) of the contract to the grant recipient. However, research funding agencies use different definitions for time to contract which are explained in footnotes. This will be harmonised in future years.

Grants: The volumes of the projects acquired by the research institutions are also stated as approval sums ("awarded"). Only those projects newly acquired in the relevant reporting year are shown and not the ongoing projects, in order to avoid double counting.

Reporting dates: All budget figures and employee headcounts are recorded as of 31 December of the relevant reporting year.

Glass Ceiling Index: According to SHE figures, this index compares the percentage of women as a share of all employees with the percentage of women in management positions.[139] The Index can take all values between zero and infinity. A value below 1 means that women are relatively overrepresented in management positions, a value above 1 means that women are underrepresented. The higher the value, the greater the level of underrepresentation.

The **Technology Readiness Level (TRL)** is a scale used to assess the state of development of new technologies based on a systematic analysis. It indicates how advanced a technology is on a scale of 1 to 9. TRL 1 refers to basic research that is still very far from application, TRL 9 to technologies that have already been successfully implemented.

139 See European Commission (2019e):

3. Artificial Intelligence (AI)

3.1 Context

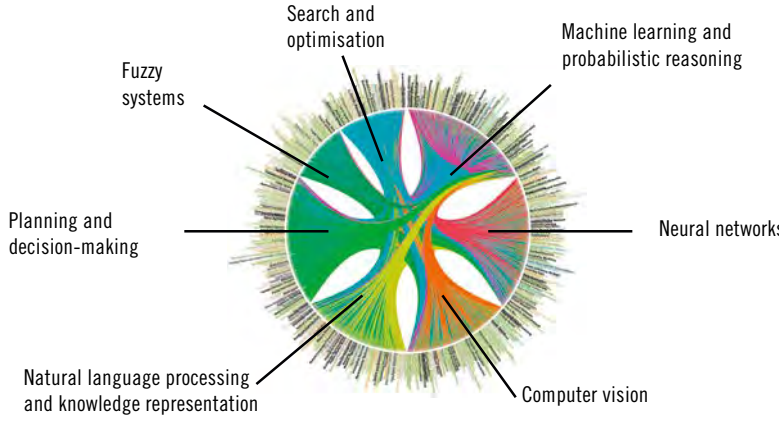
Digitalisation is a major trend in national and international innovation systems (see also Austrian Research and Technology Report 2019), and the area of artificial intelligence (AI) is attracting particular attention. The increasing use of AI and its rapid technological development at present are benefiting most notably from the availability of large volumes of data (big data), the rapid growth in computers' processing power and algorithms that are constantly improving.

Based on the European Commission's definition of the term, **artificial intelligence** means artificial systems that appear to demonstrate intelligent behaviour. These systems analyse their environment and act with a certain degree of autonomy in order to achieve specific objectives. They can be software-only systems that perform actions in virtual environments or systems embedded in hardware, such as smart robots, drones and autonomous vehicles.[140] An important distinction is made in the AI field between narrow and general AI.[141] A general AI system is conceived as a system capable of carrying out most of the activities that humans can. Narrow AI systems, by contrast, are able to perform one or a few specific tasks. The AI systems currently in use are all examples of narrow AI.

This definition of AI presents significant obstacles to more detailed analysis. In particular, research papers/findings, applications, companies and projects in this field are difficult to classify due to the **duality of applications and technologies** (i.e. AI refers both to the technology/technologies used and to a broad range of different applications). Another issue preventing clear categorisation is the simple fact that many AI disciplines currently employ methods borrowed from other fields – robotics and speech recognition often use learning systems, for instance, while many modern robots use image analysis systems.[142]

As Fig. 3-1 clearly shows, AI covers much more than just learning systems that approximate functions based on an extensive data pool. Modern AI research encompasses a large number of areas that do not use any data at all to create models or solve problems, such as "searching" or "planning". However, the feasibility of an AI project is heavily dependent on the structure of the problem at hand and often requires in-depth expert knowledge of the relevant domain.

Fig. 3-1: Areas of AI research



Source: de Kleijn (2018), revised.

140 See European Commission (2019a).
141 See Nilsson (2009).
142 See Prem and Ruhland (2019).

Consequently, we can also make a rough categorisation of AI based on **technology and areas of application,** which can be understood as a pragmatic grouping:

- knowledge-based systems (which work primarily using symbols with linguistic connotations and with logical and database methods);
- learning systems (especially the kind of numerical and statistical methods used in neural networks);
- robotics (potentially restricted to autonomous and smart robot systems as distinct from traditional industrial robotics) and autonomous driving;
- pattern recognition, image processing and video analysis (or image understanding methods);
- speech processing systems (both generating and analysing text and speech).

The use of AI will undoubtedly bring about fundamental disruptive changes to the relevant societies in all manner of different areas. AI is also seen as harbouring the potential to help solve the big societal challenges.[143] The corresponding areas of application are varied and diverse.

In November 2018, therefore, an Austrian Council of Ministers approved a resolution for a federal strategy with the working title of "**Artificial Intelligence Mission Austria 2030 (AIM AT 2030)**", which establishes a framework for the use of AI in all areas of life. This was based on the definition of artificial intelligence agreed by the Austrian Council for Robotics and Artificial Intelligence (ACRAI): *"Artificial intelligence (AI) refers to systems with 'intelligent' behaviour that analyse their environment and act with a certain degree of autonomy in order to achieve specific objectives."*[144]

A broad-based discussion process was thus launched that was designed to enable as many experts and other interested parties as possible to be active participants. It was underpinned by an analysis of the current situation in Austria and an international comparison with the pioneers in the AI field. One initial outcome of this process was the finding that Austria already enjoys a very good position in some niches (e.g. machine learning, robotics and autonomous systems). Experts were then invited to join one of seven working groups to contribute their specific skills. As well as the various fields of activity, discussions centred mainly around the options for action, which were to be combined to form potential strategies for Austria. The findings from all the working groups were subsequently discussed with all the participants and consolidated further. The corresponding results report[145] was published in November 2019. Although the strategy development was not completed due to early elections, there is now not only a comprehensive analysis of AI in Austria but also a roadmap for the future to develop a federal AI strategy.

The current federal government's programme underlines the significance of AI as part of the digitalisation-driven technological change that society is undergoing. Developing the AI strategy announced in 2018 is one of the explicit aims of this programme and combines the technological opportunities opened up by expanding on Austria's existing AI strengths with the formulation of ethical guidelines for using AI.[146]

3.2 AI in schools and higher education

In the Artificial Intelligence Mission Austria 2030 (AIM AT 2030), the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Federal Ministry for Digital and Economic Affairs (BMDW) state that *"Knowledge in dealing with AI systems is essential not only for experts. Digital skills for citi-*

143 See Austrian Council on Robotics and Artificial Intelligence (2019).
144 ibid.
145 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019b).
146 See Federal Chancellery (BKA) (2020).

zens are a prerequisite for a fearless and productive use of AI technologies and for participating in society. AI competencies must therefore have their place in education and training at schools, in teaching and at universities. AI can help learners and educators to make learning more effective and exciting."[147] AI is a cross-cutting theme whose rapid development will see it affect virtually everyone in Austria in the future, which will make critical reflection and a fundamental understanding essential. AI can be deployed in all manner of different ways in school and higher education, in particular in order to expand and broaden the opportunities afforded to educators and learners.[148]

The "Zusammenfassung der Ergebnisse der Expertinnen und Experten zur Erarbeitung eines Strategieplans für Künstliche Intelligenz" ("Summary of experts' findings for developing an artificial intelligence strategy") builds on this and identifies the following required improvements in terms of qualifications, training and continuing education:

- *"determine the specific AI qualification needs from a broad perspective as against the degree of specialist depth required in qualification measures for the individual target groups (develop a competency map);*
- *re- and upskill so that people in gainful employment can acquire AI competencies even while at work, focusing on basic AI skills;*
- *anchor AI application expertise in the education system as early as possible;*
- *establish an overview of AI learning software;*
- *integrate ethical and data protection aspects into training and continuing education for software developers;*
- *expand existing sub-areas of AI such as machine learning, expert systems, robotics, autonomous systems and computer vision in research and teaching, and strengthen niches;*
- *intensify training for AI developers;*
- *set up AI-specific professorships in the tertiary sector and step up cooperation with international experts, taking particular account of sustainability issues;*
- *implement excellence initiatives for AI research both on a broad base and in depth, and fund infrastructure;*
- *raise awareness to combat discrimination in collecting/analysing data;*
- *anchor ethical questions in research and teaching as a central theme for gender equality and diversity (focus on the Third Mission);*
- *standardise and certify AI-related competencies;*
- *integrate '21st-century skills' and update schoolbooks and teaching materials."* [149]

Two discernible sub-areas emerge from these challenges: firstly, teaching about AI and the critical reflection on and discussion of its impact, and, secondly, the specific use of AI in areas of teaching and learning.

The focus in school education lies in particular on strengthening STEM teaching and developing AI competencies as well as on integrating AI into teacher training. In this context, the "Zusammenfassung der Ergebnisse der Expertinnen und Experten zur Erarbeitung eines Strategieplans für Künstliche Intelligenz" ("Summary of experts' findings for developing an artificial intelligence strategy") recommends anchoring digital and, in particular, AI competencies in educational strategies as early as possible and explicitly encouraging women and girls. Schools are also to be helped to set their own AI priorities within the scope of the autonomy afforded to them. For VET colleges, the experts recommend increasing the

147 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019a, 12).

148 See Birkelbach et al. (2019).

149 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019b).

number of STEM students accepted and AI topics covered in future. Measures must also be taken to close the skills gap between school education and the requirements of a degree or job. As regards the specific use of AI in school education, the recommendation is to further enhance teachers' skills in using AI sensibly and beneficially in lessons by making AI an integral part of their training and continuing education and development. Teachers are also to be supported by providing them with an (information) platform showcasing available AI systems and the methodological opportunities that they offer.[150]

One area of application in higher education that uses artificial intelligence and that is already being discussed and trialled at Austrian higher education institutions (sometimes under a different name) is **learning analytics (LA).** Learning analytics *"means analysing, presenting and interpreting data from teaching and learning settings so that students can make direct, immediate changes to their learning"*.[151] AI technologies (such as machine and deep learning) can be used to gain new insights into successful learning and its potential determining factors from a significant volume of data of all conceivable kinds. Learning analytics puts students at the centre and gives them support, particularly to improve their learning performance, e.g. via adaptive feedback, personalised answers or recommendations. And this support need not necessarily be delivered by automatic means. Instead, it generally requires input from teachers, who can use dashboards (a graphical user interface) to view the insights obtained from the data and presented in visual form. Learning analytics can also improve teachers' teaching skills by encouraging them to reflect on their teaching methods and strategies and enabling them to provide their students with more targeted, more tailored support. Analysing learning processes also allows flawed approaches to be identified and thus the quality of teaching to be improved for everyone involved.

In November 2019, the Forum Neue Medien in der Lehre Austria (Austrian Forum for New Media in Teaching), which is made up of representatives from Austrian higher education institutions and the Federal Ministry of Education, Science and Research (BMBWF), published a white paper entitled "Learning Analytics: Einsatz an österreichischen Hochschulen" ("Learning analytics: its use at Austrian higher education institutions") in order to raise awareness of the topic and place it in the public eye. The paper makes four substantive recommendations:

- *"produce and share information on learning analytics in a targeted way to inform, mobilise and raise awareness amongst all stakeholders;*
- *promote specific implementation projects of varying sizes in Austrian educational establishments;*
- *build up a national exchange platform to promote expert exchange on the ethical and legal framework, formulate a common code of conduct or develop joint technical standards amongst educational establishments;*
- *actively involve all stakeholders, particularly students."* [152]

So-called **intelligent tutoring systems** are another area in which AI can be used. Unlike with learning analytics, intelligent tutoring systems are designed to give students personalised feedback independently and in real time – to simulate the teacher, in other words. Virtual tutors "observe" students' behaviour and draw their own conclusions from their learning history, which is backed up by data. AI can thus be used to provide students with targeted support commensurate with their competency level and relieve the burden on teaching staff. In turn, the data generated by the intelligent tutoring system help to improve the AI systems.

Following on from a call for tenders issued in 2019

150 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019b).

151 Forum Neue Medien in der Lehre Austria (Austrian Forum for New Media in Teaching) (2019, 8).

152 Forum Neue Medien in der Lehre Austria (Austrian Forum for New Media in Teaching) (2019, 4).

on "digital and social transformation in higher education", the Federal Ministry of Education, Science and Research (BMBWF) is funding selected university projects, some of which also have an AI element (see the section entitled "Current topics and trends in the higher education sector"). For example, the project "PASSt – Predictive Analytics Services für Studienerfolgsmanagement" ("PASSt – Predictive Analytics Services for Managing Study Success"), run by the Vienna University of Technology (in cooperation with the Graz University of Technology), is looking at using data to support students, while the project "Learning Analytics – Studierende im Fokus" ("Learning Analytics – Focus on Students") at Graz University of Technology (in cooperation with Vienna University of Technology) is concentrating on combining digitalisation with a social dimension by making the individual student's studies visible.

At bachelor's and master's level, higher education teaching traditionally treats the topic of artificial intelligence as part of the core discipline of computer science or as part of a "Data Science" degree, as is the case at Vienna University of Technology and Graz University of Technology and at the universities of Vienna, Innsbruck, Salzburg and Klagenfurt. At master's level, specialised degrees such as "Visual Computing" (Vienna University of Technology) and "Information and Computer Engineering" (Graz University of Technology) have a strong AI element. Robotics courses form part of most computer science degrees but are also found in degrees such as mechatronics and electrical engineering. In the 2019 winter semester, the Johannes Kepler University Linz became the first university in Austria to offer both a bachelor's and a master's degree programme called Artificial Intelligence. Universities also offer specialised continuing education courses. In 2019, for instance, Graz University of Technology developed a two-day course in "AI Essentials" in cooperation with Know-Center that is intended particularly for business owners and entrepreneurs.

Amongst the universities of applied sciences, many offer courses with a practical bent that explore AI and teach relevant basic knowledge in this area. Relevant courses on computer science, mechatronics, automation engineering, robotics, *data science* and other topics are offered at the universities of applied sciences in Upper Austria, Salzburg, Carinthia, Burgenland and Vorarlberg, at the University of Applied Sciences Kufstein Tirol, MCI Management Center Innsbruck, St. Pölten University of Applied Sciences, University of Applied Sciences Wiener Neustadt, FH Joanneum University of Applied Sciences, CAMPUS 02 University of Applied Sciences, UAS Technikum Wien, and at FH Campus Wien.

Experts consulted to draft a strategy for artificial intelligence recommend increasing the amount of AI taught at higher education institutions in order to make the relevant competencies accessible to as many people as possible and place emphasis on anchoring AI in the curriculum. Throughout this anchoring process, AI must always be understood as an inter-disciplinary topic and must include topics from the humanities and social sciences as well. Existing competency areas are also to be strengthened further. Other recommendations are to set up research funding programmes for machine learning, expert systems, robotics, autonomous systems and computer vision and to enhance knowledge and technology transfer.[153]

3.3 Achievements in AI research at universities and research institutions

The most significant contributions to AI research are published at international level by universities. A recent study commissioned by the Federal Ministry of Education, Science and Research (BMBWF) conducted statistical and bibliometric analyses to rank Austrian universities' AI research against that of other

153 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019b).

countries. This revealed that the number of articles appearing in *Web of Science* has risen sharply over the past ten years and that the debate has a distinctly European flavour. Nevertheless, there are signs of major catching-up processes under way in the USA and China as the two countries have become increasingly specialised: whilst they are concentrating specifically on forward-looking topics within AI, Europe is not exhibiting any such focus. Austria's strengths lie more in application-oriented fields of research such as expert systems, robotics, machine learning and autonomous systems.[154] This reveals that all universities, technical universities and medical universities and at least two arts-focused higher education institutions offer corresponding activities, most notably the technical universities in Vienna and Graz as well as the University of Vienna and the Johannes Kepler University Linz (see Table 3-1).

International co-publications reveal the networking that goes on between Austrian universities and prestigious international institutions such as ETH Zurich, the Technical University of Munich and University College London. Intensive research partnerships cover areas including neuroscience, e.g. on the early detection of autism, involving Graz University of Technology, the Medical University of Graz and the University of Graz, where AI research methods are being used to enable autism in children to be spotted and treated as early as possible with the help of video recordings. A project involving the Medical University of Vienna and the University of Vienna is also

Table 3-1: Austrian universities' AI publications and projects

University	Publications (2016-2018)	EU projects (2007-2018)	FWF projects (2007-2018)
University of Vienna	125	7	5
University of Graz	40	7	2
University of Innsbruck	77	13	3
University of Salzburg	68	4	4
Johannes Kepler University Linz	124	13	7
University of Klagenfurt	59	1	1
Vienna University of Technology	243	28	18
Graz University of Technology	172	18	19
University of Leoben	7	2	2
University of Natural Resources and Life Sciences	3	2	0
University of Veterinary Medicine Vienna	5	0	0
Vienna University of Economics and Business	11	1	0
Danube University Krems	10	0	0
Medical University of Vienna	116	5	1
Medical University of Graz	43	2	0
Medical University of Innsbruck	24	3	2
Academy of Fine Arts Vienna	0	0	0
University of Applied Arts Vienna	0	0	1
University of Music and Performing Arts Vienna	0	0	0
Mozarteum University Salzburg	0	0	0
University of Music and Performing Arts Graz	0	0	0
University of Art and Design Linz	2	1	0

Source: Heller-Schuh et al. (2019).

154 See Heller-Schuh et al. (2019).

employing AI methods in retinal research to improve the diagnosis of diseases affecting the human eye.[155]

To further improve Austria's research performance in the AI field, the topic of AI has also already been anchored for various projects in the performance agreements concluded between the universities and the Federal Ministry of Education, Science and Research (BMBWF) for 2019–2021. Whilst these performance agreements focus on the brief period from 2019 to 2021, the development plans for 2019–2024 have a longer planning horizon, meaning that, in some cases, much more extensive measures are being lined up for AI as an area of future thinking. Examples include:

- University of Vienna: new momentum is being injected into the field of machine/deep learning through the university's collaboration with the Austrian Research Institute for Artificial Intelligence (OFAI).
- University of Graz: the Business Analytics and Data Science-Center (BANDAS), which is currently being set up, is using big data analysis and machine learning to study societal and economic issues from an interdisciplinary and application-specific perspective.
- Medical University of Vienna: research activities in the field of digital medicine, including machine learning, data mining, bioinformatics, etc. are being expanded by setting up new professorships.
- Vienna University of Technology: the new Vienna Center for Technology and Society is conducting research into topics such as automated decision-making and artificial intelligence.
- University of Leoben: research into implementing smart logistics is being undertaken using the technologies of automation, sensor systems and cyber-physical systems. The creation of a professorship for cyber-physical systems (CPS) is placing emphasis on automated or automation-supported control, monitoring and fault detection for machinery and components.
- University of Art and Design Linz: the Creative Robotics robot laboratory provides a research infrastructure that creates a space for unconventional, innovative research at the interface between the digital and physical worlds.

In their role as key drivers of AI research, the Austrian universities have produced a joint position paper that contains the following tangible measures for promoting and further developing AI: International networking, especially involving the two European initiatives the Confederation of Laboratories for Artificial Intelligence Research in Europe (CLAIRE)[156] and the European Laboratory for Learning and Intelligent Systems (ELLIS),[157] which aim to strengthen academic research and its transfer to industrial areas of application, is to be supported both intellectually and financially in Austria. A national AI network for cooperative research and for developing and exchanging joint teaching programmes also needs to be established in Austria, with the various institutions to work together in a targeted way, both within and across disciplines, to leverage synergy effects. To be able to compete in AI research, especially with private research institutions and multinational IT corporations, Austria will need a better infrastructural framework. For instance, Universities Austria (uniko) recommends setting up a shared cloud infrastructure for research data or a GPU cluster (computer cluster) in order to increase universities' processing capacities. These efforts could build on the Vienna Scientific Cluster (VSC) or the European Open Science Cloud (EOSC), for instance.[158]

Many of these proposals have recently been implemented, resulting in two Austrian research institutions – the Johannes Kepler University Linz and the Institute of Science and Technology Austria (IST Austria) – being chosen at European level as

155 See Heller-Schuh et al. (2019).
156 See https://claire-ai.org/?lang=de
157 See https://ellis.eu/
158 See uniko (2019).

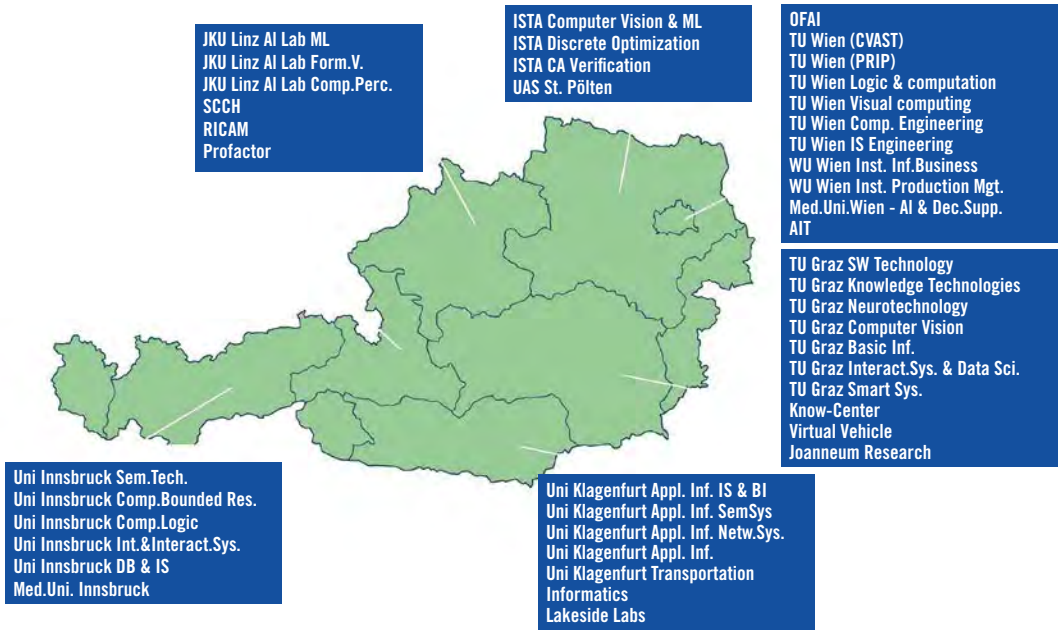
ELLIS locations on the basis of their academic excellence.[159] Each of the locations has committed to providing local funding of at least €1.5 million per year for at least five years, meaning that over €200 million will be invested in AI research in total over the next five years at the 17 locations in Europe and Israel. The Austrian government's current work programme for 2020–2024 also includes the following measure based on uniko's recommendation: *"Expanding a research data centre equipped with sufficient processing capacity (particularly graphics processing units) to ensure that cutting-edge research – especially in the field of data-based AI – can continue (building on the Vienna Scientific Cluster)."*[160]

AI is also anchored in some research activities at universities of applied sciences. One highlight has been the creation of the Big Data Analytics & Artificial Intelligence Research Center, an application-focused research and innovation centre at FH Joanneum University of Applied Sciences, as part of the COIN programme line, which was supported by the Federal Ministry for Digital and Economic Affairs (BMDW) and administered by the Austrian Research Promotion Agency (FFG); another has been University of Applied Sciences Upper Austria's introduction of a supercomputer for AI and machine learning in research and teaching in 2019.

However, AI has not just become an integral part of the work done at universities, a great many research institutions are now boasting AI expertise too. Fig. 3-2 provides an overview of this and shows the geographical distribution of institutions that include significant AI competencies or AI projects on their website.

Many of the above research institutions have a wide range of activities and areas of expertise and are thus not only assigned to computer-science-related subjects. In the past, it is fair to say that only a small handful of institutions in Austria developed solutions that were explicitly AI-driven. Nowadays, by contrast, the issue has greater topical relevance

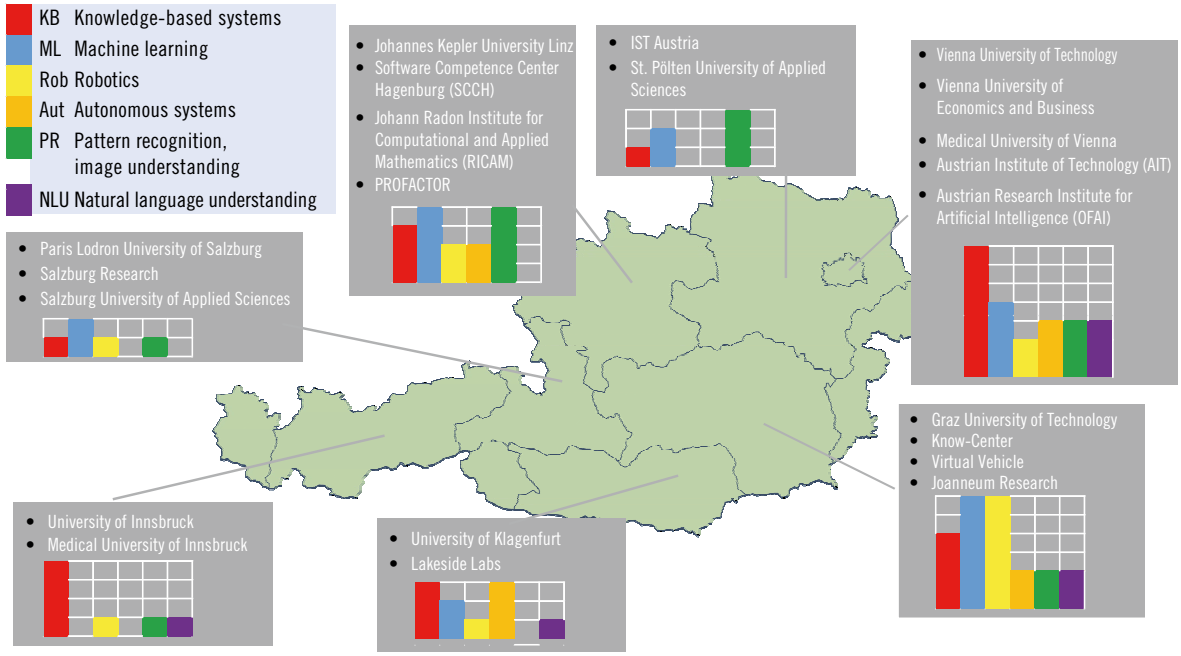
Fig. 3-2: AI research institutions in Austria



Source: Prem and Ruhland (2019).

159 See https://ist.ac.at/de/news/jku-ist-austria-join-ellis-network/
160 See Federal Chancellery (BKA) (2020, 323).

Fig. 3-3: Research priority of research institutions with AI activities in Austria



Source: Prem and Ruhland (2019).

and AI is listed as a field of expertise or project focus on many research institutions' websites.

As far as Austria's research institutions are concerned, Prem and Ruhland[161] have established that the relevant AI institutions cover the whole of the technological spectrum (see also Fig. 3-3 in this regard). Although machine learning activities are particularly prominent, symbolic methods (knowledge representation), robotics and autonomous systems are also well represented. AI research is being conducted more or less throughout Austria, with major hubs in Vienna and Graz, but also in Linz (and Hagenberg) as well as Klagenfurt. Other regional activities are centred in Innsbruck, St. Pölten and Klosterneuburg as well as Salzburg. Using algorithms to support machine learning systems is one important area of research. However, some of the existing groups – especially those outside Vienna and Graz – are very small, with some topics only being covered by one professor or even just by students, for example.

3.4 AI at companies

If AI is to be used appropriately at companies, it has to be an integral part of their overall digitalisation strategy. This includes, in particular, building up corresponding technological expertise and an organisational culture that supports and helps to deliver this transformation. Besides availability, the key prerequisites for using AI technologies at companies are, above all, the skills available and a corresponding level of trust in AI technologies.[162]

Determining what companies are undertaking what AI-related activities in Austria is a challenge. For one, there are no representative surveys on the use or development of AI at companies; for another, the many different ways in which AI terms can be defined and combined (e.g. as search words or similar) prevent a corresponding search strategy from delivering clear results without undue effort. An analysis of AI potential[163] commissioned by the former

161 See Prem and Ruhland (2019).
162 See Schaper-Rinkel et al. (2019).
163 See Prem and Ruhland (2019).

Federal Ministry for Transport, Innovation and Technology (BMVIT) – now the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) – analysed various data sources to identify some 600 companies in Austria that are involved in AI issues. This means that only a relatively small proportion of companies in the country overall (at least to the extent that can be verified based on available data sources) are active in the AI field.

The largest group (around one third) of these companies are software developers and users of (proprietary) solutions as well as providers of relevant data processing solutions (ranging from business intelligence to imaging analysis in the medical industry), often in combination with consulting services. Management and market consultants, most of whom develop their own software and use it to analyse corporate data, stock market prices, etc., are also particularly significant, making up around a quarter of all companies identified as engaging in AI activities. In some cases, analysing these companies' customer profiles reveals that they specialise in areas of strength for Austria such as automotive and mechanical engineering. Companies from the following economic sectors are also relevant to Austrian AI activities: R&D (4% of companies identified), financial and insurance services (also 4%), telecommunications (2%), manufacturing (mechanical engineering, plant engineering, automotive engineering, electrical equipment, computers, pharmaceutical products, sensors, etc.). Taken together, this last category accounts for around 28% of the companies identified as undertaking AI activities, with the most common segments being computer manufacturing (around 7% of all AI companies) and mechanical engineering (4%).

The greatest concentration of AI companies (i.e. percentage share of all companies in the relevant economic sector) can be found in the pharmaceutical products manufacturing segment (20%), oil processing (20%), insurance (8%) and the manufacture of computers, electronic appliances and optical products (4%). However, the first three of these sectors are much smaller in terms of the number of companies.

AI is a technology with the potential to find a use in all sectors of the economy and all departments of a company. As there are always question marks over how fast innovation in the technology will progress, the question of which precise niches and highly promising areas of application AI will occupy in future is not that easy to answer. Nevertheless, there are some clues in terms of subject areas and potential uses: amongst others, these will be applications that [Austrian] firms are already developing and/or have already launched or, as the case may be, various areas in which growing potential for AI has been identified and that also hint at possible future applications.[164]

A German study analysing the extent to which AI could accelerate annual growth in gross value added in selected economic sub-sectors identified manufacturing as offering the most potential, followed by agriculture and various services segments (financial and insurance services, wholesale and retail, etc.). Potential was regarded as relatively low in health and social care, building and the education sector.[165] This finding very closely matches those made by Prem and Ruhland (2019) for Austria, in which, amongst other things, construction and healthcare were also cited as sectors using no or only a few AI applications. A further study, which considered the potential impact of AI on economic sub-sectors in Austria, highlighted those of goods manufacturing, professional/technical services and wholesale/retail as being capable of making a particularly strong contribution to Austria's future economic clout in 2035 thanks to AI.[166]

The main motivation for companies in Austria to use and/or develop AI for innovative products and services lies above all in automating and optimising

164 See Schaper-Rinkel et al. (2019), Prem and Ruhland (2019).
165 See Seifert et al. (2018).
166 See Accenture (2019).

their processes (adaptation and acceleration) and thus in improving efficiency (in terms of costs and/or personnel) or increasing flexibility as well as managing complexity and knowledge. The main objectives with automation are to increase the percentage of routine tasks that are automated and to bring about a general improvement in system autonomy (e.g. autonomous driving, firewalls). Within IT itself, software automation (via learning) plays a key role. The major areas of focus in process optimisation include improving existing systems (adaptation), accelerating processes and thus saving time, and enhancing quality (e.g. of forecasts). For the companies involved, improving efficiency primarily means cutting costs, but also increasing flexibility. Amongst other things, they want to handle complexity more effectively with the help of adaptive/learning systems (e.g. security) and/or data science methods (dealing with large volumes of data). Better knowledge management, i.e. gaining new insights from large data volumes and spotting connections, is another important factor.[167]

Innovations (new products and services) are a particularly strong motivation for Austrian companies to use AI. A look at the applications that firms have developed to date reveals a broad picture. There is a whole range of applications that cover speech and language, dialogue systems (chatbots, assistance systems, smart searching, etc.) or that analyse text documents, manage knowledge or extract it (trend and risk analysis for documents, data classification, etc.).

There are also numerous applications connected with industrial automation and process/plant engineering (factory automation, Industry 4.0, system optimisation, predictive maintenance, simulation in production, engineering tools, analysis in production, sensor fusion, etc.). Other applications are used to classify and analyse image and video data (with many centred around automation/autonomous operation, especially autonomous driving) or optimise transport/logistics (rolling stock optimisation, train scheduling, etc.). IT itself is another area of application for AI technology, e.g. in the fields of software-defined networks, software management, security (IT systems) and making sensitive personal data anonymous. Finally, AI at Austrian companies can also be found in risk management, controlling and, in many cases, data analysis. The AI technologies used here mainly comprise machine learning, data analysis and forecasting techniques, speech processing, image analysis, and deductive and knowledge-based systems.

AI can have an innovative effect in various ways. It is seen as having great economic potential (productivity and price impact), particularly with regard to the automation of routine activities, while also being capable of forming the basis for enhanced and/or new products and services. Companies can harness the potential offered by AI in various ways. Knowledge can either be developed chiefly in house or bought in from outside, And there would appear to be many different possible gradations between these two extremes.[168]

Being both so popular and so disruptive, AI will offer a great deal of potential and bring a great deal of impact – neither of which will be particularly easy to forecast – for a large number of industries and companies. Besides its ramifications within a company itself, AI will also cause shifts within and between industries and thus drive forward structural change. Companies often view AI as a sub-field and combine it with other digitalisation issues and strategies, which causes boundaries to be blurred. This is compounded by legislative and regulatory grey areas, which can either accelerate or curb the use of AI. The main technical challenges relate to access, availability and quality as well as the processing of data in AI systems, system architectures and aspects of security, data protection and privacy (e.g. personal data).[169]

167 See Prem and Ruhland (2019).
168 See Schaper-Rinkel (2019).
169 See Schaper-Rinkel (2019).

A fundamental challenge, or perhaps a fundamental obstacle, to the use of AI at companies is posed in particular by users' skills in the relevant industries and/or the availability of staff with AI expertise. This relates both to AI generalists and AI specialists in areas including neural networks as well as software engineers in AI. Another related obstacle is how much it costs to create the necessary expertise in AI and to implement the innovations that have been devised.[170]

For SMEs in particular, (high) investment costs are a major barrier preventing the use of AI and/or leading to a certain reluctance to embrace AI applications. Perhaps more than any other type of company, SMEs also face the problem of not having the necessary quality and quantity of data at their disposal for AI learning processes. Overall, however, the main AI-related barriers for SMEs concern their personnel. They need staff with the relevant skills and would appear to have a hard time successfully getting into AI "on the side, without interrupting normal operations" using their existing workforce.[171]

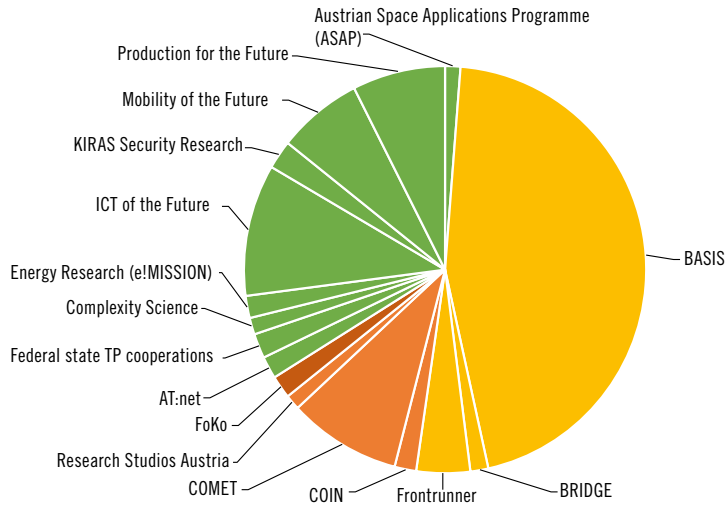
A further challenge lies in the lack of standards to provide legal certainty, increase interoperability, cut the cost of implementing IT solutions and expand sales markets (international compatibility of solutions developed in Austria).[172]

3.5 AI as a topic in applied research funding

The major and ever-growing significance of AI is also reflected in research funding. Between 2012 and 2017, the federal government provided €349.9 million in funds for the AI field, the bulk of which (94%) went to programmes implemented by the Austrian Research Promotion Agency (FFG).

Fig. 3-4 shows a recent evaluation of the agency's funding statistics for the total funding approved between 2017 and 2019 (funding and expenses) that can be attributed to the topic of artificial intelligence using a text mining process that the agency itself

Fig. 3-4: Total AI-related funding (funding and expenses) granted to the Austrian Research Promotion Agency (FFG), 2017–2019



Note: The figure only shows the programmes that made up at least 1% of the total AI-related funding amount.
Source: Austrian Research Promotion Agency (FFG) funding statistics 2020. A text mining process developed by the Austrian Research Promotion Agency (FFG) was used to classify the programmes.

170 See Prem and Ruhland (2019).
171 See Schaper-Rinkel (2019).
172 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019b).

carried out. This indicates that AI is seeing strong growth in research funding, with more being awarded in these three years (€372.54 million) than in the six years before that. Fig. 3-4 uses different colours to illustrate how these funds were distributed across the individual areas of the Austrian Research Promotion Agency (FFG) and the associated funding programmes.

Nearly half of all funds awarded between 2017 and 2019 went to the General Programmes, around one third supporting the Thematic Programmes (especially ICT of the Future, Production of the Future and Mobility for the Future) and a further 15% the Structural Programmes (of which about a quarter is personnel-related funding such as talented individuals or spin-off fellowships). The biggest programmes in terms of funding AI projects are thus the General Programme, ICT of the Future, Production of the Future, COMET and Mobility for the Future.

3.6 An international comparison of AI

Austria's position in the AI field compared to other countries is illustrated below with the aid of two examples: an international comparative analysis by the *AI* Index Steering Committee at Stanford University and recent analyses by the Austrian Patent Office on the number of and trend in patent applications.
In the former,[173] which was published recently, Austria is only included in the analyses insofar as it is mentioned that a relevant advisory body exists in the form of the Austrian Council on Robotics and Artificial Intelligence and that a strategy is being developed. In this connection, however, various secondary statistical data were also published that were analysed and compared as part of the so-called Global AI Vibrancy Tool.[174] Although this takes account of all relevant activities undertaken by the individual countries, the focus is not on comparing their rankings. Nevertheless, analysing the data for Austria reveals a number of interesting findings. Comparing the data used for this purpose with those that take population into account puts Austria above average for all high-wage countries studied for 2018 in terms of the economy (expressed as the spread of professionally relevant AI skills amongst the general population, number of AI-related start-ups established, amount of private investment in these start-ups, etc.) and inclusion (expressed as the percentage of women authors in relevant AI publications as the only available data source). In R&D (based on the number of scientific publications, patents and similar, insofar as the data were available), Austria came out below average. Overall, i.e. expressed via a corresponding composite index, Austria has improved its position slightly since the first analyses in 2015 and is ahead of countries such as Germany, Denmark and Finland. It must be borne in mind, however, that the main leaders in developing and applying AI at present are the USA and China. In their analysis,[175] published in 2019, the authors from the Center for Data Innovation thus established that the USA was currently out in front in AI, with China quickly closing the gap and the EU lagging behind both countries. According to the study, the USA led the field in four of the six categories studied (talent, research, development and hardware) and China in two (adoption and data). The USA scored highest in the analysis with 44.2 out of a possible total of 100 points based on the calculation methodology, followed by China on 32.3 and the EU on 23.5.

Plans to include AI in the Europe-wide survey of ICT use in companies this year will enable the positioning of Austrian companies to be analysed at least in comparison to their European counterparts. Amongst other things, there is set to be a module containing questions on the methods used to conduct big data analyses using AI technologies such as machine learning, natural language processing or natural

173 See Perrault (2019).
174 See https://vibrancy.aiindex.org/
175 See Castro et al. (2019).

language generation. The same survey is expected to include a dedicated module on AI in 2021 that will ask questions about the technologies used, the purpose of this use and whether the technology applied was developed by the company itself or by external providers. In February 2020, the European Commission and the OECD also agreed to harmonise the EU's AI Watch platform and the OECD's AI Policy Observatory (OECD.AI) in terms of the information used in and for them. The first phase of collaboration focused on building a database of national AI strategies and policies. In connection with the coordinated AI plan, the EU Member States have committed to developing national AI strategies to dovetail their AI policies and investments. The next phase will concentrate on making the reports from AI Watch and other EU publications available via the AI Policy Observatory, exchanging data more comprehensively and working more closely on designing improved data collection methods.[176] The WIPO Technology Trends[177] series, which builds on the expertise that the World Intellectual Property Organization (WIPO) has in analysing patent data, published analyses on the global trends in AI issues in 2019. This publication is one of the first to systematically investigate trends in AI technology. It analyses which areas are demonstrating the largest amount of innovative AI activities, which companies and institutions are leading the way in AI development and where the growth markets of the future will be. To this end, WIPO has devised a new framework for understanding trends in this area, with AI-related technologies being divided into groups to reflect three dimensions of AI: techniques used in AI (e.g. machine learning), functional applications (e.g. speech processing and computer vision) and areas of application (e.g. telecommunications and logistics). For each of these areas, the report provides data and analyses that highlight trends, key players, geographical distribution and market activities, including acquisitions and legal disputes.

The most important finding from this analysis is that AI-related inventions are booming and are shifting from the theory books to the commercial market: the ratio of academic papers to concrete inventions fell from 8:1 in 2010 to 3:1 in 2016. Since artificial intelligence emerged in the 1950s, innovators and researchers have registered nearly 340,000 inventions with an AI element. The patenting of AI-related inventions is increasing sharply: over half of the inventions identified have been published since 2013. As well as revealing AI techniques and applications, AI-related patents are often also connected to a specific area of application or industry. WIPO's analysis showed that many sectors and industries are conducting research into the commercial use of AI. It identified 20 different areas of application, with at least one being cited in 62% of all the AI patent data collected. These included, in descending order of size: telecommunications (cited in 15% of all patent documents identified), transportation (15%), life and medical sciences (12%), and personal devices, computing and human-computer interaction (11%). Other sectors were banking, entertainment, security, industry and manufacturing, agriculture, and networks (including social networks, smart cities and the Internet of Things). Companies, particularly those from Japan, the USA and China, are the dominant forces in patent activity. In total, there are 26 companies in the top 30 applicants for AI-related patents, compared with only four universities and public research institutions. This is the case for most AI techniques, applications and fields. Of the top 20 companies applying for AI-related patents, twelve are based in Japan, three are from the USA and two are Chinese. Japanese firms in the entertainment electronics industry are especially well represented. Despite companies dominating the AI field, universities and public research organisations are playing a leading role in coming up with inventions in selected areas of AI. Chinese organisations make up 17 of the leading 20

176 See https://ec.europa.eu/digital-single-market/en/news/european-commission-and-oecd-collaborate-global-monitoring-and-analysis-artificial-intelligence

177 See World Intellectual Property Organization (WIPO) (2019).

academic performers in patenting AI as well as 10 of the top 20 for AI-related academic publications.

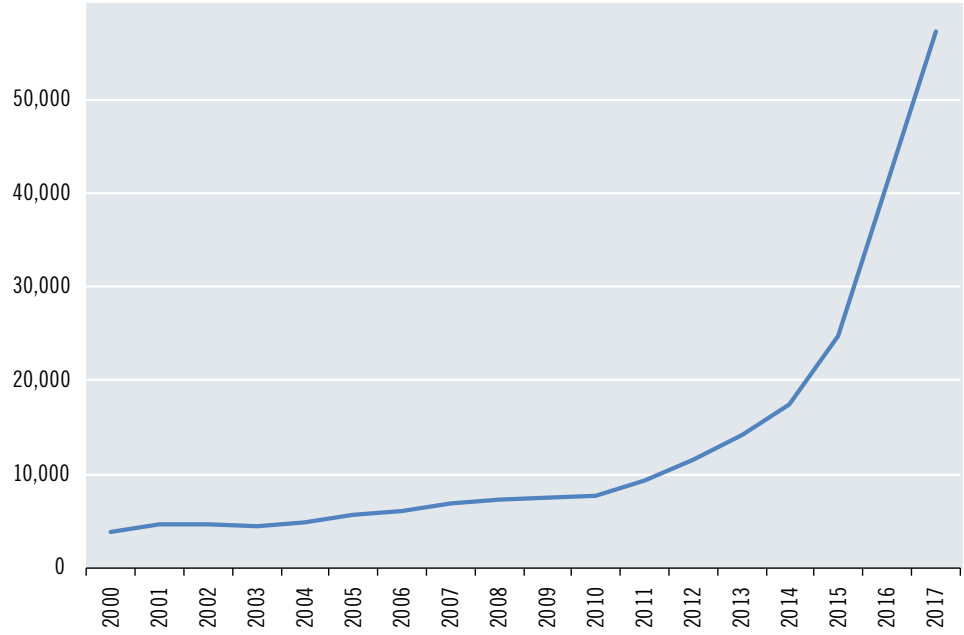
WIPO's analyses[178] have shown that, although the Austrian Patent Office occupies 15th place in the rankings of the world's most relevant patent offices in terms of AI, the overall statistics are dominated by other countries and patent offices, namely the United States Patent and Trademark Office, the State Intellectual Property Office (China), the Japan Patent Office, WIPO itself and the European Patent Office.

Based on WIPO's methodology, recent analyses by the Austrian Patent Office presented in Fig. 3-5 show first of all that the total number of AI-related innovations for which a patent has been applied has grown sharply, particularly since 2012. Fig. 3-6 illustrates this in more detail using the AI patent family (a collection of all patent applications[179] derived from a single original application).

With the countries varying in size, the only reasonable way to compare their AI-related patent applications is by using normalised values, particularly population (see Fig. 3-6). These analyses, which cover the USA and South Korea as well as the EU-28, put Austria in 11th place for the last available year (2017), closely behind the UK and France. South Korea is the runaway leader, however, filing nearly 13 times as many patents per million inhabitants as Austria. Even countries in the comparison that are of direct relevance such as Sweden, Finland, Germany and the Netherlands are registering between 2.5 times (Netherlands) and 4.6 times (Sweden) as many patents.

The underlying trends vary between the countries analysed (see Fig. 3-7). Taking the number of inventions in 2000 as the basis, the number of patented inventions – normalised by population – has, for example, grown by a factor of 12 in Denmark and increased nearly six fold in Finland. Austria is in a

Fig. 3-5: AI-related inventions (patent families) worldwide since 2000

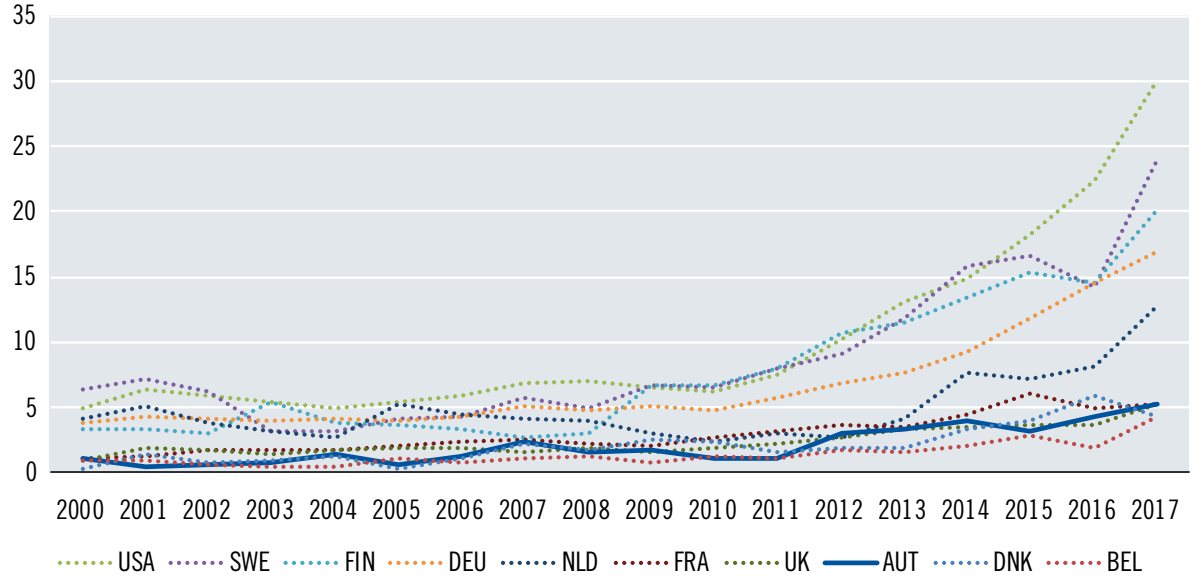


Source: Austrian Patent Office (2019).

178 See World Intellectual Property Organization (WIPO) (2019).

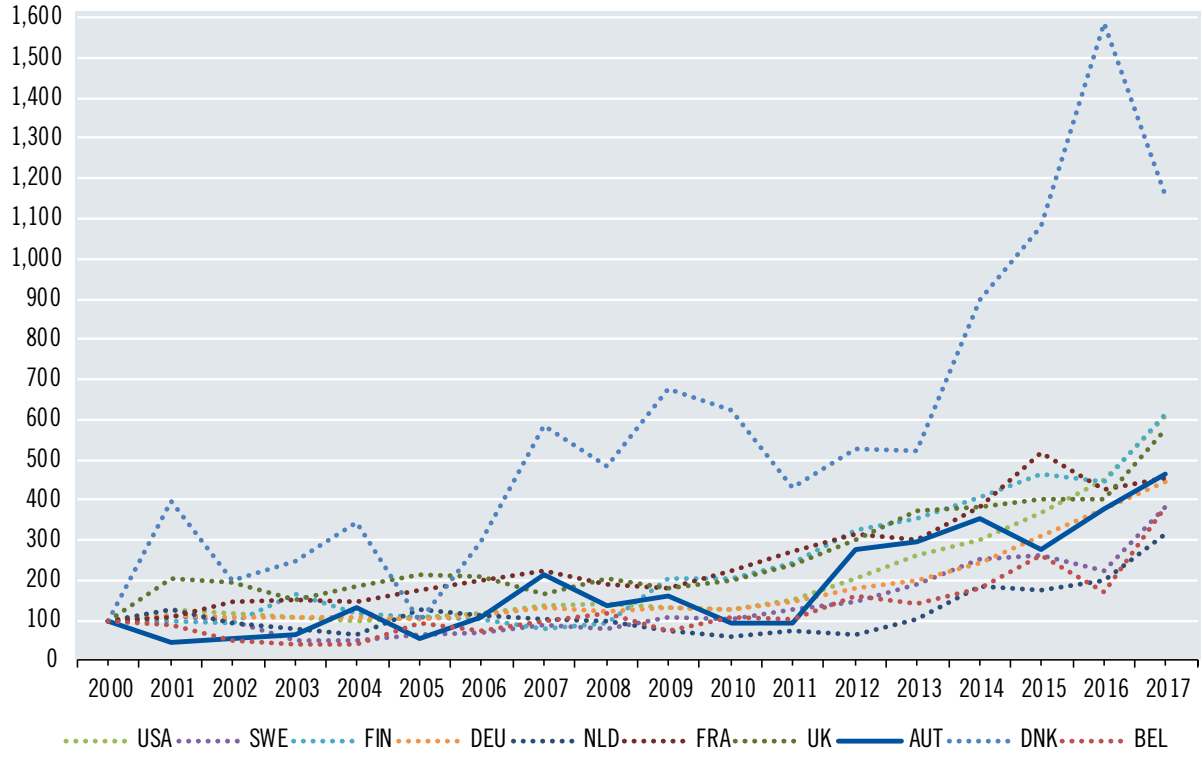
179 If, for instance, a patent is filed for an invention in Austria, further applications can also be made at a later date (usually within a year) e.g. in the USA and South Korea. This makes a total of three patent applications, all describing the same invention, which together form a patent family. The terms "invention" and "patent family" are thus largely synonymous.

Fig. 3-6: Number of inventions (patent families) per million inhabitants; comparison of selected countries (for patents filed in 2017)



Source: Austrian Patent Office (2019).

Fig. 3-7: Trend in the number of inventions (patent families) per million inhabitants; comparison of selected countries (benchmark year 2000 = 100)



Source: Austrian Patent Office (2019).

mid-table position according to the analysis and has seen (slightly) faster growth than France, Germany, Sweden, the Netherlands and Belgium during the observation period.

3.7 AI in public administration

Amongst other things, the results report on drafting a strategy for artificial intelligence,[180] which was published in November 2019, summarises the present situation regarding the use of AI in public administration. According to the report, AI does enjoy limited use in public administration for specific applications: its use in individual services as a way to communicate with citizens (chatbots, smart searching, process support, etc.) is currently being trialled. However, the experts involved in the report conclude that there is still a lack of any significant awareness in public-sector organisations regarding AI's possible uses. Nevertheless, there are a number of projects under way at all administrative levels that are designed not least to raise the necessary awareness within public administration. In the future, potential AI applications beyond the scope of the public sector's actual administrative processes could build on data that already exist in databases, process data, historical documentation, legal information and rulings on sensor data through to data from historical recordings such as weather data. One of the key fields of activity identified thus consists in managing data and building AI-related databases while also guaranteeing the protection of personal information. If non-discriminatory AI-based decision-making is to be ensured, potential distortions in the underlying data will have to be eliminated and the traceability and transparency of the decisions made and the processes that led up to them will have to be presented clearly.

Major challenges also lie in building up AI expertise at the various administrative levels, defining and critically evaluating potential areas of application and setting the "red lines"[181] for the use of AI by the Austrian government; amongst other things, this means that administrative decisions with a direct impact on people may be assisted by machines but not made by them (see also Chapter 3.8).

The results report on drafting a strategy for artificial intelligence[182] also defines measures that could potentially create a suitable framework for using AI in administration. Of these, the following are key:

- establishing a legal framework for using AI in administration in order to prevent discrimination and systemic inequality and to safeguard people's right to privacy and data protection;
- "AI check" for new digitalisation projects (e.g. as part of an outcome-oriented impact assessment);
- developing a strategy/concept/infrastructure for the public sector data, i.e. discussing and regulating the provision of large volumes of public data and accompanying regulatory or organisational measures (data hubs) for AI research, but also companies;
- making use of public procurement (promoting innovation), i.e. public administration generates demand for ethical AI or for applications in certain industries such as healthcare or similar, enabling it to define markets and set standards;
- using AI to optimise administration workflows to reduce companies' and citizens' obligations towards the administration through the use of AI.

In addition, a clear overview of public-sector AI applications in Austria is not currently available. Furthermore, in a recent study by the Federal Ministry for

180 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019b).

181 See Federal Chancellery (BKA) (2020).

182 See Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) (2019b).

Transport, Innovation and Technology (BMVIT),[183] the experts questioned were only able to give a handful of examples of AI being used in the public sector. With regard to the narrower realm of government administration, security applications such as pattern recognition in fraud cases, image recognition for criminological analyses or video analyses for security applications were mentioned relatively frequently. Some very important AI applications are being anticipated in the medical/healthcare industry at present. In Austria, too, there are various developments, companies and real-life applications that are relevant here. Current examples of AI being used in administration also include AI in the electronic file (ELAK). As part of efforts to further develop and ultimately replace the ELAK, AI methods are to be used in future to help users make decisions and choose courses of action, save time, and speed up workflows. In particular, the inbuilt smart search function will use AI to increase accuracy by making semantic suggestions. AI is also used for a number of electronic communication tasks such as automatically identifying senders, automatic keywording, logging and assigning information. In addition, AI forms part of the official services provided digitally via the oesterreich.gv.at platform: its chatbot "Mona" is on hand to provide administrative assistance, currently for passport reminders and the mobile signature service, and is being expanded on an on-going basis. The chatbot was also deployed to the USP company service portal during the coronavirus crisis, where it served as a hub for all company-related information throughout the crisis. The SourcePIN Register Authority has also already embraced automation solutions (*robotic process automation*) and AI elements to improve its services by speeding up searches and preparing results/data for subject specialists. Currently at the planning stage, a pilot project run by the Federal Ministry for Digital and Economic Affairs (BMDW) aims to use AI to enable companies to receive automatic recommendations for suitable funding. As the prerequisites for funding can be expressed as logical rules ("if x, then y"), the goal of this initiative is to convert the prerequisites for funding into a machine-readable format.

The analysis commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT) on "AI Potenzial in Österreich" (The Potential for AI in Austria)[184] concludes that there are currently a number of major barriers preventing AI from being used in public administration in Austria. One major obstacle is the fact that, in principle, public authorities are only allowed to use data for the purpose for which they were collected. The public sector thus often employs rule-based systems that generally do not learn from personal data. The lack of legal clarity over the use of AI systems in the public sector also makes those responsible extremely cautious. A corresponding debate on data protection or a broader debate on data use may be needed in order to create greater clarity. Another way would be to set up a public-sector or public-sector-dominated centre of excellence for AI and data that covers the whole spectrum of administration-related AI activities, from research to implementation and so-called regulatory sandboxes. As well as legal and technical aspects and standardisation, this would also, and in particular, have to deal with topical research issues such as questions about anonymisation, privacy-preserving machine learning[185] or homomorphic encryption methods.[186] The current government programme addresses a number of these points.

The reticence being shown towards AI applications in the core areas of public administration is also

183 See Prem and Ruhland (2019).
184 See Prem and Ruhland (2019).
185 *Privacy-preserving machine learning*.
186 For example, methods like these allow operations to be run and output on database contents without disclosing those contents.

due to the fact that the chain of responsibility for AI-based decision-making ends at an algorithm, not an individual. Advice systems providing no-obligation support are one example of such a core area. Here too, however, complex legal questions can arise very quickly if the people affected miss deadlines or encounter other problems as a result of recommendations made to them. Public authorities can also be active in areas that involve objects (rather than individuals). AI applications in automated transport are one potential area of focus in this context, as is the issue of efficiency savings in public services. The whole field of the "smart city" is thus also often cited as an area with great potential for AI. Dedicated applications here might include traffic forecasts and other predictions as well as route optimisation, but also ways to optimise energy consumption in buildings or predictive urban development.

3.8 Ethics and AI

Although the use of AI can benefit both individuals and society as a whole, it can also bring major risks and significant consequences – the latter being hard to predict and quantify. In particular, the EU Commission's Expert Group on Artificial Intelligence[187] has identified risks to democracy, the rule of law, distributive justice and the human mind.

The use of personal data harbours the risk of asymmetries of power and information being magnified and abused. These asymmetries can be found in all areas of life, such as between teachers and students, between companies and consumers and between employers and employees. Children and young people need particular protection in this regard. Data used for AI purposes must therefore be prepared transparently at all times so that users always know what data are being stored and why they are being used. Two key questions thus arise: who are the stakeholders providing AI systems, and how do they treat the data generated? The danger here is that individual multinational companies and platforms gain increasing influence over fundamental areas of our lives such as education and healthcare through their hardware and software.

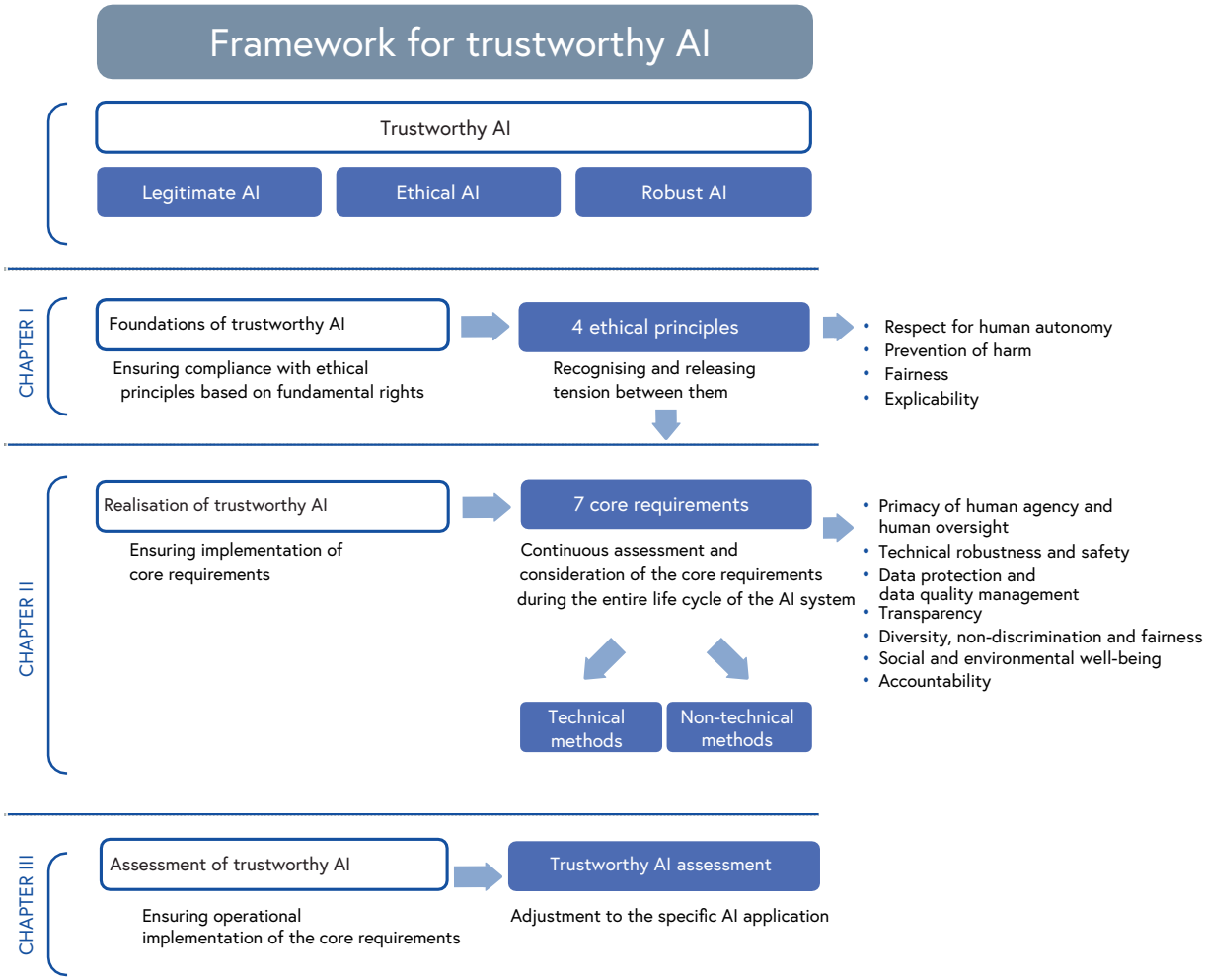
Indeed, some AI processes do not allow users or even the programmers themselves to see what factors are determining the AI's interaction with its environment. This is because, although the underlying algorithms were created by programmers, they draw their own conclusions via self-learning ("black box"). This situation can result in a lack of transparency. Open-source technologies thus need to offer the benefit of greater transparency. Austria's Open Innovation Strategy explicitly mentions the anchoring of *open science*, i.e. striving towards an open, collaborative approach by researchers working closely with stakeholders and civil society.[188] As algorithms continuously evolve based on user behaviour in order to adapt their own behaviour, to a certain extent they reproduce the racism and sexism inherent in the underlying data structure. In its Ethics Guidelines, therefore, the European Commission's Expert Group on Artificial Intelligence recommends that users should always *"be given the knowledge and tools to comprehend and interact with AI systems to a satisfactory degree and, where possible, be enabled to reasonably self-assess or challenge the system."*[189] The principle of user autonomy has to underpin the workings of an AI system. The primacy of human agency and human oversight over AI is thus one of the principle ethical guidelines. For this reason, Article 22 of the European General Data Protection Reg-

187 See High-Level Expert Group on Artificial Intelligence (2019, 2).

188 See Federal Ministry of Science, Research and Economy (BMWFW) and Federal Ministry for Transport, Innovation and Technology (BMVIT) (2016).

189 See High-Level Expert Group on Artificial Intelligence (2019).

Fig. 3-8: Framework for trustworthy AI



Source: High-Level Expert Group on Artificial Intelligence (2019).

ulation (GDPR) gives a person the right not to be subject to a decision based solely on automated processing.

In its Ethics Guidelines, the EU Commission's Expert Group on Artificial Intelligence defines four ethical principles for trustworthy AI. Alongside the comprehensive set of indivisible rights set out in international human rights law, the EU Treaties and the Charter of Fundamental Rights of the European Union, these form the basis for overcoming the challenges described (see also Fig. 3-8):

1. Respect for human autonomy
2. Prevention of harm
3. Fairness
4. Explicability

The principle of respect for human autonomy, for instance, requires humans interacting with AI systems to be able to keep full and effective self-determination over themselves. AI systems should not unjustifiably subordinate, coerce, deceive, manipulate, condition or herd humans. Instead, they should be designed to augment, complement and empower human cognitive, social and cultural skills. In accordance with the second principle, AI systems should neither cause nor exacerbate harm or otherwise adversely affect human beings. This entails the protection of human dignity as well as mental and physical integrity. Particular attention must be paid to situations where AI systems can cause or exacerbate adverse impacts due to asymmetries of power or information,

such as between employers and employees, businesses and consumers or governments and citizens. Preventing harm also entails consideration of the natural environment and all living beings. The principle of fairness is based on ensuring non-discrimination and non-stigmatisation, equal opportunities and the ability to contest decisions made by AI systems and obtain effective redress. The principle of explicability means that processes must always be presented transparently, that the capabilities and purpose of AI systems must be openly communicated and that decisions – to the extent possible – must be explainable to those directly and indirectly affected.[190]

The Austrian Council on Robotics and Artificial Intelligence recommends that these European Ethics Guidelines be taken into account in all matters relating to the country's strategic process for preparing an AI strategy and that they be implemented in the future.[191]

3.9 Summary

Given the advancing of digitalisation – a megatrend in education, scientific, academic and economic systems in Austria and around the world – technologies and applications from the field of artificial intelligence are becoming increasingly important, especially due to the availability of large volumes of data and the constant improvement in the quality of algorithms. Artificial intelligence (AI) refers to artificial systems that appear to demonstrate intelligent, i.e. self-learning, behaviour and thus act with a certain degree of autonomy. The use of AI will bring about fundamental changes and can contribute to efforts to overcome the major societal challenges; AI can also help to ensure the competitiveness of companies and to create and preserve jobs.

In Austria, therefore, there is a broad-based political commitment to AI and its potential applications as well as the need to take the relevant ethics guidelines and legal situation into account. This is reflected not least in the strategy development work initiated by a government resolution as well as in the current federal government's programme.

Austrian research institutions are active in the entire AI-related technology spectrum. Recognisable focal points can be found in the areas of machine learning, symbolic methods, robotics and autonomous systems. AI research is thus being conducted more or less throughout Austria, with regional hubs in Vienna and Graz, Linz (and Hagenberg) and Klagenfurt, and significant AI work being done in Innsbruck, St. Pölten, Klosterneuburg and Salzburg. There is evidence of AI research activities at virtually all Austrian universities. Besides the technical universities in Vienna and Graz, the University of Vienna and Johannes Kepler University Linz are also major centres of Austrian AI research in the academic sphere.

Learning analytics and intelligent tutoring systems are two areas of application of AI in higher education that are already being discussed and, in some cases, trialled. The use of AI is designed to provide students with targeted support commensurate with their competency level as well as more personalised assistance, while also relieving the burden on teaching staff and improving the quality of teaching for everyone involved.

At bachelor's and master's level, higher education teaching traditionally treats the topic of artificial intelligence as part of the core discipline of computer science or as part of a "Data Science" degree, as is the case at Vienna University of Technology and Graz University of Technology and at the universities of Vienna, Innsbruck, Salzburg and Klagenfurt. In the 2019 winter semester, the Johannes Kepler University Linz became the first university in Austria to offer both a bachelor's and a master's degree programme called Artificial Intelligence.

Obtaining a full picture of the AI-related activities

190 ibid.

191 See Austrian Council on Robotics and Artificial Intelligence (2019).

being undertaken by Austrian companies is only possible to a limited extent at present. Based on recent analyses, however, it can be assumed that several hundred firms are grappling with the issue of AI and developing or deploying solutions in different ways and to varying degrees. Most of these companies are software developers or management/market consultants. The relevant areas of application reflect Austria's areas of strength in manufacturing, primarily automotive and mechanical engineering. The concentration of companies active in the AI field (i.e. these as a percentage of all companies in a sector) is highest in the pharmaceutical products manufacturing segment (20%), oil processing (20%), insurance (8%) and the manufacture of computers, electronic appliances and optical products (4%). Overall, it would appear that Austrian companies mainly use AI for automating and optimising processes and for increasing efficiency.

The potentially disruptive nature of AI itself and its various applications will also drive structural change in Austria. In addition, developing and using AI poses various challenges to companies, particularly of a regulatory nature, but also in terms of technology, security, privacy and data protection (e.g. personal data) as well as the skills in using AI that are required and actually available (especially the availability of staff). SMEs in particular face barriers to a more widespread use of AI in the form of (high) investment costs and the shortage of skilled workers as well as the issue of the volume and quality of their data relevant for AI purposes.

There is currently only limited information available to determine Austria's relative position in the topic area of AI. The plan to include AI in the next (2020) Europe-wide survey of ICT use in companies will improve the situation. Amongst other things, there is set to be a module containing questions on the methods used to conduct *big data analyses* using AI technologies. The same survey is expected to include a dedicated module on AI in 2021.

The AI Index Steering Committee at Stanford University published country-specific analyses in its "Global AI Vibrancy Tool" in 2019. Normalised by population, this puts Austria above average for all high-wage countries studied in 2018 in terms of the economy (expressed as the spread of professionally relevant AI skills amongst the general population, number of AI-related start-ups established, amount of private investment in these start-ups, etc.) and inclusion (expressed as the percentage of women authors in relevant AI publications as the only available data source). In R&D (based on the number of scientific publications, patents and similar, insofar as the data were available), Austria came out below average. Overall, Austria has improved its position slightly since the first analyses in 2015 and is ahead of countries such as Germany, Denmark and Finland. In global terms, however, the USA and China are well ahead of the rest of the field. Recent analyses by the Austrian Patent Office show that the total number of AI-related innovations for which a patent has been applied has grown sharply, particularly since 2012. These analyses, which cover South Korea and the EU-28 as well as the USA, put Austria in 11th place for the last available year (2017), closely behind the UK and France. South Korea is the runaway leader (followed by Ireland, the USA, Sweden and Finland), filing nearly 13 times as many patents per million inhabitants as Austria. Although Sweden, Finland, Germany and the Netherlands boast a higher patent intensity, Austria has enjoyed faster growth since 2000.

4. RTI Evaluation Culture and Practice

Evaluations are an important instrument in RTI policy and administrative management and they help support transparency, accountability and evidence-based decision-making. Their implementation in Austria is based on general legal requirements, on specific requirements in the context of guidelines and funding activities, on budgetary requirements, and it is also sometimes done on a voluntary basis.[192] As far as the institutions are concerned, RTI policy is primarily determined by the Federal Ministry of Education, Science and Research (BMBWF), the Federal Ministry for Digital and Economic Affairs (BMDW) and the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). These are the main clients for evaluations at the federal level, and they frequently act together. The subject matter of the evaluations – often RTI programmes – is in turn generally implemented by agencies on behalf of a ministry. In the field of applied research, these agencies are the Austrian Research Promotion Agency (Forschungsförderungsgesellschaft – FFG) and the Austrian Promotional Bank (Austria Wirtschaftsservice GmbH – aws). In fundamental research, it is the Austrian Science Fund (Fonds zur Förderung der wissenschaftlichen Forschung – FWF).

Austria is one of the top-ranking countries in Europe when it comes to the number of evaluations done in the RTI sector. Studies dealing with evaluations emphasise the generally high professionalism and quality of Austrian evaluations.[193] On the other hand, an increased institutionalisation and routinisation can be observed which impacts the benefits of evaluations and lessons learned from them.[194] For this reason, there has been a lively discussion in recent years regarding the possibilities, functions and benefits of evaluations, the requirements placed on those evaluations and the process for dealing with them.[195] This discussion has not only led to new standards for evaluation in research and technology policy[196], but is also reflected in current developments and challenges. These include the discussion on granting evaluators limited access to the planned research funding database covering the whole of Austria for the duration of the relevant evaluation project, as well as the accessibility of registry data and microdata of official statistics for the scientific community. A report on this latter factor and on the market situation in the area of RTI evaluation in Austria can be found in Section 4.1.

4.1 Current trends

This section presents the latest evaluations that have been completed in the RTI sector – extracts of which are reported in Chapter 4.2 – as well as other current trends that are significant for the structure of Austrian evaluation practice. These are:

1. access to microdata from official statistics and to registry data;
2. market situation in the area of RTI evaluation in Austria.

Access to microdata from official statistics and to registry data

The current government programme[197] published at the beginning of January 2020 contains a separate subchapter dedicated to innovation through transparency and access to scientific data. In order to enable registry research, a working group was established in the Federal Ministry of Education, Science and Research (BMBWF) in 2019 with the aim of es-

192 See Streicher et al. (2019).

193 See Tsipouri and Sidiropolous (2014); Dinges and Schmidmayer (2010); Reiner and Smoliner (2012), Federal Ministry of Science, Research and Economy (BMWFW) and Federal Ministry for Transport, Innovation and Technology (BMVIT) (2017).

194 See Streicher (2017); Landsteiner (2015); Biegelbauer (2013).

195 See OECD (2018a); Federal Ministry of Science, Research and Economy (BMWFW) and Federal Ministry for Transport, Innovation and Technology (BMVIT) (2017); Warta and Philipp (2016).

196 See fteval (2019). https://www.fteval.at/content/home/standards/fteval_standards/

197 See Federal Chancellery (BKA) (2020).

tablishing a legal basis, identifying registries and implementing a pilot project in 2020. The project will be based on a research question about the education sector and the goal is to demonstrate the benefits of registry research. In addition, the 2020–2024 government programme stipulates the establishment of an "Austrian Micro Data Center" at Statistics Austria in order to create one-stop-shop data access for the scientific community to microdata of official statistics and to registry data from all federal ministries, taking into account the requirements of European statistics and data protection law.

Market situation in the area of RTI evaluation in Austria

The Austrian Platform for Research and Technology Policy Evaluation (fteval) commissioned a study[198] in 2019 in order to examine the market situation in the area of RTI evaluation in Austria. The aim of the study was to determine the nature of the Austrian market for scientific RTI evaluations, particularly with respect to market size and market volume, market structure and the characteristics of the market participants. Assessments were also gathered from market participants related to the market and competitive situation as well as to relevant trends. The study included 107 evaluations in the RTI sector over a ten-year examination period (2009 to 2018). The centrepiece of the study involved empirical findings based on secondary data[199] and a survey of market participants carried out between May and June 2019. The response rate was approximately 90%.

Around nine in ten cases involving RTI policy evaluations were headed by an Austrian institution over the entire period. About three quarters of all evaluations were carried out by institutions that were also members of the Austrian evaluation platform fteval as of June 2019. However, the share of fteval members in the evaluations carried out has decreased in the last few years as new providers have appeared. The overall average annual contract volume between 2016 and 2018 is approximately €755,000 for RTI-related evaluations. This equates to an average contract volume of just under €60,000 for the 38 RTI-related evaluations identified in this period.

In terms of total turnover, there is a wide variety of sizes among the institutions on the Austrian market that offer evaluations in the RTI field. These providers often operate internationally: eight out of twelve state that they are active in selected European countries. The entire EU represents a market for more than half of them. Almost all of the providers surveyed have also cooperated with other partners in recent years for the purposes of RTI evaluations. RTI evaluations play an important role in the business activities of the contractors surveyed, although they do not represent their main business. The proportion of corresponding evaluations as a percentage of the total budget or turnover in 2018 was 27% (awarded in Austria) and 15% (awarded abroad). A slight shift in these percentages in favour of evaluations awarded abroad is expected for the years up to 2023.

Although only 25% of the contractors surveyed consider competition at national level to have remained consistent in recent times, 67% (eight out of twelve) state that the competitive situation has become tougher, although the perception of this is even higher at the international level (82%). Seven out of eight of the clients surveyed also consider competition in Austria to be very strong. The professionalism of Austrian providers is perceived as "very high" (50%) or "high" (50%) (four out of eight in each case). Providers from other countries are also not seen as offering higher quality as compared with Austrian providers. Overall, this study could not confirm the assumptions sometimes made that the Austrian evaluation market is characterised by low competition and a comparatively small number of provid-

198 See Streicher et al. (2019).

199 Secondary data was taken from the following sources: the fteval repository, publications of the federal research database, websites of the relevant ministries and federal funding agencies as well as public intermediaries and evaluation providers; responses to parliamentary questions and contract award notices in the "Supplement to the Official Journal of the EU".

ers. The market poses some major challenges for contractors, particularly due to its small size, the limited number of clients, new competitors entering the market and the increase in content-related requirements despite low budgets.

4.2 Selected evaluations

4.2.1 Accompanying evaluation of the pilot call for proposals for Ideas Lab 4.0

The Austrian Research Promotion Agency (FFG) launched the Ideas Lab 4.0 pilot programme in 2017 in close cooperation with the Federal Ministry for Digital and Economic Affairs (BMDW) and with funding from the Austria Fund and the National Foundation for Research, Technology and Development, based on a recommendation by the Council for Research and Technology Development and the results of a study on radical innovations[200]. The programme represents the first time that the sandpit method was used in the Austrian Research Promotion Agency (FFG), and is the first time that it was used in Austria with a focus on interdisciplinary projects with a potential for application in industry.

Given that the programme was a novel concept, the Austrian Research Promotion Agency (FFG) commissioned a hypothesis-based accompanying evaluation[201] which was carried out by inspire research. The goal of the evaluation was to document the most important learning experiences from the proposal and selection phase, to explain them, and then to process the available information to evaluate the achievement of the call's objectives. The evaluation is mainly based on interviews with those involved in the programme (e.g. jury, participants, moderators and the Austrian Research Promotion Agency – FFG). During the workshop a participatory observation was also carried out.

How the sandpit format works

Potential cooperation partners are brought together in the idea development phase in the "sandpits". Interested parties apply with their motivation letter and their potential solutions to the question of the call for proposals and are selected by a jury to take part in an Ideas Lab lasting several days. This is where the interdisciplinary and heterogeneous group meets for the first time. In an iterative process led by moderators, the participants get together in teams where they develop ideas along the lines of the question at the heart of the call for proposals. They plan collaborations, present projects, receive feedback and finally submit a short funding application at the end of the Ideas Lab. The Ideas Lab aims to facilitate new forms of cooperation and new interdisciplinary approaches. Recommendations for the projects submitted are made at the end of the event by the on-site jury, which took on the role of mentors during the event.

The pilot tender and the process: an overview

The programme's pilot call for proposals was launched in April 2018 for the challenge "Human 4.0? – The Future of Collaboration between Humans and Machines", which also covered the social implications in the context of digitisation of the world of work. The call for proposals was aimed both at collaborative research performing organisations and at researchers from commercial companies. A total of 112 individuals applied for the pilot call for proposals, 30 of whom were selected to participate in the Ideas Lab because they i) showed the potential to develop new ideas on the problem posed, ii) brought relevant expertise with them and could be expected to work together across disciplinary boundaries, iii) demonstrated teamwork skills, and iv) were also able to explain their research to laypersons. The five-day workshop was held in September 2018 and included an introduction phase, a methodology/creative phase, a

200 See Warta and Dudenbostel (2016).
201 See Geyer and Good (2019).

selection phase and a development phase. This process resulted in five short applications for collaborative R&D projects, three of which received positive assessments from the mentors during the workshop. Collaborative R&D projects were just one of the possible funding instruments – others included exploratory studies and R&D services. The short proposals were developed into full proposals by November 2018, which in turn all received a recommendation for funding.

Results of the evaluation

The evaluation shows that the sandpit method clearly results in more interdisciplinary sets of teams than those found in traditional R&D projects, and that stakeholders joined forces who "should have long since been working together".[202] It was possible to successfully integrate individuals with non-technical expertise into the consortia. More diverse teams would have been possible if more suitable application and implementation partners from companies and research institutions had applied for the programme.

The sandpit method, involving a multi-stage selection procedure plus a creative process, enabled above all lateral thinking in the creativity phase. However, this creativity could not be translated into the further phases of the process, as there was not enough time and space from the participants' point of view for detailed development of ideas and for these to be transferred into short proposals. This is also why the creative process was unable to help the Austrian Research Promotion Agency (FFG) in selecting better projects on issues that required a high degree of interdisciplinary cooperation and/or new approaches in order to be solved. Nevertheless, the Ideas Lab has resulted in the selected teams pursuing more interdisciplinary projects, approaches and working methods than is the case in other Austrian Research Promotion Agency (FFG) programmes. The selected projects also had a strong interdisciplinary composition. However, the mentors did not identify any radically new approaches or contributions that were of particular relevance in helping to solve problems.

The requirements for applicants outlined above have proven to be effective. This was not as true for the criteria for project selection because the need for application orientation made it difficult for participants to pursue unconventional project ideas. It was not until the Austrian Research Promotion Agency (FFG) made it clear to them, that they realised that the criteria for project selection related to the possible funding instruments were a decisive specification in the openly worded call for proposals. In any case, there were indications that the intensive exchanges in the workshop resulted in new contacts between the highly diverse participants.

New stakeholders were also found for the Austrian Research Promotion Agency (FFG) from among the applications for participation in particular, although these were less successful with the selection for the Ideas Lab and with the short applications. Participation by women and their success was a welcome factor. As regards the type of organisation, universities and non-university research institutes were particularly successful.

Recommendations

Based on these results, the evaluation team recommends that in future the structural requirements of the projects should better reflect the thematic breadth of the text for the call for proposals. This would manage the expectations of the participants more effectively so their professional potential can be leveraged more fully. This can be achieved by providing better information – including information about the planned process – for participants and mentors, so that participants can recognise the process steps as being interrelated and mentors have even clearer information about their tasks and roles.

The Austrian Research Promotion Agency (FFG) should also reduce the number of possible funding

202 See Geyer and Good (2019, 10).

instruments and focus on smaller funding formats in the process. A larger number of applications with different project options should be possible in the short application phase, so that the results of the creative phase can be transferred more effectively to the short application phases. The call for proposals should also be advertised more widely among the target group of companies and application-oriented researchers in order to ensure that sufficient numbers of these participate in the programme. The Austrian Research Promotion Agency (FFG) should also as far as possible allow changes to the project design during the full application phase. Finally, the Austrian Research Promotion Agency (FFG) should create networking opportunities for the participants in order to help them stay in touch after the projects.

Further trends

Due to the supportive nature of the evaluation, some recommendations were already implemented by the Austrian Research Promotion Agency (FFG) in the second pilot call for proposals in 2019. Among other things, companies were specifically addressed through appropriate wording of the call for proposals question, the duration of the event was reduced to 3.5 days and the newly formed consortia submitted their final application on the last day of the Ideas Lab. The jury was then able to recommend six highly interdisciplinary projects for funding from the ten exploratory projects that were submitted.[203]

The programme, evaluation results, as well as the cooperation in developing the programme with the Ludwig Bolzmann Society, which had conducted a first Ideas Lab in 2017, were presented and discussed with fteval members at an event organised by fteval and the Austrian Research Promotion Agency (FFG) in December 2019.

4.2.2 Evaluation of OSTA Washington and Beijing

International cooperation has become an increasingly important element in national and international research, technology and innovation policy in recent decades. Both European as well as non-European collaborations have been and are receiving public support in many countries as well as at the European level. In Austria, the establishment of both the Offices of Science and Technology Austria (OSTA) in Washington and Beijing should be seen in the context of intensified cooperation efforts. OSTA Washington was founded in 2001 and since then has been driven by the motivation of linking in with the USA as the leading research nation and of supporting the many Austrian researchers in the country. OSTA Beijing was established in 2012 in accordance with the strategy "Beyond Europe – Austria's internationalisation in research, technology and innovation" as the significance of the emerging research nations became increasingly clear in the form of the BRICS countries.[204] Both offices are aimed at strengthening bilateral relations with North America and Mexico as well as China and Mongolia.

Both OSTAs are based in the Austrian embassies and are managed by a steering committee that meets regularly in accordance with a joint interministerial framework agreement. The steering committee is made up of representatives from the Federal Ministry for European and International Affairs, the Federal Ministry of Education, Science and Research (BMWF), the Federal Ministry for Digital and Economic Affairs (BMDW) and, until the end of 2019, from the then Federal Ministry of Transport, Innovation and Technology.

The Centre for Social Innovation (ZSI) was appointed together with Joanneum Research GmbH to carry out an evaluation[205] of both OSTAs in February

203 See https://www.ffg.at/ideenlab/ausschreibung2019

204 See Federal Ministry for Transport, Innovation and Technology (BMVIT), Federal Ministry of Science and Research (BMWF), Austrian Federal Ministry of Economy, Family and Youth (BMWFJ) and Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA) (2013).

205 See Sturn et al. (2019).

2019. This included an assessment of the activities and their impact and a comparison with Sweden and Switzerland; it evaluated reporting and monitoring activities, estimated benefits and significance, proposed recommendations and outlined four future scenarios.

Methods

Different methods were used as part of the evaluation: an online survey was used to question organisations and individuals who have used OSTA services (researchers, research institutions and universities, companies, participants in network meetings) in Austria and the two countries where OSTA is based regarding their experiences with OSTA services and activities as well as the impact and sustainability of the services. Interviews were carried out in person and on the telephone with all responsible ministerial departments as well as with central stakeholders and actors in Austria and the countries in which the relevant party is based. Representatives from other European countries were also interviewed for the purposes of the international comparison. Desk research was used to analyse relevant literature and a wide range of materials from both OSTAs (planning documents, reports and management). Two focus groups were also held with stakeholders and institutional players in Austria, not least in order to validate the results of the survey and interviews. An on-site visit supported the in-depth evaluation of the activities and structures of the offices.

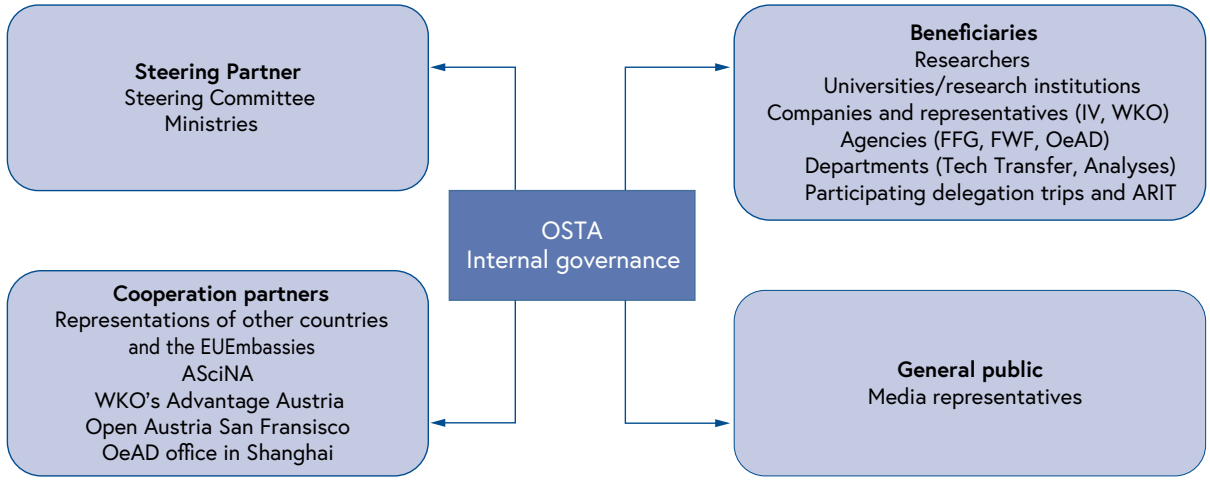
Target groups and stakeholders

The diverse responsibilities of the OSTAs clearly show that they address a large number of target groups from a broad area. Fig. 4-1 first of all shows the customers in Austria and in the countries where the organisation is based receiving services from the OSTAs, as well as the management of the offices with the steering committee and the ministries, collaboration with the cooperation partners in Austria and locally, and finally the general public. The evaluation addressed all these groups using the methods mentioned above.

Findings

Both offices are actively pursuing their tasks with great commitment and the work programmes agreed with the steering committee are largely being implemented and documented in annual reports. They are well connected with other (Austrian) organisations locally, and their employees are service-oriented, competent and qualified. A majority of the people and organisations that use OSTA services are also

Fig. 4-1: Target groups, partners and stakeholders of both OSTAs



Source: Sturn et al. (2019).

satisfied with them. However, interministerial governance is proving to be a very time-consuming and complicated process. Both OSTAs focus on different work areas adapted to the relevant needs at the location. While Washington is focused on supporting and supervising Austrian scientists and organising the annual network event ARIT, OSTA Beijing focusses mainly on bilateral RTI cooperation and the related trips of the delegates (both incoming and outgoing). The financing ministerial departments have different portfolios and associated expectations and it was not possible for the OSTAs to meet all of them.

Based on these findings, a reduction in effort and a greater flexibility in the current design was recommended. To achieve this, the evaluation set out a number of recommendations:

- clearer positioning, definition of the goals, agenda and strategic direction;
- improve connectivity in Austria;
- define cooperation with and demarcation from the foreign trade centres;
- optimise reporting procedures and introduce planning horizons covering multiple years;
- reduce operating effort on all sides.

Outlook and scenarios

The evaluation team developed four future scenarios with respect to the repositioning for the OSTAs that will be required in 2020. The overriding principle for each of these scenarios was to maintain the high level of benefits for customers and the motivation and engagement in the teams, to meet the expectations of the financing ministerial departments more effectively and to simplify the governance. The following scenarios were presented in accordance with this:

- Scenario 1: small OSTAs with variable geometry;
- Scenario 2: office community of attachés;
- Scenario 3: RTI agency responsible for the OSTAs;
- Scenario 4: internationalisation programme.

4.2.3 Impact monitoring of Austrian Research Promotion Agency (FFG) funding in companies and research institutions

Impact indicators have been collected in Austria on corporate R&D funding for over 40 years. This impact monitoring was initially used for ongoing monitoring of the impact of the subsidies of the former Industrial Research Promotion Fund (FFF) and now forms the basis for monitoring the majority of the portfolio of the organisation known in the meantime as the Austrian Research Promotion Agency (FFG). The companies that receive funding are surveyed four years after completion of the projects, since the medium-term effects on the behaviour of funding recipients and the economic results of risky R&D projects frequently only become evident after a delay. This temporal structure has been maintained until today with the exception of the period between 1986-1997, when the survey was already carried out three years after the end of the project. Since 2014, research institutions have also been surveyed. The annual monitoring reports are freely accessible on the Austrian Research Promotion Agency (FFG) website.[206]

Selected results from the period between 2011-2019 are set out below. The survey was extended in 2011 to include project funding for the Thematic and Structural Programmes and the questionnaires were developed further in connection with this. The sample comprises institutions that completed funded R&D projects in the period between 2007-2015 (2010-2015) and completed a questionnaire on the impact of the project on their organisation four years after the end of the project. The response rate has traditionally been very high since the impact monitoring began in 1977; the sample presented here is based on an average response rate of 71% for companies and 57% for research institutions.

Selected results

In the period between 2011-2019, small enterprises (according to the EU classification) represented 37%-

206 See https://www.ffg.at/content/evaluierung-der-foerderung

48% of the enterprises receiving funding, medium-sized enterprises made up 13%-25% and large enterprises 36%-41%. When looking at the number of projects implemented, however, these statistics shift in favour of large enterprises, which implemented 45% of all projects (this figure was 40% for small enterprises and 15% for medium-sized enterprises). Participation by small enterprises increased significantly over time (primarily at the expense of medium-sized enterprises), especially in knowledge-intensive services. The reason for this is the increased participation by small enterprises in the Thematic and Structural Programmes (innovation networks), with the proportion of small enterprises traditionally being high in the General Programmes. It stands to reason that large enterprises handle larger projects in terms of volume, meaning that these projects account for around 62% of the total volume of funding examined of approximately €630 million.

The shift in the number of funding recipients in particular from medium-sized enterprises to small enterprises partly reflects an incipient structural change in the Austrian economy, i.e. the increase in knowledge-intensive services. While the traditionally strong area of medium high-technology in Austria accounts for a constant share of the projects funded by the Austrian Research Promotion Agency (FFG), providers of knowledge-intensive services have significantly increased their share in the FFG portfolio in recent years.

The FFG contributes to a widening of the R&D-driven corporate basis in that, for an average of 10% of project participants, project funding from the Austrian Research Promotion Agency (FFG) represents the first R&D activity in the company. For 70% of those companies engaging in R&D for the first time, the funded project acted as an impetus for further R&D projects within four years.

At the same time, there is a slow but steady shift of projects from existing to new areas of activity of the companies (from 32% to 38% of projects), with projects from small and medium-sized companies being more often the stimulus for new activities than those from large companies. This means project funding tends to support existing specialisations in larger companies, while it tends to benefit new applications in smaller companies.

According to the 2019 survey, in 48% of the projects the results were exploited on a commercial basis within four years of project completion (process innovations were implemented, new products or services adapted etc.). This represents a decrease of 20 percentage points since 2011. At the same time, the share of projects with results that will be exploited in the future has increased from around 7% to 15%, and the share purely involving knowledge gained or with no objective to put them to commercial use is on average 28%, although there are some big differences between the different programmes. In terms of company size, large and medium-sized enterprises show the best prospects of benefitting commercially on a long-term average (57% and 54% respectively), although smaller companies also exploit almost 50% of the project results within four years after the end of the project. However, for all size categories there is an overall trend towards longer periods before commercial exploitation is possible.

The reasons for this can range from whether an R&D project in the portfolio has a practical application or not to the general demand situation in the market. In 2011 the General Programmes still accounted for 89% of all project participations, but they have fallen to 42%-46% in recent years. The shift is mainly in favour of the Thematic and Structural Programmes, which are based on different intervention logic and which sometimes support higher risk projects that are not necessarily intended to achieve rapid commercial exploitation.

The involvement of research institutions in the Austrian Research Promotion Agency (FFG) funding portfolio increased significantly due to the expansion of programmes involving a duty to cooperate. The R&D projects resulted in follow-up projects in more than 60% of cases, with around 45% of these also funded by the Austrian Research Promotion Agency (FFG); funding was provided as part of an

EU project in around 15% of cases and approximately 20% of cases result in direct follow-up orders from companies.

In terms of the impact of the projects within the sphere of the scientific community, the evidence shows that 2.4 theses are produced on average for each funded project, and the additional financial resources allow scientific staff to continue working at the research institutes in around 55% of the projects. For each project, around 3.6 articles are published in scientific journals together with the project partners, and another 3.8 articles are published by the research institution alone. The transfer of research results is advanced further through additional activities within the scope of conferences, specialist events, articles in industry journals and through social media. The findings from around two thirds of the projects can also be used in other applications, thereby resulting in knowledge and technology spillovers.

Cooperation, contacts and networking also contribute to the transfer of knowledge among companies. New contacts were established in 80% of the funded projects. Universities are traditionally the most important partners for companies: 83% of these companies made new contacts with Austrian universities and 58% with international ones. Universities of applied sciences are more relevant in a national context, while non-university research institutes also play a role at the international level. Interestingly, small enterprises have the highest proportion of contacts with international research institutions. Small companies are also highly active in terms of contacts with other companies, particularly along the value-added chain (customers and suppliers), with this being an indicator of the important role that companies have along the value chain for R&D activities.

Conclusion

The monitoring of the research funding provided by the Austrian Research Promotion Agency (FFG) develops on an on-going basis, reflecting the changes to the funding environment and addressing topics that are politically, economically and socially relevant. At the same time, new scientific trends and best practices must be taken into account in terms of survey methods and the preparation of questionnaires, in order to make clear statements that are as representative as possible on the impact of the interventions. Statements on medium to longer-term developments in the portfolio are of particular interest here, along with specific statements on individual programmes on a case-by-case basis. Some statements can also be made regarding the structural change in the Austrian research-related industry.[207]

Further development of the impact monitoring of funding provided by the Austrian Research Promotion Agency (FFG) should include a precise and structured record of the content at the most suitable points (project applications, application evaluations, final project reports, impact monitoring), and this could increase the depth of future analyses even further by combining these sources of information.

4.2.4 Evaluation of endowed professorships

Since 2014, the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) – formerly the Federal Ministry for Transport, Innovation and Technology (BMVIT) – has been using the "BMVIT endowed professorship" instrument to support the development and establishment of new topics at Austrian universities that are of particular strategic relevance for Austria as a location for innovation by appointing outstanding researchers as new professors at Austrian universities. The basic intervention logic for this instrument postulates the interdependency between establishing additional structures to close gaps in the research portfolios (and therefore the teaching offer) of Austrian universities and the investments made possible as a result of this. The direct results or effects of the

207 See Nindl and Kaufmann (2018).

funding correspond with the indicators that are "typical" for scientific organisations. The funding should indirectly generate (additional) visibility (for the universities, the professors and the topics). The research/technology topics of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) should be enshrined within universities and cooperation must be reinforced between universities and companies. The instrument is also associated with structural change at universities, i.e. technological developments must be reflected more strongly in research and teaching activities by way of funded professorships. A total of nine "BMVIT endowed professorships" have been approved so far, with seven of these positions already filled.

The goal of the instrument evaluation[208] was to examine its effectiveness over the period between 2014 and 2019 in relation to explicit and implicit strategic and operational objectives. The question of how suitable the instrument is in terms of structural changes with respect to priority setting and the development of new research areas was also a central issue. The beneficial and/or inhibiting factors at the universities and among the co-financing partners that are important for the formation and sustainable establishment of endowed professorships were identified in the process. The analyses also included experiences with endowed professorships in Germany and Switzerland in addition to experiences in Austria.

Analysis and evaluation

The evaluation team found that the "BMVIT endowed professorship" instrument generally has a high degree of certainty of achieving its goals. Given the outputs and outcomes that can be recorded or identified, as well as the steps planned or initiated with the aim of stabilising the funded structures, it is evident that the intended effects have been achieved primarily by creating new structures (professorships with corresponding activities in research and teaching as well as cooperation with companies), or the basis has been formed for these to be achieved.

However, the additionality of the structures created with the aid of the funding appears to generally be only temporary, according to the analyses. It can normally be assumed that the department in question at the funded university will not have increased in size by the end of the funding period, but rather that the university budget will be shifted. A permanent increase in size can only be achieved through third-party funding. This means that the impact of the instrument is felt much more deeply as a structural change (frequently in association with technological change). The sustainable establishment of additional structures achieved directly through the funding could only be achieved if this were to be used as an instrument for developing entire specialist departments, university institutes, etc. through the combination of multiple endowed professorships. However, the current use of the "BMVIT endowed professorships" is based around individual cases as needed. In this respect, the lack of additionality can be attributed to the current use of the instrument; the instrument itself could certainly achieve this type of effect under modified conditions (e.g. higher funding and the tender/awarding of contracts as a concerted activity, e.g. involving different donors or sponsors).

The condition that the universities appoint the endowed professors in accordance with Section 98 of the Universities Act (UG) was recognised as a key success factor for funding. This requires the professorships to be embedded in the development plans which, together with the lack of a transitional period after the end of the funding/endowment period (e.g. if following an appointment in accordance with Section 99 of the Universities Act (UG), a new invitation to tender for a university professorship would be required in accordance with Section 98 of the Universities Act (UG) for a continuation at the end of the endowment period) and planning security for the uni-

208 See Ruhland et al. (2020).

versity and professors are central factors that make the funded structures sustainable. They also make the advertised professorships appealing to top researchers.

The results show that good budgetary resources are important in order for the instrument to be effective. A lower funding volume or a smaller project size would be incapable of establishing structures, while significantly higher budgets would present the universities with greater challenges in terms of funding once the existing funding runs out. Significantly larger funding volumes would also only make sense if structures larger than individual professorships were addressed.

The unique national and international formal (financial) integration of (primarily) companies as co-funding partners of a publicly funded endowed professorship is a further success factor according to the evaluation, as the professors thereby become part of a network relevant to the universities and the funding parties from the very beginning, which enables them to design and implement collaborative research projects. This would also ensure that important operational and strategic objectives can be achieved for the funding party.

The instrument is a relatively lean tool in terms of application (compared to the funding volume) and processing, but is very time-consuming due to the length of university appointment procedures. The time required for a professor to start work is relatively long and the processes can only be controlled to a limited extent (it has so far taken between almost two years to nearly four and a half years from development of the idea of implementing the instrument and the date that the appointed individual takes up the position). The main risk associated with this is that the co-funding partners may show a decreased willingness to get involved financially. In addition, the strategy and content-related interest of funding applicants and co-funding partners could change during this period and the integration of professors at the university and in the partner network could be put at risk as a result.

According to the evaluation, the greatest overall risk lies in appointing a person to a "BMVIT endowed professorship" who either does not provide the agreed services or turns out to be unsuitable for the purposes of the foundation and the interests of the co-funding partners for other reasons. However, these types of difficulties have so far been largely avoided or solved in the medium term in the "BMVIT endowed professorships" funded to date.

Key recommendations

Based on the results of the evaluation, the evaluation report advises the funding agency to initiate an appointment procedure according to Section 99a of the Universities Act (UG) (i.e. the newly established option of "headhunting") in exceptional cases for the recruitment of top international researchers as BMVIT endowed professors (and in order to reduce uncertainty regarding the individual appointed) as an alternative to the procedure according to Section 98 of the Universities Act (UG). This option would also speed up the required appointment procedures even further.

The fact that the universities' future dealings with co-funding partners are secured and that the (potential) funding recipients reveal their strategies are both crucial for the evaluation team. To this end, the instrument should include an obligation to develop a code of conduct (i.e. the rights and obligations of the universities and co-funding companies/companies providing the endowment) or to provide this if a code is already in place as an integral part of the grant application process, as is already the case at various universities. This should also contain rules for mediation in the event of a conflict.

The relevant rectorate should be involved in each application in order to reinforce the commitments made in the statements in funding applications regarding the funding for endowed professorships once existing funding or financial or in-kind contributions of the universities run out, and to maintain this commitment throughout the entire application process as well as the appointment process once the

funding has been promised. The rectorates should also issue a letter of commitment regarding the "in-kind contributions" to be provided in an explicit and comprehensible manner (which should also be made transparent to the applicants).

It is hardly possible to shorten the time-consuming processes due to the central autonomy of the universities in appointment procedures. One key option for (at least) condensing the process would involve formal acceptance of the final version of the job advertisements for the professorships by the funding party. A potential requirement for the funding recipients to publish the vacancy notice within 12 months (or less) after the receipt of the funding commitment is a sensible step, and this should even involve a potential suspension of the funding if they fail to comply. Universities should be required to provide status updates to the funding body at regular intervals, including during the appointment process, and as soon as possible in the event of any delays.

Foundation advisory boards are more or less the established standard in connection with endowed professorships and should be formed as mandatory for the "BMVIT endowed professorship". In any case, the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) should, as the funding party, be a member of the foundation's advisory board.

4.2.5 Evaluation of the Space Strategy 2012–2020 and of the Austrian Space Applications Programme

The evaluation covers both the "Space – Future Space" strategy adopted in 2012 and the national "Austrian Space Applications Programme (ASAP)" as an important instrument in implementing the strategy.[209] The Austrian Space Strategy was developed as part of a multi-year coordination process between the Federal Ministry for Transport, Innovation and Technology – BMVIT (now the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology – BMK), the Austrian Research Promotion Agency (FFG), other ministries and agencies as well as space science, research and industry, and represents one of the first RTI sub-strategies at the federal level. In addition to outlining the priorities and competences of the Austrian space sector, the strategy represents for the first time a vision defined with four objectives, four general guidelines, five measures aimed at improving organisation and cooperation between the stakeholders, and a further 13 measures for the programme-related orientation of the space activities at the Federal Ministry for Transport, Innovation and Technology (BMVIT).

Austria has had a national space promotion programme in place since 2002. At that time, it was being implemented via the two programme lines (ASAP and ARTIST[210]). The two programmes were merged into the Austrian Space Programme (ÖWP) in 2005, and this was renamed the Austrian Space Applications Programme (ASAP) in 2007.

The evaluation aims to provide recommendations for further development of the strategy and the programme based on an analysis of the commitment to space research in the period between 2012-2018. In addition to an analysis of the strategy document with respect to its structure, internal coherence and logic, an analysis of the content was also carried out by comparing this with the space strategies in other countries and a two-stage online Delphi[211] with national and international experts and Austrian stakeholders from industry and research. The competitiveness of Austrian space research and the economic competitiveness of Austrian companies in the space sector were also mapped out. An analysis was also completed of the level to which the Austrian Space Applications Programme (ASAP) is enshrined within

209 See Kaufmann et al. (2020).

210 ARTIST stands for "Austrian Radionavigation Technology and Integrated Satnav services and products Testbed."

211 Systematic multi-stage survey of experts.

the space strategy and of the effects of the programme in terms of leveraging clients, principally international ones.

The space strategy

In terms of formulating the strategy, the stringent relationship needs to be improved between the mission, objectives, specific sub-objectives, measures and indicators. This relates to the linkage between the strategic and operational levels, as well as the linkage with specific measures derived from these, which are not only intended as a guide for future action, but which also allow stakeholders to monitor progress and make it compulsory.

In terms of content, it can be noted that publicly funded space agencies such as the ESA or NASA will continue to be the most important customers for the space industry, even though commercial end-customers are becoming more significant, and companies such as SpaceX, Blue Origin and OneWeb are challenging established stakeholders with new technologies and business models. Government stakeholders are also increasingly investing in space travel (China, India, Saudi Arabia, etc.). This is resulting in a dynamic policy field overall and a market that requires a short-term flexible approach concerning more opportunities for venture capital and cooperation and a medium-term adaptable strategic direction. Any future space strategy should take into account the opportunities and challenges arising from this.

The competitiveness of the Austrian space industry and research

For the majority of the members of the Austrospace platform, which represents the main stakeholders in the space sector, the average turnover for space-related products and services increased between 2012–2018 by approximately 70%. As a rough comparison, the global growth of the space sector over this period according to an estimate by the Space Foundation (2019) was around 37%. The exports by space companies in the observation period since 2012 are in general significantly above the Austrian average of all economic sectors based on the foreign trade statistics from Statistics Austria. Nine companies with business models that are very clearly within the field of space have also been founded in Austria since 2012, and another 35 companies have also been founded in sub-sectors involving space or using satellite-based data.

Measured in terms of publication activity in the field of space research, the output of scientific publications by Austrian institutions is on a par with that of Germany, which already holds a strong position internationally. However, the output is behind that of Switzerland, which is a leader in this area. The number of cited articles with Austrian involvement is also on a par with Germany, although this is once again below that of Switzerland. It is possible to conclude from this that Austrian institutions are successful in achieving internationally visible scientific results through the scientific cooperation they have established with partners abroad.

The Austrian Space Applications Programme

The national funding programme operates on an international level in terms of the quality-related requirements for project applications. A large part of the funded activities in the Austrian Space Applications Programme (ASAP) in the past was allocated to the upstream sector according the actual significance of the added value, i.e. products and services for space objects, launchers and instruments that are taken into space or are being upgraded there. However, the growing share of applications on Earth is increasing the importance of the midstream (in-orbit/on ground operations services and data management and distribution) and downstream sectors (products and services for satellite-based applications in science, navigation, meteorology, telecommunications and Earth observation).

The Austrian Space Applications Programme (ASAP) is above all used by the funding recipients to develop or test ideas in projects so that they can then continue these primarily in ESA programmes.

The intended leverage effect of the Austrian Space Applications Programme (ASAP) is therefore also evident in practice: most of the projects are being pursued by both research institutions and companies, either within the framework of other funding programmes (the ESA and at EU level) or with the intention of commercial exploitation. The effects of the programme in terms of its economic impact in companies and knowledge transfer at research institutions and companies are broadly comparable with other topic-based funding programmes in the Austrian Research Promotion Agency (FFG) portfolio. The programme objectives can be considered to have largely been achieved overall in terms of the indicators selected.

The most significant recommendations

The new space strategy should focus on pursuing a strengths-based approach by continuing to support current upstream strengths, and on developing synergies between upstream, midstream and downstream for the purposes of diversification into new areas based on existing competencies. The assessments of potential carried out in the evaluation are already a useful starting point in this regard.

In terms of technology transfer, technologies from other areas should increasingly be linked with space-specific issues in order to support spillover effects. This could be achieved through incentives by formulating calls for proposals on specific topics with synergy potentials for which the Austrian Space Applications Programme (ASAP) or other programmes in Austria's innovation promotion portfolio could be used.

The new strategy requires a clear structure. To this end, a stringent relationship between a mission, the global objectives and specific sub-objectives is helpful, with specific measures assigned to each of these. The strong dynamics in the policy field of space, which is already relatively complex, require the future strategy to be structured in a way that is adaptable so the dynamics of its implementation enable a continuous alignment of objectives and measures with developments in the sector. This will allow short-term corrections in direction if necessary.

Austria should make sure to increase the leverage with the EU in particular due to the increasing significance of space programmes at the European level. In order to achieve this leverage effect, consideration should also be given to strengthening preparatory work at the national level in the Austrian Space Applications Programme (ASAP) and other programmes. This could be done by implementing strategic preparatory projects with appropriate consortia and international involvement. The practice of co-funding by foreign partners, first implemented as of 2018, can be used to a greater extent in order to achieve these types of partnerships.

Finally, policymakers must ask themselves what position and what share Austria wishes to take in space research and the space market in view of growing ESA and EU budgets and the growing commercial market. This would have budgetary consequences, although these would be dealt with more effectively at the national level in preparation for leverage in the international market.

4.2.6 Evaluation of the Austrian Climate Research Programme (ACRP)

Launched in 2008, the Austrian Climate Research Programme (ACRP) is a programme of the Austrian Climate and Energy Fund (KLIEN) in cooperation with the former Federal Ministry for Sustainability and Tourism (BMNT), which was also responsible for the funding of the Climate and Energy Fund as part of its departmental competences at the time of the evaluation. The ACRP's content focuses primarily on researching the national characteristics, impacts and adaptation requirements of climate change. The ACRP pursues two thematic priorities: i) expanding Austrian research competence in content-related focal points and integrating this more thoroughly into international research, and ii) providing decision-makers in politics and administration with sound scientif-

ic bases for decision-making for the purposes of managing climate change.

The ACRP promotes research projects on various topics within the framework of annual competitive calls for proposals. In these projects climate research in Austria should be coordinated and boosted and also integrated more effectively into international climate research. The research projects that receive funding should deliver results that are useful for science, business and the public sector, while at the same time offering the potential for international recognition and topic-based leadership for Austrian climate researchers. Last but not least, the capacities for progressive interdisciplinary and transdisciplinary work with relevance for policy formulation and policy making should be established and expanded in Austria.

The Climate and Energy Fund appointed Technopolis Group Austria to carry out the evaluation[212]. The empirical basis for the evaluation involved analysis of the programme-related documents and websites, the evaluation of monitoring data, interviews with all groups of people belonging to the ACRP, four focus groups with participants in funded projects and six case studies on selected projects.

Key data

Seven calls for proposals were launched during the evaluation period from 2011 to 2017, with 137 projects receiving an average of €264,236 in funds during this time. The average duration of these projects was 31 months. A total of 92% of the funded projects were collaborative, with the most frequent ones being projects involving three or four participating institutions. This is in line with the goal of connecting Austrian climate research. The ACRP also successfully supported the international focus for Austrian climate research: partner organisations from abroad took part in 59 of the 126 collaborative projects, i.e. almost half of all projects involved (47%). A total of 134 different institutions participated in funded projects in the calls for proposals examined. The "core" of the Austrian ACRP participants is made up of 33 institutions that have taken part in several ACRP projects.

Significance and assessment

The results of the evaluation show that the ACRP has made substantial progress in achieving the programme objectives: capacities have been established both in research and in programme management, additional stakeholders have been recruited for research on climate change, and competencies have been developed and broadened in interdisciplinary and transdisciplinary research, both in relation to the technical subject matter and methodology. The foundation for building up these competencies is the conception of the ACRP as a competitive funding programme with a selection procedure based primarily on research quality and the qualifications of the project teams.

There would be little interdisciplinary or transdisciplinary climate research in Austria without the ACRP. The essential stakeholders are well-connected, and many of them also work in the funded projects in international partnerships as well as with practical stakeholders from public institutions, associations, NGOs, civil society and companies. The specific research questions in the funded projects were often research-driven in the sense that they were formulated and proposed by researchers. Stakeholder involvement is a significant demand imposed by the ACRP Steering Committee, but this often only takes place in a relatively loose form that is not binding for practitioners, e.g. in the form of workshops on the specific orientation of research questions or reflecting on results. Nevertheless, many ACRP projects have produced substantial results towards the goal of overcoming the climate crisis in Austria. The most recent maximum permissible project size of €250,000 is at variance with the requirements of collaborative research, particularly in transdisciplinary

212 See Tiefenthaler and Ohler (2019).

constellations, although collaboration with stakeholders from practice is essential for the purposes of achieving the programme objectives.

Communication regarding the programme and its results has some weaknesses according to the evaluators, mainly due to the insufficient resources available for programme management. The ACRP's climate policy objectives are clearly in need of improvement.

The ACRP's two central goals of building up research competence on the one hand and providing scientifically sound bases for decision-making in practical applications on the other complement each other in a meaningful way, but also leave the relevant stakeholders exposed to an area of conflict. This conflict arises from the fact that research has to bridge the gap between conflicting requirements stipulated by both programme objectives. Table 4-1 provides a stylised overview.

The gap between these areas of conflict cannot be bridged adequately with the ACRP instruments used so far, particularly in light of the growing relevance of the topic. Despite all of its practically-oriented features, the existing governance model for the ACRP is clearly dominated by the logic of research, which was and remains important in terms of the objective of developing expertise. The second objective of relevance to society is not reflected adequately in the steering process. Both objectives must be brought more closely into line in the future.

Assessment and recommendations

The political relevance of the ACRP is beyond dispute according to evaluators: Managing climate change and containing it wherever possible is one of the key challenges of our time, particularly since, along with the decline in biodiversity, climate change represents the other breaking point for the planet that could cause Earth's systems to topple with irreversible consequences[213]. As shown in the Fifth IPCC Assessment Report[214], there is already a fundamental understanding of climate change and its causes, meaning that there is already an adequate knowledge base available for decisive political action. However, there are also still many open questions and therefore further research is needed to fill these gaps in knowledge, with the ACRP playing a key role here. Although

Table 4-1: Areas of conflict within the ACRP due to the dual objectives

	Objective: Research competencies	Objective: Bases for decision-making in practice
Primary target group	International scientific community	Stakeholders from practice working on practical applications, primarily in politics & administration, national and regional
Expectation	Sound scientific findings as a basis for further research; practical applicability is of secondary importance	Answers that are easy to understand and results that can be applied in specific cases focusing on topics that are relevant in Austria
Preferred working method	(Inter)disciplinary, international cooperation	Transdisciplinary, at least some consultation with partners working on practical applications
Preferred forms of publication	Scientific journals, conferences, ACRP research reports Dominant language: Technical English	Briefings, expert reports, manuals Dominant language: German
Dominant requirement	Innovative research	Research that fills gaps in knowledge
Predominant research logic	Scholarly research Research for other researchers in accordance with the logic of the scientific system	Departmental research Research for practice targeted at knowledge that can be put into practice; researchers in an advisory capacity

Source: Tiefenthaler and Ohler (2019).

213 See Will et al. (2015).
214 See IPCC (2014).

research cannot solve the problems associated with climate change, it can provide the knowledge required in this regard. In addition to requiring fundamental research, this also in particular requires practical research in the interests of the ACRP's dual objective. The evaluators' recommendation therefore is to decisively strengthen, expand and develop the ACRP even further. Increasing the budget is recommended in particular. The objectives should continue to apply, with the competence goal expanded to include the maintenance and further development of those items already achieved, establishing expertise on research issues that have been less represented in the programme to date, as well as establishing demand and research expertise among stakeholders working on practical applications. The range of instruments available should be expanded and differentiated for this in order to enable transdisciplinary work and co-creation processes even more effectively and to promote partnerships with stakeholders working on practical applications. Governance and selection procedures should be developed further in such a way that the application orientation is highlighted more strongly without compromising the research quality. Intensifying communication is also recommended for the purposes of promoting the use of research results.

4.2.7 Evaluation of the Institute for Advanced Studies (IHS)

The Institute for Advanced Studies (IHS) launched an institutional evaluation by an external panel in the winter of 2018/2019 on its own initiative. Since the IHS had set itself a new mission and ambitious goals in 2015, the intention of the responsible IHS Board of Trustees was to have the status of implementation of the new mission reviewed externally and to collect ideas and suggestions for further improvements to the IHS. The evaluation stems from the reorganisation process that began in 2014.

The IHS was originally founded in 1963 as a non-university research institution with the aim of reviving social sciences in the Austrian higher education landscape as these were underdeveloped at that time. For this reason, the IHS was founded as an independent organisation by renowned emigrants and the Ford Foundation.[215] In the following years, the IHS succeeded in establishing itself as a core part of social sciences in Austria and gained widespread acceptance with its postgraduate programmes. The IHS environment has changed with the increased performance capability of Austrian universities in the fields of economics and empirical social sciences. Its has thus also lost its relatively unique selling proposition with respect to qualitatively ambitious research and teaching in the social and economic sciences, especially in the postgraduate area. The IHS failed to fundamentally adapt its own structure and range of services to the changes in environmental conditions. Although it is still an important stakeholder in the context of national research, albeit one that is increasingly losing importance, organisational and academic silos at the Institute demonstrated a low level of research performance overall in many departments and considerable identity problems.

Furthermore, the Ministry of Science discontinued the provision of basic funding following a change in policy, meaning that the Ministry of Finance became the main financier together with the Austrian National Bank, which had remained on board. Other contributors also withdrew or significantly reduced their basic support. The situation at the IHS was so critical at the start of the 2010s that the new Board of Trustees and key stakeholders took action and decided on a comprehensive reform in 2014/15. The most significant changes included a new mission statement, abandoning teaching of

215 For a more in-depth history of the IHS, see Christian Fleck: "Wie Neues nicht entstanden ist. Die Gründung des Instituts für Höhere Studien in Wien durch Ex-Österreicher und die Ford Foundation" (How new things were not created. The founding of the Institute for Advanced Studies in Vienna by Expats and the Ford Foundation). Österreichische Zeitschrift für Geschichtswissenschaften (Austrian Journal of Historical Sciences) 11/1, 2000, 129-178, https://nbn-resolving.org/urn:nbn:de:0168-ssoar-234866.

economics, professionalisation of internal management and above all a new internal structure with research groups often with an interdisciplinary focus along topic-based groupings (also known as "grand challenges"). The IHS then set up a new statute, a new scientific advisory board and a new director. A vision ("The IHS in 2025") was drawn up along with targets up to the year 2020.

The IHS is currently a medium-sized social science research institute with a focus on important societal challenges and policy areas such as higher education, health, inequality research and social policy. In addition, the focus on the areas of finance policy, selected macroeconomic issues and economic forecasts forms an important part of the IHS's work. The total staff numbers approximately 150 (headcount, including doctoral candidates), with around 80 of these working as researchers. Aside from a number of administrative units, the IHS is organised into ten research units.

Methods

In order to evaluate implementation of the reforms, an international evaluation panel was asked to assess research capacity at the IHS, its reform steps since 2014 and plans for the next few years, and to make recommendations for next steps in the reform process for the IHS. The IHS mission statement was used as the cornerstone for the evaluation. In this respect, the evaluation was meant to assess the extent to which the IHS has already made progress in implementing its mission and how it can further improve the methods in order to fulfil this mission.

The evaluation content consisted of three parts:

a. assessment of IHS performance between 2016–2018;
b. assessment of the vision for the next few years (2025);
c. assessment of the Institute's overall capacity for the purposes of fulfilling its mission.

To assess the Institute's performance over the last three years, the evaluation was based on the list of "Objectives for 2020" adopted by the IHS Board of Trustees together with the new mission in 2015. The "Vision for 2025" was used to assess the ambitious goals for the next few years. This serves as a strategic objective as well as a starting point for negotiations with the Austrian government on the next performance agreement. The IHS's capacity to fulfil its mission was ultimately evaluated based on four dimensions: organisational structure, focal points for research units and research priorities, human and financial resources, as well as management processes and governance, including digital management.

The evaluation was conducted by a panel consisting of renowned external experts: Achim Wambach from the Centre for European Economic Research (ZEW) (chairman of the panel), Shaun Hargreaves from King's College London, Merle Jacobs from Lund University, Jutta Allmendinger from the WZB Berlin Social Science Center and Daniel Gros from CEPS. The panel received a self-evaluation report from the IHS prior to its on-site visit.

The members of the evaluation panel were appointed by the IHS Board of Trustees, to which the panel was also required to report. The IHS Scientific Advisory Board provided its comments on the assessment report. The panel was supported by the Vienna Science and Technology Fund (WWTF GmbH) acting as a local secretariat in order to maintain the maximum possible independence from the IHS administration. The secretariat served as the contact point between the IHS and the panel on all content-related matters.

Findings

The evaluation panel found the IHS to be a research institute undergoing a major change process following a long period of stagnation and difficulties. The panel endorsed the strategic orientation of the IHS as manifested in its mission statement ("The IHS in 2025") and the "objectives for 2020" resulting from this, in particular the efforts to combine applied and academic research as well as excellence and relevance and to become a respected centre of excellence at the European level. The panel believed that

the focus on empirical research, interdisciplinary work and societal challenges appeared to be consistent and appropriate. Although the IHS has made good progress in its two main objectives of "achieving high scientific quality" and "attracting excellent researchers", there is still some way to go.

The new organisational structure established currently following the 2015 reforms, involving ten interdisciplinary research groups/centres of excellence that focus on relevant policy areas and societal issues, appears to be appropriate overall and capable of meeting the current and future requirements of the academic and societal environment of the IHS. At the same time, however, the research groups are not consistent in terms of academic quality and performance, thematic scope and overall orientation. Not all of the groups have a clear profile. The number of groups seems too high to the panel for the basic budget currently available, which is why the IHS should further develop and rationalise its new internal structure along topic-based departments. The IHS should consider reducing the number of research groups, as this would free up some of the available resources for medium to long-term research objectives and help increase the academic quality of the output.

According to the panel, the performance of the research groups can be described as good but not optimal. Aside from the IHS's funding difficulties, the composition of the groups and their competencies is a major reason why the academic quality of the results is not optimal. Some group portfolios for instance are still dominated by descriptive research with limited academic impact and/or more traditional methodological approaches. The IHS was therefore advised to be more ambitious in its research and efforts to become a recognised player in Europe in selected topics, and to increase its proportion of medium and long-term research in its portfolio as well as its number of leading publications. A fully-fledged data service centre should also be established as a high priority.

With regard to academic orientation, the recommendation was that the IHS should also attract high-ranking researchers with outstanding academic achievements who can also be employed accordingly in fundamental research. Collaboration with universities should then be intensified in accordance with this. The advice was also to continue investing in early-stage research talents by introducing a professional PhD track. According to the panel, a clearer career model and a strong research environment should ultimately appeal to excellent postdocs.

A heavy research focus at the IHS is proposed as a prerequisite for it being able to achieve its goals, but this area is neither fully developed nor adequately covered currently by the current financial framework. The IHS lacks sufficient funding for medium and long-term research as the basic funding level at research group level is low. Most basic funds are used at present to cover administrative costs and some of the overheads. The panel on the other hand recommends increasing the budget in order to ensure first-class research. A higher basic budget for the IHS would be a step in the right direction here, as both the amount and the share of this are small by international standards. A new cost model should be developed in parallel.

The panel concludes that both governance at the IHS and its management processes have been greatly improved in recent years. However, administrative processes should be increasingly digitalised and a management information system should be set up.

Outlook

The panel chairman Prof. Dr Achim Wambach, President of the Centre for European Economic Research in Mannheim (ZEW), presented the main results of the evaluation on 21 January 2020. The IHS management is responsible for implementing the recommendations. In this respect, negotiating a suitable performance agreement for 2021 that includes the results of the evaluation will also be an important milestone for further development of the IHS.

4.2.8 Evaluation of the Institute of Science and Technology Austria (IST Austria)

Background

Activities at the Institute of Science and Technology Austria (IST Austria) are evaluated every four years in accordance with the IST Austria Act[216]. The third scientific evaluation report was submitted in February 2020 and reviewed the period from 2016–2019. It was completed in February 2020. The subject matter of the evaluation covered the following points:

- the scientific achievements, general development and the appointment strategy at the Institute;
- the research portfolio;
- the doctoral programme;
- the existing scientific and administrative services and structures;
- the activities related to technology transfer and science mediation;
- the internal organisation and plans for the future.

IST Austria[217] was founded by the Austrian federal government and the state of Lower Austria in 2006 before opening in 2009, and serves as a centre for top-level research in the field of fundamental research in the natural sciences. The objective is to establish a first-class institute for fundamental research that delivers excellence, competes with the best academic institutions in the world, provides high-quality graduate training to doctoral candidates and trains talented postdocs.

IST Austria aims to provide the ideal environment for its researchers so that they can conduct globally competitive research in the fields of mathematics, physics, chemistry, biology and computer science and to train young people to become first-class researchers in these fields.

Methods

The evaluation[218] was carried out by seven researchers who are highly renowned internationally, including two Nobel Prize winners.

The evaluation committee visited IST Austria in December 2019 and interviewed a large number of relevant stakeholders. In addition to interviews with representatives from the Institute's executive bodies, it also surveyed the majority of professors, assistant professors, students and postdocs. The committee also saw the central facilities of the Institute, including the Graduate School, the Scientific Service Units, the Technology Transfer Office, as well as the Science Communication and Public Relations department. In addition, the international experts took part in scientific lectures by assistant professors and evaluated the scientific facilities that are available as central services and infrastructures for the purposes of supplying science and research to the campus.

Results of the evaluation

The evaluators note that the number of professors has risen steadily by around five per year in recent years, with persistent success in funding applications. For example, 47% of all funding applications submitted to the European Research Council (ERC) were accepted, which is the highest success rate among all institutions of the European Union and the states associated to Horizon 2020. The Nature Index Ranking 2019, which measures both the quantity as well as the quality of publications and therefore also takes smaller institutions into account, also ranks IST Austria in third place globally. This is the best ranking for a European institution. Together with the successful statistics related to the ERC, this ranking is a very good indicator of the excellence achieved by IST Austria.

216 See Federal Law Gazette I No. 69/2006 https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20004760

217 See also Chapter 2.2.

218 See Haroche et al. (2020).

The evaluation committee gave a positive assessment of the recruitment strategy – both for assistant professors and for professors with tenure – which is based on excellence and not any specific topic (person before topic). The search for top talent should in future be accompanied by a strategy for building up strengths in carefully considered areas. This is important in order to provide a good working environment for all professors and to guarantee adequate diversity so that all main scientific fields are covered for students. The recruitment strategy should also aim to increase the number of female professors, particularly in the fields of mathematics, physics and computer science.

In addition to the quality of the professors, any attempts to establish an excellent institute also crucially depend on the quality of the students. The evaluation acknowledged IST Austria's efforts to attract highly qualified students from all over the world. It finds that the students are generally very satisfied with their education. The organisation and management of the Graduate School are considered to be highly successful and efficient.

As an integral part of IST Austria, the Graduate School is limited in law to awarding PhD degrees. Combined master's degrees/PhD programmes are already standard at top institutions internationally. Students who are accepted onto a PhD programme can also acquire a master's degree on their way towards their PhD. The evaluation committee concluded that the fact that IST Austria cannot offer combined master's degrees/PhD programmes puts the Institute at a disadvantage compared with universities, as many bachelor's students would prefer to graduate from an institution that also awards master's degrees. IST Austria should therefore also be given this same opportunity. This would accordingly increase the competitiveness of IST Austria by attracting more promising young students as a result.

Furthermore, the evaluation panel gave an excellent assessment on the diversity and quality of the scientific infrastructure in the fields of biology, physics, chemistry and computing. The various service facilities are well equipped, financed and managed.

The financial resources of the Institute were considered to be in a positive state by the evaluation panel. The evaluation panel was critical of the strong dependence on the European Research Council, where the IST Austria is particularly successful in obtaining ERC grants. Greater diversification is recommended therefore when it comes to third-party funding and other funding sources.

The evaluation welcomed the establishment of the subsidiary TWIST aimed at developing spin-offs. The international experts also believe that establishing an industrial technology park that accommodates start-ups as well as other laboratories and companies that can benefit from the scientific expertise of IST Austria, leading to a fruitful, mutual knowledge and technology transfer is a sensible idea.

The future Visitor Center will help to intensify contact and exchanges with the general public and the local environment, including in particular children.

The evaluation committee considers further growth towards 150 research groups by 2036 to be a reasonable prospect. The experts believe that the additional planned construction measures are required in order to be able to implement the plans for infrastructure and staff expansions. A new ten-year funding commitment should be in place by 2020 or 2021 in order to allow for timely planning of the new infrastructure.

The decision was taken to establish three research areas since the growth of the Institute requires certain adjustments to be made to the current management structures. This arises from the fact that the governing board will not be able to continue tracking the development of the careers of all researchers in the long term if this growth continues. The evaluation committee concludes that together with the staff, the management of IST Austria will keep the Institute on the right track.

Recommendations

In summary, the evaluation report highlights the following five recommendations:[219]

1. The growth rate at IST Austria should continue to be around five professors per year so that the milestone of 90 professorships can be reached by 2026 and the milestone of 150 professorships is possible by 2036. This requires that the Austrian government commits funding for the period 2026 to 2036 and that the federal state of Lower Austria continues to commit to the corresponding construction programme, combined with an agreement that IST Austria will retain full control over all activities on the campus grounds.
2. Due to the increasing number of professors, IST Austria's management has decided to divide the administrative management of the Institute into three research areas, each of which is headed by one professor appointed by the president for a period of three years. This new structure must remain flexible. Consultation mechanisms within the Institute would empower professors, give assistant professors a voice and give everyone more opportunities to help shape the future of the Institute.
3. The committee supports IST Austria's objective of offering a combined master's degree/PhD programme and hopes to soon see a change in the law to make this possible.
4. IST Austria should intensify its efforts aimed at achieving a strong presence in the field of chemistry by identifying young and promising researchers and making attractive offers to them.
5. Efforts should continue aimed at increasing the proportion of female professors, particularly in the fields of mathematics, physics and computer science.

219 See Haroche et al. (2020, 45).

5. List of Figures and Tables

5.1 List of Figures

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7. Annex I

7.1 Country codes

Country	Code	Country	Code	Country	Code
Albania	ALB	France	FRA	Nigeria	NGA
Argentina	ARG	Hong Kong	HKG	Netherlands	NLD
Austria	AUT	Croatia	HRV	Norway	NOR
Australia	AUS	Hungary	HUN	New Zeeland	NZL
Belgium	BEL	Ireland	IRL	Poland	POL
Bulgaria	BGR	India	IND	Portugal	PRT
Brazil	BRA	Israel	ISR	Romania	ROU
Canada	CAN	Iceland	ISL	Serbia	SRB
Switzerland	CHE	Italy	ITA	Russia	RUS
Chile	CHL	Japan	JPN	Sweden	SWE
China	CHN	South Korea	KOR	Singapore	SGP
Cyprus	CYP	Liechtenstein	LIE	Slovenia	SVN
Czechia	CZE	Lithuania	LTU	Slovakia	SVK
Germany	DEU	Luxembourg	LUX	Turkey	TUR
Denmark	DNK	Latvia	LVA	Taiwan	TWN
Estonia	EST	Montenegro	MNE	Ukraine	UKR
Greece	GRC	Macedonia	MKD	United Kingdom	UK
Spain	ESP	Malta	MLT	United States	USA
Finland	FIN	Mexico	MEX	South Africa	ZAF

7.2 List of Abbreviations

Abbreviation	Name
ABA	Austrian Business Agency
ACR	Austrian Cooperative Research
ACRP	Austrian Climate Research Programme
AI	Artificial intelligence
AIT	Austrian Institute of Technology GmbH
ALR	Agentur für Luft- und Raumfahrt (Aeronautics and Space Agency)
aws	Austria Wirtschaftsservice Gesellschaft mbH (Austrian Federal Promotional Bank)
BDI	Bundesverband der Deutschen Industrie (Federation of German Industries)
BKA	Bundeskanzleramt (Austrian Federal Chancellery)
BMBWF	Bundesministerium für Bildung, Wissenschaft und Forschung (Austrian Federal Ministry of Education, Science and Research)
BMDW	Bundesministerium für Digitalisierung und Wirtschaftsstandort (Austrian Federal Ministry for Digital and Economic Affairs)
BMF	Bundesministerium für Finanzen (Austrian Federal Ministry of Finance)
BMK	Bundesministeriums für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology)
BMNT	Bundesministerium für Nachhaltigkeit und Tourismus (Austrian Federal Ministry for Sustainability and Tourism)
BMLRT	Bundesministerium für Landwirtschaft, Regionen und Tourismus (Austrian Federal Ministry of Agriculture, Regions and Tourism)
BMÖDS	Bundesministerium für öffentlichen Dienst und Sport (Austrian Federal Ministry for the Civil Service and Sport)
BMVIT	Bundesministerium für Verkehr, Innovation und Technologie (Austrian Federal Ministry for Transport, Innovation and Technology)
BMWFW	Bundesministerium für Wissenschaft, Forschung und Wirtschaft (Austrian Federal Ministry of Science, Research and Economy)
CDG	Christian Doppler Forschungsgesellschaft (Christian Doppler Research Association)
CIS	Community Innovation Survey
CPS	Cyber-Physical-Systems
DESI	Digital Economy and Society Index
DIA	Digitalisierungsagentur (Austrian Digitalisation Agency)
DOI	Digital Object Identifier
EEK	Entwicklung und Erschließung der Künste (Advancement and Appreciation of the Arts)
EFRE	Europäische Fonds für regionale Entwicklung (European Regional Development Fund)
EIC	European Innovation Council
EIF	European Investment Fund
EIS	European Innovation Scoreboard
EIT	European Institute of Innovation and Technology

Abbreviation	Name
EP	Entwicklungsplan (Development plan)
EPO	European Patent Office
ERA	European Research Area
ERAC	European Research Area and Innovation Committee
ERC	European Research Council
ESFRI	European Strategy Forum on Research Infrastructures
FFG	Österreichische Forschungsförderungsgesellschaft (Austrian Research Promotion Agency)
FFG-EIP	European and international programmes offered by the Austrian Research Promotion Agency
fteval	Österreichische Plattform für Forschungs- und Technologiepolitikevaluierung (Austrian Platform for Research and Technology Policy Evaluation)
FWF	Fonds zur Förderung der wissenschaftlichen Forschung (Austrian Science Fund)
GBA	Geologische Bundesanstalt (Geological Survey of Austria)
GCI	Global Competitiveness Index
GCR	Global Competitiveness Report
GII	Global Innovation Index
GSK	Geistes-, Sozial- und Kulturwissenschaften (Humanities, social sciences and cultural studies)
GUEP	Gesamtösterreichischer Universitätsentwicklungsplan (Austrian National Development Plan for Public Universities)
H2020	Horizon 2020
HoP	Österreichischer Hochschulentwicklungsplan (Austrian Development Plan for Higher Education)
ICT	Information and Communication Technologies
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change
IST Austria	Institute of Science and Technology Austria
JKU	Johannes Kepler University Linz
JPI	Joint Programming Initiatives
JRC	Joint Research Centre
JR Centres	Josef Ressel Centres
KLIEN	Klima- und Energiefonds (Climate and Energy Fund)
LBG	Ludwig Boltzmann Society
LISA	Life Science Austria GmbH
LV	Leistungsvereinbarung (Performance agreement)
MSCA	Marie Skłodowska-Curie Actions
NCP	National Contact Point
NCP-IP	National Contact Point for Knowledge Transfer and Intellectual Property
NFTE	Nationalstiftung für Forschung, Technologie und Entwicklung (National Foundation for Research, Technology and Development)
OA	Open Access
OeAW	Österreichische Akademie der Wissenschaften (Austrian Academy of Sciences)
OeAD	Österreichischer Austauschdienst GmbH (Austrian Exchange Service)
OECD	Organisation for Economic Co-operation and Development
ÖGMBT	Österrreichische Gesellschaft für Molekulare Biowissenschaften und Biotechnologie (Austrian Society for Molecular Biosciences and Biotechnology)
OI Strategy	Open Innovation Strategy
ÖPA	Österreichisches Patentamt (Austrian Patent Office)
OSTA	Offices of Science and Technology Austria
PPPI	Public Procurement Promoting Innovation
RFTE	Rat für Forschung und Technologieentwicklung (Council for Research and Technology Development)
SAL	Silicon Austria Labs GmbH
SDG	Sustainable Development Goal
SMEs	Small and medium-sized enterprises
TRC	Translational Research Center
TU Wien	Technische Universität Wien (Vienna University of Technology)
UNIKO	Österreichische Universitätenkonferenz (Universities Austria)
VBCF	Vienna Biocenter Core Facilities GmbH (Vienna Biocenter Core Facilities)
WEF	World Economic Forum
WFA	Wirkungsorientierte Folgenabschätzung (Outcome-oriented impact assessment)
WIPO	World International Property Organization
ZAMG	Zentralanstalt für Meteorologie und Geodynamik (The Central Institute for Meteorology and Geodynamics)
ZEW	Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH Mannheim (Leibniz Centre for European Economic Research in Mannheim)
ZSI	Zentrum für Soziale Innovation GmbH (Centre for Social Innovation)

7.3 Overview of Open Innovation measures and examples of their implementation initiatives

		Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6
		Building Open Innovation and experimental spaces	Embed Open Innovation elements at kindergartens and schools as well as in teacher training	Further develop public administration by means of Open Innovation and greater public involvement	Set up and operate an Open Innovation platform for social/societal innovation and as a contribution to overcoming global challenges	Set up and operate an innovation map including a matchmaking platform for innovation actors	Build up research competence for the application of Open Innovation in science
Action area 1	Creation of a culture of Open Innovation and teaching of Open Innovation skills to children and adults		FFG – lateral entry for teachers within the framework of Impact Innovation FFG, BMK – Regional Talents	BMK – open consultations as part of the efforts to draw up an AI expert paper			LBG – Open Innovation in Science Research and Competence Center (OIS)
Action area 2	Formation of heterogeneous open innovation networks and partnerships across all disciplines, industries and organisations	BMK – test environments for automated driving FFG, KLIEN – flagship region for energy FFG – create Open Innovation testbeds in selected projects of the COMET centres		PPPI, BMDW, BMK – Matchmaking platform & crowdsourcing challenges	FFG – Laura Bassi 4.0 BMK – innovation platform AAL Austria	Austrian Patent Office – Open Data Initiative BMBWF research infrastructure database	
Action area 3	Mobilisation of resources and creation of the framework conditions for open innovation	ÖBB – Open Innovation Lab & Service Design Center FFG – innovation workshops FFG, BMK – innovation laboratories FFG – Education LABs	FFG – Education LABs FFG – contentXchange within the framework of Impact Innovation	BMK, BBG – "naBe" platform		BMK – Open4Innovation platform	

Measure 7	Measure 8	Measure 9	Measure 10	Measure 11	Measure 12	Measure 13	Measure 14
Establish incentive mechanisms for research partnerships with non-traditional players in research funding to strengthen Open Innovation	Increase involvement of users and members of the public in RTI funding programmes	Develop fair sharing and compensation models for crowdwork	Further develop and provide Open Innovation methods and Open Innovation instruments specifically for small and medium-sized enterprises (SMEs)	Develop and implement co-creation and Open Innovation training programmes	Embed principles of Open Data and Open Access in research	Gear the IP and exploitation strategies of companies, universities, research institutions and intermediaries to Open Innovation in order to optimise innovation potential	Implement a comprehensive communication initiative about Open Innovation to raise awareness and create networks
	FFG – Open Innovation workshops with the management of the COMET centres		Salzburg – Competence Centre for Open Innovation (KOI) FFG – Research competence for the industry – Funding of Open Innovation qualification projects	Austrian Patent Office – Training and events FFG – Crash course on Open Innovation methods in the context of Impact Innovation	Austrian Patent Office – Open Data Initiative FWF – Plan S – Making Open Access a reality by 2020	Austrian Patent Office – Raising awareness of exploitation strategies aws (ncp-ip) – Web-Guide faire.open.innovation	BMBWF & BMK – Information & communication work via the official Open Innovation website (www.openinnovation.gv.at) BMBWF & BMK – Focus on networking with OI in workshops
FFG – Ideas Lab 4.0	BMK – AAL test regions IHS – RiConfigure – Democratizing innovation BMK – Involving of future female users in FEMtech Research Projects		FFG, BMDW – Focus on open innovation in the COIN networks		BMK – "e-genius" open content platform BMK – Exchange of open RTI data pioneers		BMK – Information & communication work within the scope of the Open4Innovation platform
FFG – Ideas Lab 4.0 CDG – Partnership in Research IHS – RiConfigure – Democratizing innovation	FFG – Impact Innovation – "Erdbeerwochen" project (Strawberry Weeks project) FFG – Involve end-users in the General Programme	aws (ncp-ip) – Web Guide www.fair-open-innovation.at	Salzburg – Competence Centre for Open Innovation (KOI) Austrian Patent Office – SME research service offering	FWF – Plan S – Making Open Access a reality by 2020 Universities, BMBWF – Implementation of the OANA recommendations on Open Access BMK – Provision of research results of funded projects (Open4Innovation – Platform) BMBWF – AT2OA Austrian Transition to Open Access BMBWF – e-Infrastructures Austria BMBWF – Open Education Austria BMBWF – Portfolio/ Showroom			

8. Annex II

Federal research funding and research contracts according to the federal research database

The database for research funding and contracts (B_f.dat)[220] for the federal government has been in place since 1975, and was set up as a "documentation of facts by the federal government". Today, the database is maintained by the Federal Ministry of Education, Science and Research (BMBWF). The mandatory reporting of the ministerial departments to the relevant Science Minister is recorded in the Research Organisation Act (FOG), Federal Law Gazette No. 341/1981, last amended by Federal Law Gazette I No. 31/2018. In 2008, it was changed to a database to which all ministerial departments have access and in which they all enter their research-related funding and contracts independently. Each ministerial department is responsible for the validity and completeness of the data in its respective field of activity. The federal research database has been accessible to the public since 1 June 2016, providing the latest overview of the projects funded by the federal ministries. As a documentation database, the B_f.dat also serves to collect brief information on the content of the listed research promotion schemes and contracts awarded. With regard to the relevant reporting year, the database contains ongoing, newly approved and already completed R&D contracts and grants, their overall funding volume and actual funds paid in the reporting year. All in all, this gives an up-to-date picture of directly commissioned R&D studies, assessments, evaluations, grants and their funding by the federal government.

The federal research database thus contributes to transparency in the allocation of public funds and to the overall picture of research funding in Austria. Overall, however, the volume of research contracts and funding directly commissioned by the ministerial departments is relatively small, especially when compared to the university budgets and the resources of the research funding agencies (for details, see the overview of the federal government's use of research-related funds in the Annex). The amounts should therefore be seen as supplementary information in the sense of providing maximum transparency and completeness.

The data in the B_f.dat reveal that a total of 411 R&D projects were funded in 2019 with a volume of €456.34 million. Approximately 87% of the funds in 2019 were paid out as global funding to research institutions. This figure also includes the global institutional funding; if that amount is excluded from the partial volumes paid, a total funding of €61.09 million remains.[221] This is €10.3 million or 14.4% less than in 2018. It should be noted that this funding for each reporting year is usually a partial amount for an ongoing or completed project and this is subject to annual fluctuations depending on the progress of the respective projects.

In 2019, the Federal Ministry of Education, Science and Research (BMBWF) was the ministerial department with the largest share of entries and funding amounts (see Figure 8-1): 32.6% of the R&D projects[222] or 73.2% of the amounts (excluding global financing) were allocated to the BMBWF. This corresponds to an increase of 4.9 percentage points in funding cases and a slight decrease of 0.2 percentage points in the amounts. In terms of the number of RTI contracts and grants, the Federal Ministry of Education, Science and Research (BMBWF) is followed by the Federal Ministry for Sustainability and Tourism (BMNT); in terms of

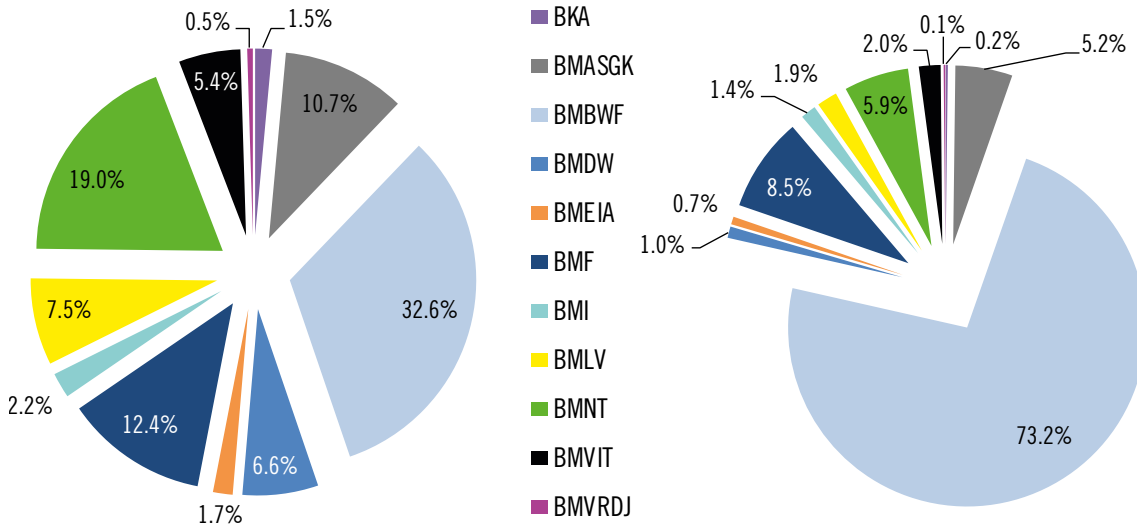
220 See www.bmbwf.gv.at/bfdat-public

221 This figure does not include institutional funding with amounts of over €500,000 each.

222 There is a possibility of double counting due to projects being shared amongst the ministries.

funding amounts it is followed by the Federal Ministry of Finance (BMF). The reason the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) had a comparatively small percentage (2.0%) was that most of the R&D funds were outsourced to the federal funding agencies Austrian Research Promotion Agency (FFG) and Austria Wirtschaftsservice (aws).

Fig. 8-1: Ongoing and completed R&D projects and funding amounts by ministerial department (in %), 2019



Source: Federal Ministry of Education, Science and Research (BMBWF), Federal research database B_f.dat (excl. "major" global financing with funding amounts higher than €500,000).

9. Statistics

9.1 Funding of gross domestic expenditure on R&D (Tables 9-1 and 9-2)[223]

The annual global estimate of expenditure on research and experimental development (R&D) for the current year was not made in 2020. The imponderable economic effects of the "coronavirus crisis" do not allow in April 2020 for a serious estimate of the expected research intensity for 2020.

Therefore, based on the available results of the 2017 R&D survey and the available documents on the financial statements and budget estimates of the federal and regional governments, the previous year's 2019 R&D global estimate was revised, and in the process the 2016-2019 values were updated.

For 2019, the research intensity is estimated to be 3.18%, a slight increase compared to 3.14% in 2018. Of the total research expenditure in 2019 (about €12.6 billion), the largest share of 47.6% (about €6.04 billion) was financed by Austrian companies. The federal government contributed 24.6% (about €3.12 billion). Indirect R&D funding in the form of the research premium accounted for 6.0%, i.e. over €750 million. Regional governments contributed 4.3% (about €550 million), 15.9% (about €2.02 billion) came from abroad and 1.6% (slightly more than €200 million) were funded by other sources. Most of the funding from abroad comes from foreign-based companies whose subsidiaries conduct research in Austria, and includes returns from EU research programmes.

9.2 Federal R&D expenditure in 2020

In Tables 9-3, 9-4 and 9-5, the total research-related expenditure of the federal government, which includes the research-related shares of the contributions to international organisations, was evaluated on the basis of the draft budget 2020 available in April. This is in line with the "GBARD" concept[224] used by the OECD and the EU, which primarily refers to the budgets of the central or federal state and, in contrast to the domestic concept, includes the research-relevant contributions to international organisations and thus also forms the basis for the classification of R&D budget data according to socio-economic objectives for reporting to the EU and the OECD.

In 2020, the following socio-economic objectives will account for the largest share of federal expenditure on research and research promotion:

- promotion of general knowledge advancement: 28.4%
- promotion of trade, commerce, and industry: 25.1%
- promotion of the health care system: 22.2%
- promotion of social and socio-economic development: 5.4%
- promotion of research covering the earth, the seas, the atmosphere, and space: 4.8%
- promotion of energy production, storage and distribution: 3.4%.

9.3 R&D expenditure of the regional governments

The research funding by the regional governments shown as a subtotal in Table 9-1 is listed from the regional government budget-based estimates of R&D expenditure reported by the offices of the regional governments. The R&D expenditure of the regional hospitals is estimated annually by Statistics Austria using a methodology agreed on with the regional governments.

9.4 An international comparison of R&D in 2017

The overview in Table 9-9 shows Austria's position compared to the other European Union Member States and the OECD in terms of the most important R&D-related indices (Source: OECD, MSTI 2019-2).

223 Each year, Statistics Austria creates a "Global estimate of the gross domestic expenditure for R&D in Austria" based on the results of the R&D statistical surveys and other currently available documents and information, in particular the R&D-related budget appropriations and outlays of the federal and regional governments. As they compile this annual global estimate, retroactive revisions or updates are made to reflect the latest data. The funding for expenditure on research and experimental development carried out in Austria is presented in accordance with the definitions of the Frascati Manual, which is valid around the world (OECD, EU) and thus ensures international comparability. According to these definitions and guidelines, foreign funding of R&D performed in Austria is included, but Austrian payments for R&D performed abroad are excluded (domestic concept).

224 GBARD: Government Budget Allocations for Research and Development.

List of Tables in the Statistical Annex

Table 9-1: Global estimate for 2019: Gross domestic expenditure on R&D funding of research and experimental development carried out in Austria, 2005–2019

Funding	2005	2006[1]	2007[1]	2008	2009[1]	2010	2011[1]	2012	2013[1]	2014	2015[1]	2016	2017[1]	2018	2019
1. Gross domestic expenditure on R&D (in € millions)	**6,029.81**	**6,318.59**	**6,867.82**	**7,548.06**	**7,479.75**	**8,066.44**	**8,276.34**	**9,287.84**	**9,571.28**	**10,275.18**	**10,499.15**	**11,145.02**	**11,289.78**	**12,110.24**	**12,688.78**
Funded by:															
Federal government[1]	1,643.51	1,616.31	1,684.20	2,016.20	2,042.83	2,257.58	2,232.63	2,410.22	2,383.70	2,592.80	2,528.17	2,825.34	2,681.89	2,954.62	3,115.26
Research premium [2]	121.35	155.75	232.76	340.58	254.63	328.85	381.66	574.05	468.98	493.23	508.02	527.67	637.48	713.00	758.00
Regional governments [3]	330.17	219.98	263.18	354.35	273.37	405.17	298.71	416.31	307.45	461.59	344.97	445.78	392.66	500.57	549.30
Business enterprise sector[4]	2,750.95	3,057.00	3,344.40	3,480.57	3,520.02	3,639.35	3,820.90	4,243.33	4,665.75	4,901.28	5,222.22	5,377.52	5,532.82	5,808.91	6,040.10
Abroad[5]	1,087.51	1,163.35	1,230.24	1,240.53	1,255.93	1,297.63	1,401.67	1,495.94	1,590.21	1,663.95	1,737.69	1,802.16	1,874.27	1,944.37	2,017.09
Other[6]	96.32	106.20	113.04	115.83	132.97	137.86	140.77	147.99	155.19	162.33	158.08	166.55	170.66	188.77	209.03
2. Nominal GDP [7])(in € billions)	254.08	267.82	283.98	293.76	288.04	295.90	310.13	318.65	323.91	333.15	344.27	357.30	370.30	385.71	398.52
3. Gross domestic expenditure on R&D as a % of GDP	***2.37***	***2.36***	***2.42***	***2.57***	***2.60***	***2.73***	***2.67***	***2.91***	***2.95***	***3.08***	***3.05***	***3.12***	***3.05***	***3.14***	***3.18***

Date: 28 April 2020.

Source: Statistics Austria (Austrian statistical office). On the basis of funding data from R&D carried out in Austria.

1) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results (federal government including the Austrian Science Fund (FWF), the Austrian Research Promotion Agency (FFG) and National Foundation for Research, Technology and Development). 2005, 2008, 2010, 2012: Annex T of the Federal Finances Acts (in each case Part b, Outlays); 2014: Federal Finances Act 2016 (BFG 2016), detailed overview of research-related appropriation of federal funds (Part b, Outlays). 2016: Federal Finances Act 2018 (BFG 2018), Detailed overview of research-related appropriation of federal funds (Part b, Outlays). 2018: Federal Financial Statements; 2019: Federal Finances Act 2019 (BFG 2019), detailed overview of research-related appropriation of federal funds (Part b, financing proposal).
2005: Including €84.4 million National Foundation for Research, Technology and Development.
2008: Including €91.0 million National Foundation for Research, Technology and Development.
2010: Including €74.6 million National Foundation for Research, Technology and Development.
2012: Including €51.3 million National Foundation for Research, Technology and Development.
2014: Including €38.7 million National Foundation for Research, Technology and Development.
2016: Including €51.7 million National Foundation for Research, Technology and Development.
2018: Including €141.0 million National Foundation for Research, Technology and Development.
2019: Including €137.5 million National Foundation for Research, Technology and Development.

2) 2006, 2007, 2009, 2011, 2013, 2015; 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Source: Federal Ministry of Finance (BMF)

3) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Based on the R&D expenditure reported by the offices of the regional governments.

4) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Estimates made by: Statistics Austria.

5) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Estimates made by: Statistics Austria.

6) Financing by local governments (excluding Vienna), chambers, social insurance institutions and other public financing and financing from the private non-profit sector. 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Estimates made by: Statistics Austria.

7) 2005–2019: Statistics Austria, date: April 2020.

Table 9-2: Global estimate for 2019: Gross domestic expenditure on R&D funding of research and experimental development carried out in Austria as a percentage of GDP, 2005–2019

Funding	2005	2006[1]	2007[1]	2008	2009[1]	2010	2011[1]	2012	2013[1]	2014	2015[1]	2016	2017[1]	2018	2019
1. Gross domestic expenditure on R&D (in € millions)	**2.37**	**2.36**	**2.42**	**2.57**	**2.60**	**2.73**	**2.67**	**2.91**	**2.95**	**3.08**	**3.05**	**3.12**	**3.05**	**3.14**	**3.18**
Funded by:															
Federal government [1]	*0.65*	*0.60*	*0.59*	*0.69*	*0.71*	*0.76*	*0.72*	*0.76*	*0.74*	*0.78*	*0.73*	*0.79*	*0.72*	*0.77*	*0.78*
Research premium[2]	*0.05*	*0.06*	*0.08*	*0.12*	*0.09*	*0.11*	*0.12*	*0.18*	*0.14*	*0.15*	*0.15*	*0.15*	*0.17*	*0.18*	*0.19*
Regional governments[3]	*0.13*	*0.08*	*0.09*	*0.12*	*0.09*	*0.14*	*0.10*	*0.13*	*0.09*	*0.14*	*0.10*	*0.12*	*0.11*	*0.13*	*0.14*
Business enterprise sector [4]	*1.08*	*1.14*	*1.18*	*1.18*	*1.22*	*1.23*	*1.23*	*1.33*	*1.44*	*1.47*	*1.52*	*1.51*	*1.49*	*1.51*	*1.52*
Abroad [5]	*0.43*	*0.43*	*0.43*	*0.42*	*0.44*	*0.44*	*0.45*	*0.47*	*0.49*	*0.50*	*0.50*	*0.50*	*0.51*	*0.50*	*0.51*
Other [6]	*0.04*	*0.04*	*0.04*	*0.04*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*
2. Nominal GDP [7] (in € billions)	**254.08**	**267.82**	**283.98**	**293.76**	**288.04**	**295.90**	**310.13**	**318.65**	**323.91**	**333.15**	**344.27**	**357.30**	**370.30**	**385.71**	**398.52**

Date: 28 April 2020.

Source: Statistics Austria (Austrian statistical office). On the basis of funding data from R&D carried out in Austria.

1) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results (federal government including the Austrian Science Fund (FWF), the Austrian Research Promotion Agency (FFG) and National Foundation for Research, Technology and Development). 2005, 2008, 2010, 2012: Annex T of the Federal Finances Acts (in each case Part b, Outlays); 2014: Federal Finances Act 2016 (BFG 2016), Detailed overview of research-related appropriation of federal funds (Part b, Outlays). 2016: Federal Finances Act 2018 (BFG 2018), Detailed overview of research-related appropriation of federal funds (Part b, Outlays). 2018: Federal Financial Statements; 2019: Federal Finances Act 2019 (BFG 2019), Detailed overview of research-related appropriation of federal funds (Part b, Financing proposal).
2005: Including €84.4 million National Foundation for Research, Technology and Development.
2008: Including €91.0 million National Foundation for Research, Technology and Development.
2010: Including €74.6 million National Foundation for Research, Technology and Development.
2012: Including €51.3 million National Foundation for Research, Technology and Development.
2014: Including €38.7 million National Foundation for Research, Technology and Development.
2016: Including €51.7 million National Foundation for Research, Technology and Development.
2018: Including €141.0 million National Foundation for Research, Technology and Development.
2019: Including €137.5 million National Foundation for Research, Technology and Development.

2) 2006, 2007, 2009, 2011, 2013, 2015; 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Source: Federal Ministry of Finance (BMF)

3) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Based on the R&D expenditure reported by the offices of the regional governments.

4) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Estimates made by: Statistics Austria.

5) 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Estimates made by: Statistics Austria.

6) Financing by local governments (excluding Vienna), chambers, social insurance institutions and other public financing and financing from the private non-profit sector. 2006, 2007, 2009, 2011, 2013, 2015, 2017: Survey results. 2005, 2008, 2010, 2012, 2014, 2016, 2018, 2019: Estimates made by: Statistics Austria.

7) 2005-2019: Statistics Austria, date: April 2020.

Table 9-3: Federal expenditure on research and research promotion, 2017 – 2020

Ministries[1]	Outlays				Financing proposal			
	2017[2]		2018[3]		2019[2]		2020[4]	
	in € millions	in %	in € millions	in %	in € millions	in %	in € millions	in %
Federal Chancellery (BKA)[5]	43,112	*1.5*	40,900	*1.4*	44,069	*1.4*	1,364	*0.0*
Federal Ministry for Family and Youth (BMFJ)	1,138	*0.0*	.	.	.	.	.	.
Federal Ministry for the Civil Service and Sport (BMÖDS)	.	.	-	-	-	-	.	.
Federal Ministry of Arts, Culture, Civil Service and Sport (BMKÖS)	.	.	.	.	.	.	38,566	*1.2*
Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA)	2,232	*0.1*	2,220	*0.1*	3,007	*0.1*	.	.
Federal Ministry for European and International Affairs (BMEIA)	.	.	.	.	.	.	2,859	*0.1*
Federal Ministry of Labour, Social Affairs and Consumer Protection (BMASK)	7,111	*0.2*	.	.	.	.	.	.
Federal Ministry for Health and Women's Affairs (BMGF)	5,649	*0.2*	.	.	.	.	.	.
Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK)	.	.	11,641	*0.4*	13,064	*0.4*	.	.
Federal Ministry of Labour, Family and Youth (BMAFJ)	.	.	.	.	.	.	7,608	*0.2*
Federal Ministry of Social Affairs, Health, Care and Consumer Protection (BMSGPK)	.	.	.	.	.	.	7,741	*0.2*
Federal Ministry of Education (BMB)	34,304	*1.2*	.	.	.	.	.	.
Federal Ministry of Science, Research and Economy (BMWFW)	2,265,857	*78.5*	.	.	.	.	.	.
Federal Ministry of Education, Science and Research (BMBWF)	.	.	2,195,673	*75.4*	2,361,438	*76.7*	2,524,363	*76.8*
Federal Ministry for Digital and Economic Affairs (BMDW)	.	.	111,038	*3.8*	99,570	*3.2*	115,656	*3.5*
Federal Ministry of Finance (BMF)	31,714	*1.1*	30,153	*1.0*	32,026	*1.0*	31,691	*1.0*
Federal Ministry of the Interior (BMI)	1,327	*0.0*	1,360	*0.0*	1,428	*0.0*	1,084	*0.0*
Federal Ministry of Defence and Sports (BMLVS)	3,202	*0.1*	.	.	.	.	.	.
Federal Ministry of Defence (BMLV)	.	.	2,988	*0.1*	4,688	*0.2*	1,960	*0.1*
Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW)	43,989	*1.5*	.	.	.	.	.	.
Federal Ministry for Sustainability and Tourism (BMNT)	.	.	42,643	*1.5*	39,191	*1.3*	.	.
Federal Ministry of Agriculture, Regions and Tourism (BMLRT)	.	.	.	.	.	.	42,458	*1.3*
Federal Ministry of Justice (BMJ)	0.063	*0.0*	.	.	.	.	0.036	*0.0*
Federal Ministry of Constitutional Affairs, Reforms, Deregulation and Justice (BMVRDJ)	.	.	0.105	*0.0*	0.059	*0.0*	.	.
Federal Ministry for Transport, Innovation and Technology (BMVIT)	450,081	*15.6*	474,648	*16.3*	482,547	*15.7*	.	.
Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)	.	.	.	.	.	.	514,886	*15.6*
Total	**2,889,779**	***100.0***	**2,913,369**	***100.0***	**3,081,087**	***100.0***	**3,290,272**	***100.0***

Date: April 2020.

Source: Statistics Austria (Austrian statistical office). On the basis of funding data from R&D carried out in Austria.

1) In accordance with the applicable version of the Federal Ministries Act of 1986 valid in the respective year (2017: Federal Law Gazette I No. 49/2016; 2018, 2019: Federal Law Gazette I No. 164/2017; 2020: Federal Law Gazette I No. 8/2020).

2) Federal Finances Act 2019 (BFG 2019), Detailed overview of research-related appropriation of federal funds.

3) Report on the Federal Financial Statements 2018.

4) Draft Budget 2020 (April 2020).

5) Including the highest executive bodies.

Table 9-4: Federal expenditure on research and research promotion by socio-economic objective, 2005-2020

Breakdown of Annex T of the Auxiliary Documents and the "Detailed overview of research-related appropriation of federal funds" (Parts a and b) for the Federal Finances Acts

Reporting year		Total federal expenditure for R&D	of which for												
			Promotion of research covering the earth, the seas, the atmosphere, and space	Promotion of agriculture and forestry	Promotion of trade, commerce and industry	Promotion of energy production, storage and distribution	Promotion of transport, traffic and communications	Promotion of schools and education	Promotion of the health care system	Promotion of social and socio-economic development	Promotion of environmental protection	Promotion of urban and physical planning	Promotion of national defence	Promotion of other objectives	Promotion of general knowledge advancement
2005[1]	in €1,000	1,619,740	85,101	57,618	347,841	28,320	35,275	9,557	362,000	73,978	46,384	13,349	243	16,165	543,909
	in %	*100.0*	*5.3*	*3.6*	*21.5*	*1.7*	*2.2*	*0.6*	*22.3*	*4.6*	*2.9*	*0.8*	*0.0*	*1.0*	*33.5*
2006[2]	in €1,000	1,697,550	76,887	57,698	411,462	20,951	42,795	18,997	379,776	81,812	53,279	9,602	126	-	544,165
	in %	*100.0*	*4.5*	*3.4*	*24.2*	*1.2*	*2.5*	*1.1*	*22.4*	*4.8*	*3.1*	*0.6*	*0.0*	-	*32.2*
2007[3]	in €1,000	1,770,144	80,962	64,637	435,799	28,001	40,013	19,990	373,431	90,639	56,075	9,673	27	894	570,003
	in %	*100.0*	*4.6*	*3.7*	*24.6*	*1.6*	*2.3*	*1.1*	*21.1*	*5.1*	*3.2*	*0.5*	*0.0*	*0.1*	*32.1*
2008[4]	in €1,000	1,986,775	87,751	66,273	525,573	24,655	39,990	37,636	422,617	90,879	57,535	12,279	142	-	621,445
	in %	*100.0*	*4.4*	*3.3*	*26.5*	*1.2*	*2.0*	*1.9*	*21.3*	*4.6*	*2.9*	*0.6*	*0.0*	-	*31.3*
2009[5]	in €1,000	2,149,787	104,775	66,647	538,539	32,964	47,300	42,581	456,544	97,076	67,985	14,522	133	-	680,721
	in %	*100.0*	*4.9*	*3.1*	*25.1*	*1.5*	*2.2*	*2.0*	*21.2*	*4.5*	*3.2*	*0.7*	*0.0*	-	*31.6*
2010[6]	in €1,000	2,269,986	103,791	67,621	587,124	39,977	56,969	50,648	472,455	99,798	67,114	12,792	123	-	711,574
	in %	*100.0*	*4.6*	*3.0*	*25.9*	*1.8*	*2.5*	*2.2*	*20.8*	*4.4*	*3.0*	*0.6*	*0.0*	-	*31.2*
2011[7]	in €1,000	2,428,143	107,277	63,063	613,692	41,294	54,043	59,479	510,359	115,792	77,578	20,170	99	-	765,297
	in %	*100.0*	*4.4*	*2.6*	*25.3*	*1.7*	*2.2*	*2.4*	*21.0*	*4.8*	*3.2*	*0.8*	*0.0*	-	*31.6*
2012[8]	in €1,000	2,452,955	103,432	60,609	607,920	55,396	47,934	65,537	499,833	121,570	86,776	20,338	120	-	783,490
	in %	*100.0*	*4.2*	*2.5*	*24.8*	*2.3*	*2.0*	*2.7*	*20.4*	*5.0*	*3.5*	*0.8*	*0.0*	-	*31.8*
2013[9]	in €1,000	2,587,586	108,966	70,897	641,851	76,014	53,713	83,087	542,560	117,714	83,556	21,985	280	-	786,963
	in %	*100.0*	*4.2*	*2.7*	*24.9*	*2.9*	*2.1*	*3.2*	*21.0*	*4.5*	*3.2*	*0.8*	*0.0*	-	*30.5*
2014[10]	in €1,000	2,647,489	113,173	60,714	689,214	64,582	64,675	81,354	566,058	119,780	48,381	22,639	961	-	815,958
	in %	*100.0*	*4.3*	*2.3*	*26.0*	*2.4*	*2.4*	*3.1*	*21.4*	*4.5*	*1.8*	*0.9*	*0.0*	-	*30.9*
2015[11]	in €1,000	2,744,844	124,648	58,414	678,572	122,624	51,785	78,241	584,254	128,733	49,176	26,817	1,949	-	839,631
	in %	*100.0*	*4.5*	*2.1*	*24.7*	*4.5*	*1.9*	*2.9*	*21.3*	*4.7*	*1.8*	*1.0*	*0.1*	-	*30.5*
2016[12]	in €1,000	2,875,706	131,240	60,828	747,264	122,903	46,654	82,610	592,407	135,709	49,586	28,435	2,610	-	875,460
	in %	*100.0*	*4.6*	*2.1*	*26.0*	*4.3*	*1.6*	*2.9*	*20.6*	*4.7*	*1.7*	*1.0*	*0.1*	-	*30.4*
2017[13]	in €1,000	2,889,779	144,552	70,329	728,136	106,887	68,214	74,493	609,919	159,300	45,228	35,171	4,899	9,730	832,921
	in %	*100.0*	*5.0*	*2.4*	*25.2*	*3.7*	*2.4*	*2.6*	*21.1*	*5.5*	*1.6*	*1.2*	*0.2*	*0.3*	*28.8*
2018[14]	in €1,000	2,913,369	147,535	69,753	752,214	107,966	69,823	75,212	615,795	158,546	45,196	35,534	5,245	8,955	821,595
	in %	*100.0*	*5.1*	*2.4*	*25.8*	*3.7*	*2.4*	*2.6*	*21.1*	*5.4*	*1.6*	*1.2*	*0.2*	0.3	*28.2*
2019[15]	in €1,000	3,081,087	154,660	68,450	752,594	110,157	83,165	78,876	678,113	168,342	47,778	37,923	6,709	9,287	885,033
	in %	*100.0*	*5.0*	*2.2*	*24.4*	*3.6*	*2.7*	*2.6*	*22.0*	*5.5*	*1.6*	*1.2*	*0.2*	0.3	*28.7*
2020[16]	in €1,000	3,290,272	157,524	74,316	827,257	112,849	91,991	79,644	729,031	178,357	52,534	40,209	4,421	9,368	932,771
	in %	*100.0*	*4.8*	*2.3*	*25.1*	*3.4*	*2.8*	*2.4*	*22.2*	*5.4*	*1.6*	*1.2*	*0.1*	0.3	*28.4*

Date: April 2020.

Source: Statistics Austria (Austrian statistical office).

1) Annex T of the Auxiliary Document for the Federal Finances Act 2007 (BFG 2007), outlays. – 2) Annex T of the Auxiliary Document for the Federal Finances Act 2008 (BFG 2008), outlays. Revised data. – 3) Annex T of the Auxiliary Document for the Federal Finances Act 2009 (BFG 2009), outlays. – 4) Annex T of the Auxiliary Document for the Federal Finances Act 2010 (BFG 2010), outlays. – 5) Annex T of the Auxiliary Document for the Federal Finances Act 2011 (BFG 2011), outlays. – 6) Annex T of the Auxiliary Document for the Federal Finances Act 2012 (BFG 2012), outlays. – 7) Annex T of the Auxiliary Document for the Federal Finances Act 2013 (BFG 2013) (financing proposal), outlays. Revised data. – 8) Annex T of the Auxiliary Document for the Federal Finances Act 2014 (BFG 2014) (financing proposal), outlays. – 9) Annex T of the Auxiliary Document for the Federal Finances Act 2015 (BFG 2015) (financing proposal), outlays. Revised data. – 10) Federal Finances Act 2016 (BFG 2016), Detailed overview of research-related appropriation of federal funds, outlays. – 11) Federal Finances Act 2017 (BFG 2017), Detailed overview of research-related appropriation of federal funds, outlays. Revised data. – 12) Federal Finances Act 2018 (BFG 2018), Detailed overview of research-related appropriation of federal funds, outlays. – 13) Federal Finances Act 2019 (BFG 2019), Detailed overview of research-related appropriation of federal funds, outlays. Revised data. – 14) Report on the Federal Financial Statements 2018 – 15) Federal Finances Act 2019 (BFG 2019), detailed overview of research-related appropriation of federal funds, financing proposal. – 16) Draft budget 2020 (April 2020), financing proposal.

Table 9-5: Federal expenditure on research and research promotion by socio-economic objective and ministry, 2020[1]

Ministries		Total federal expenditure for R&D	of which for												
			Promotion of research covering the earth, the seas, the atmosphere, and space	Promotion of agriculture and forestry	Promotion of trade, commerce and industry	Promotion of energy production, storage and distribution	Promotion of transport, traffic and communications	Promotion of schools and education	Promotion of the health care system	Promotion of social and socio-economic development	Promotion of environmental protection	Promotion of urban and physical planning	Promotion of national defence	Promotion of other objectives	Promotion of general knowledge advancement
BKA[2]	in €1,000	1,364	-	-	-	-	2	-	-	688	-	217	-	-	457
	in %	*100.0*	-	-	-	-	*0.1*	-	-	*50.5*	-	*15.9*	-	-	*33.5*
BMKÖS	in €1,000	38,566	5,719	-	-	-	-	-	-	6,968	-	-	-	-	25,879
	in %	*100.0*	*14.8*	-	-	-	-	-	-	*18.1*	-	-	-	-	*67.1*
BMEIA	in €1,000	2,859	-	-	-	1,138	-	-	-	1,721	-	-	-	-	-
	in %	*100.0*	-	-	-	*39.8*	-	-	-	*60.2*	-	-	-	-	-
BMAFJ	in €1,000	7,608	-	-	-	-	-	-	-	7,608	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMBWF	in €1,000	2,524,363	124,663	35,120	440,502	32,015	46,638	78,515	687,718	145,069	29,790	38,217	3,005	-	863,111
	in %	*100.0*	*4.9*	*1.4*	*17.5*	*1.3*	*1.8*	*3.1*	*27.2*	*5.7*	*1.2*	*1.5*	*0.1*	*0.0*	*34.3*
BMDW	in €1,000	115,656	-	-	115,656	-	-	-	-	-	-	-	-	-	-
	in %	*100.0*	-	-	*100.0*	-	-	-	-	-	-	-	-	-	-
BMF	in €1,000	31,691	1,291	1,452	5,044	351	586	963	6,471	7,937	376	468	-	-	6,752
	in %	*100.0*	*4.1*	*4.6*	*15.9*	*1.1*	*1.8*	*3.0*	*20.4*	*25.0*	*1.2*	*1.5*	-	-	*21.4*
BMI	in €1,000	1,084	-	-	-	-	-	-	-	1,084	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMJ	in €1,000	36	-	-	-	-	-	-	-	36	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	100.0	-	-	-	-	-
BMK	in €1,000	514,886	24,948	4,061	261,672	78,831	44,726	-	28,803	3,495	22,184	1,307	-	9,368	35,491
	in %	*100.0*	*4.8*	*0.8*	*50.8*	15.3	8.7	-	5.6	*0.7*	*4.3*	0.3	-	1.8	*6.9*
BMLV	in €1,000	1,960	-	-	-	-	-	-	-	-	-	-	1,416	-	544
	in %	*100.0*	-	-	-	-	-	-	-	-	-	-	72.2	-	27.8
BMLRT	in €1,000	42,458	903	33,683	4,383	514	39	166	291	1,758	184	-	-	-	537
	in %	*100.0*	*2.1*	*79.4*	*10.3*	*1.2*	*0.1*	0	*0.7*	*4.1*	*0.4*	-	-	-	*1.3*
BMSGPK	in €1,000	7,741	-	-	-	-	-	-	5,748	1,993	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	*74.3*	*25.7*	-	-	-	-	-
Total	**in €1,000**	**3,290,272**	**157,524**	**74,316**	**827,257**	**112,849**	**91,991**	**79,644**	**729,031**	**178,357**	**52,534**	**40,209**	**4,421**	**9,368**	**932,771**
	in %	***100.0***	***4.8***	***2.3***	***25.1***	***3.4***	***2.8***	***2.4***	***22.2***	***5.4***	***1.6***	***1.2***	***0.1***	***0.3***	***28.4***

Date: April 2020.

Source: Statistics Austria (Austrian statistical office).

1) Draft budget 2020 (April 2020), financing proposal.

2) Including the highest executive bodies.

Table 9-6: General research-related university expenditure by the federal government ("General University Funds"), 2000–2020[1]

Year	General University Funds	
	total	R&D
	in € millions	
2000	1,956,167	842,494
2001	2,008,803	866,361
2002	2,104,550	918,817
2003	2,063,685	899,326
2004	2,091,159	980,984
2005	2,136,412	1,014,543
2006	2,157,147	1,027,270
2007	2,314,955	1,083,555
2008	2,396,291	1,133,472
2009	2,626,038	1,236,757
2010	2,777,698	1,310,745
2011	2,791,094	1,388,546
2012	2,871,833	1,395,130
2013	3,000,004	1,453,596
2014	3,059,949	1,481,744
2015	3,117,320	1,509,576
2016	3,262,376	1,610,742
2017	3,319,288	1,638,460
2018	3,294,879	1,658,500
2019	3,610,048	1,781,501
2020	3,833,110	1,928,267

Date: April 2020.

Source: Statistics Austria (Austrian statistical office).

1) 2000-2017, 2019: Based on Annex T of the Auxiliary Document and the "Detailed overview of research-related appropriation of federal funds" for the Federal Finances Acts (BFG). 2018: Based on the Report on the Federal Financial Statements 2018. 2020: Based on the draft budget 2020 (April 2020). Draft budget 2020 (April 2020), financing proposal.

Table 9-7: Research promotion schemes and contracts awarded by the federal government in 2019, by sector/area of performance and awarding ministry

Analysis of the federal research database[1] without "major" global financing[2]

Minis tries	Partial amounts 2019	of which awarded to																				
		Higher education sector					Government sector							Private non-profit sector			Business enterprise sector					
		Universities (including teaching hospitals)	Universities of the arts	Universities of applied sciences	Other higher education sector [3]	Combined	Federal institutions (outside of the higher education sector)	Austrian Institute of Technology (AIT)	Austrian Academy of Sciences (OeAW)	private non-profit facilities mostly run on public financing	Ludwig Boltzmann Society (LBG)	Other public sector [4]	Combined	private non-profit sector	Individual researchers	Combined	Institutes' sub-sector ("Kooperativer Bereich") incl. competence centres (excluding AIT)	Company R&D sub-sector Firmeneigener Bereich	Combined	Austrian Science Fund (FWF)	Austrian Research Promotion Agency (FFG)	Abroad
	in €	in %																				
BKA	120,164	-	-	-	-	-	20.8	20.0	-	13.3	-	-	54.1	-	-	-	-	45.9	45.9	-	-	-
BMASGK	3,151,001	13.8	-	-	-	13.8	40.2	-	1.0	22.4	-	-	63.6	2.1	0.4	2.5	5.6	12.3	17.9	-	-	2.2
BMBWF	44,706,175	6.1	0.2	0.1		6.5	1.0	0.0	0.2	9.7	-	-	10.9	2.5	0.0	2.5	-	0.2	0.2	-	3.9	76.0
BMDW	627,855	20.1	-	3.1	-	23.2	1.0	2.8	-	48.3	-	-	52.1	6.2	-	6.2	2.6	15.9	18.5	-	-	-
BMEIA	426,926	-	-	6.5	-	6.5	-	-	-	-	-	-	-	-	-	-	-	93.5	93.5	-	-	-
BMF	5,208,981	0.7	-	-	-	0.7	29.7	-	-	18.3	-	-	48.0	0.1	3.0	3.1	-	9.1	9.1	-	37.2	1.9
BMI	854,821	13.6	-	43.0	-	56.6	-	-	-	35.0	2.7	-	37.7	-	-	-	-	4.6	4.6	-	-	1.1
BMLV	1,130,168	7.0	-	14.1		21.8	5.9	20.0	0.6	-	-	-	26.5	-	7.0	7.0	17.5	18.7	36.2	-	-	8.5
BMNT	3,577,393	59.6	-	-	-	59.6	23.7	1.0	-	1.7	-	-	26.4	2.2	-	2.2	1.7	3.5	5.2	-	6.6	-
BMVIT	1,196,647	-	-	-	-	-	-	-	-	38.1	-	6.0	44.1	10.1	-	10.1	40.9	4.9	45.8	-	-	-
BMVRDJ	86,500	-	-	-	-	-	-	-	-	100.0	-	-	100.0	-	-	-	-	-	-	-	-	-
Total	**61,086,631**	**9.2**	**0.1**	**1.0**		**10.4**	**7.0**	**0.5**	**0.2**	**11.8**	**0.0**	**0.1**	**19.6**	**2.4**	**0.4**	**2.8**	**1.5**	**3.2**	**4.7**	**-**	**6.4**	**56.1**

Date: April 2020.

Source: Statistics Austria (Austrian statistical office).

1) Data as per: 17 March 2020.

2) i.e. without institutional funding where funding amounts exceed €500,000.

3) Private universities, university colleges of teacher education, testing agencies at technical federal colleges and other institutions categorised within the higher education sector.

4) State, local and chamber institutions as well as facilities of social insurance institutions.

Table 9-8: Research promotion schemes and contracts awarded by federal government in 2019, by socio-economic objective and awarding ministry

Analysis of the federal research database[1] without "major" global financing[2]

Ministries	Total federal expenditure for R&D	of which for												
		Promotion of research covering the earth, the seas, the atmosphere, and space	Promotion of agriculture and forestry	Promotion of trade, commerce and industry	Promotion of energy production, storage and distribution	Promotion of transport, traffic and communications	Promotion of schools and education	Promotion of the health care system	Promotion of social and socio-economic development	Promotion of environmental protection	Promotion of urban and physical planning	Promotion of national defence	Promotion of other objectives	Promotion of general knowledge advancement
BKA	in €	120,164	-	-	-	-	-	-	-	120,164	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-
BMASGK	in €	3,151,001	10,000	150,000	-	-	-	-	181,753	2,632,392	-	-	-	176,856
	in %	*100.0*	*0.3*	*4.8*	-	-	-	-	*5.8*	*83.5*	-	-	-	*5.6*
BMBWF	in €	44,706,175	7,260,721	5,500	45,000	-	-	-	4,907,118	2,097,622	762,544	-	-	29,627,670
	in %	*100.0*	*16.2*	*0.0*	*0.1*	-	-	-	*11.0*	*4.7*	*1.7*	-	-	*66.3*
BMDW	in €	627,855	-	6,000	-	-	-	-	6,000	300,243	-	-	-	315,612
	in %	*100.0*	-	*1.0*	-	-	-	-	*1.0*	*47.8*	-	-	-	*50.2*
BMEIA	in €	426,926	-	-	-	-	-	-	-	418,386	8,540	-	-	-
	in %	100	-	-	-	-	-	-	-	*98.0*	*2.0*	-	-	-
BMF	in €	5,208,981	-	-	108,000	-	-	-	97,702	2,978,249	-	-	-	2,025,030
	in %	*100.0*	-	-	*2.1*	-	-	-	*1.9*	*57.1*	-	-	-	*38.9*
BMI	in €	854,821	-	-	-	-	-	-	368,000	454,821	-	-	-	32,000
	in %	*100.0*	-	-	-	-	-	-	*43.0*	*53.3*	-	-	-	*3.7*
BMLV	in €	1,130,168	120,625	-	163,949	-	8,376	-	217,016	82,500	-	-	196,890	340,812
	in %	*100.0*	*10.7*	-	*14.5*	-	*0.7*	-	*19.2*	*7.3*	-	-	*17.4*	*30.2*
BMNT	in €	3,577,393	222,157	2,561,111	108,392	-	-	-	110,029	136,024	285,178	-	-	154,502
	in %	*100.0*	*6.2*	*71.6*	*3.0*	-	-	-	*3.1*	*3.8*	*8.0*	-	-	*4.3*
BMVIT	in €	1,196,647	-	-	366,500	38,000	-	-	-	22,000	-	72,000	-	698,147
	in %	*100.0*	-	-	*30.6*	*3.2*	-	-	-	*1.8*	-	*6.0*	-	*58.4*
BMVRDJ	in €	86,500	-	-	-	-	-	-	-	86,500	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-
Total	**in €**	**61,086,631**	**7,613,503**	**2,722,611**	**791,841**	**38,000**	**8,376**	**-**	**5,887,618**	**9,328,901**	**1,056,262**	**72,000**	**196,890**	**33,370,629**
	in %	***100.0***	***12.5***	***4.5***	***1.3***	***0.1***	***0.0***	**-**	***9.6***	***15.3***	***1.7***	***0.1***	***0.3***	***54.6***

Date: April 2020.

Source: Statistics Austria (Austrian statistical office).

1) Data as per: 17 March 2020.

2) i.e. excluding institutional funding where funding amounts exceed €500,000

Table 9-9: An international comparison of research and experimental development (R&D) in 2017

Country	Gross domestic expenditure on R&D in % of GDP	Funding of gross domestic expenditure for R&D by		Employees in R&D in full-time equivalents	Gross expenditure on R&D by the			
		Government	Business		Business enterprise sector	Higher education sector	Government sector	Private non-profit sector
		in %			in % of gross domestic expenditure on R&D			
Belgium	*2.66*	*20.0*	*63.5*	82,686	*70.2*	*19.8*	*9.4*	*0.6*
Denmark p)	*3.05*	*27.2* d)	*58.5*	63,243	*64.7*	*32.1*	*3.0*	*0.3*
Germany	*3.07*	*27.7* d)	*66.2* d)	686,349	*69.1*	*17.4*	*13.5* d)	.
Finland	*2.73*	*29.0*	*58.0*	48,999	*65.3*	*25.4*	*8.5*	*0.8*
France p)	*2.21*	*32.4*	*56.1*	441,509	*65.3*	*20.7*	*12.5*	*1.6*
Greece	*1.13*	*37.6*	*44.8*	47,585 d)	*48.8*	*28.3*	*22.1*	*0.8*
Ireland e)4)	*1.17*	*25.8*	*49.0*	34,374	*72.2*	*23.6*	*4.2*	.
Italy	*1.37*	*32.3*	*53.7*	317,628 d)	*62.4*	*23.6* e)	*12.4*	*1.7*
Luxembourg	*1.27*	*43.1*	*49.6*	5,545	*55.8*	*20.4*	*23.9* d)	.
The Netherlands	*1.98*	*31.4*	*51.6*	135,626	*58.1*	*30.8*	*11.1* d)	.
Austria 5)	*3.05*	*27.6*	*54.7*	76,010	*69.9*	*22.4*	*7.1*	*0.5*
Portugal	*1.32*	*41.0*	*46.5*	54,995	*50.4*	*42.5*	*5.5*	*1.6*
Sweden v)	*3.37*	*25.0*	*60.8*	88,928	*71.3*	*24.9*	*3.6*	*0.1*
Spain	*1.21*	*38.9*	*47.8*	215,744 d)	*55.0*	*27.1*	*17.7*	*0.2*
United Kingdom	*1.65*	*26.3* e)4)	*51.8* e)4)	424,510 p)	*67.6* p)	*23.7* p)	*6.5* p)	*2.2* p)
EU-15 e)	***2.13***	***29.3***	***58.3***	**2,725,370**	***66.1***	***21.9***	***11.1***	***0.9***
Estonia	*1.28*	*40.2*	*43.6*	6,048	*47.2*	*39.6*	*11.8*	*1.4*
Latvia	*0.51*	*43.6*	*24.1*	5,378 d)	*27.2*	*46.7*	*26.1*	.
Lithuania	*0.90*	*36.4*	*35.4*	11,577	*36.8*	*35.3*	*27.9*	.
Poland	*1.03*	*38.3*	*52.5*	144,103 d)	*64.5*	*32.9*	*2.3*	*0.3*
Slovakia	*0.89*	*35.5*	*49.0*	19,011	*54.1*	*24.7*	*20.8*	*0.4*
Slovenia	*1.87*	*22.9*	*63.1*	14,713	*74.8*	*11.2*	*13.8*	*0.2*
Czechia	*1.79*	*34.6*	*39.3*	69,736	*62.9*	*19.6*	*17.2*	*0.3*
Hungary	*1.33*	*31.9*	*52.7*	40,432	*73.1* d)	*13.3* d)	*12.6* d)	.
Romania	*0.50*	*35.9*	*54.4*	32,586	*56.7*	*10.6*	*32.4*	*0.3*
EU-28 e)	***1.98***	***29.7***	***57.6***	**3,107,095**	***65.8***	***22.1***	***11.2***	***0.9***
Australia	*1.79*	*34.6* 1)	*61.9* 1)	147,809 e)2)	*52.7* e)	*34.0* e)	*10.1* e)	*3.2* e)
Chile p)	*0.36*	*47.0*	*31.4*	16,620 d)	*34.2*	*45.8*	*13.1*	*6.8*
Iceland	*2.10*	*34.5*	*36.4*	3,172	*64.3* d)	*31.5*	*4.2*	.
Israel d)e)	*4.82*	*10.6*	*35.8*	77,143 3)	*87.8*	*9.8*	*1.5*	*0.9*
Japan	*3.21*	*15.0* e)	*78.3*	890,749 d)	*78.8*	*12.0*	*7.8*	*1.4*
Canada	*1.67*	*32.5* e)	*42.7*	223,146 4)	*52.3*	*40.1*	*7.1*	*0.5*
Korea	*4.29*	*21.6*	*76.2*	471,201	*79.4*	*8.5*	*10.7*	*1.4*
Mexico	*0.33*	*76.8* e)	*19.0* e)	65,824 4)	*22.5* e)	*50.3* e)	*26.2* e)	*1.1* e)
New Zeeland	*1.37*	*35.8*	*46.4*	36,000	*55.2*	*24.7*	*20.1*	.
Norway	*2.10*	*46.7*	*42.8*	46,234	*52.6*	*33.7*	*13.7*	.
Switzerland	*3.37*	*25.9*	*67.0*	81,751	*69.4*	*27.6*	*0.8* d)	*2.2*
Turkey	*0.96*	*33.6*	*49.4*	153,552	*56.9*	*33.5*	*9.6* d)	.
United States d)p)	*2.81*	*23.1*	*62.5*	.	*72.9*	*13.0*	*9.9*	*4.3* e)
OECD total e)	***2.37***	***25.1***	***62.3***	.	***70.4***	***17.3***	***9.9***	***2.4***
People's Republic of China	*2.15*	*19.8*	*76.5*	4,033,597	*77.6*	*7.2*	*15.2*	.

Source: OECD (MSTI 2019-2), Statistics Austria (Austrian statistical office).

d) Different definition. – e) Estimated values. – p) Preliminary values.

1) 2008. – 2) 2010. – 3) 2012. – 4) 2016. – 5) Statistics Austria; results of the survey on research and experimental development 2017.

Full-time equivalent = person-year.