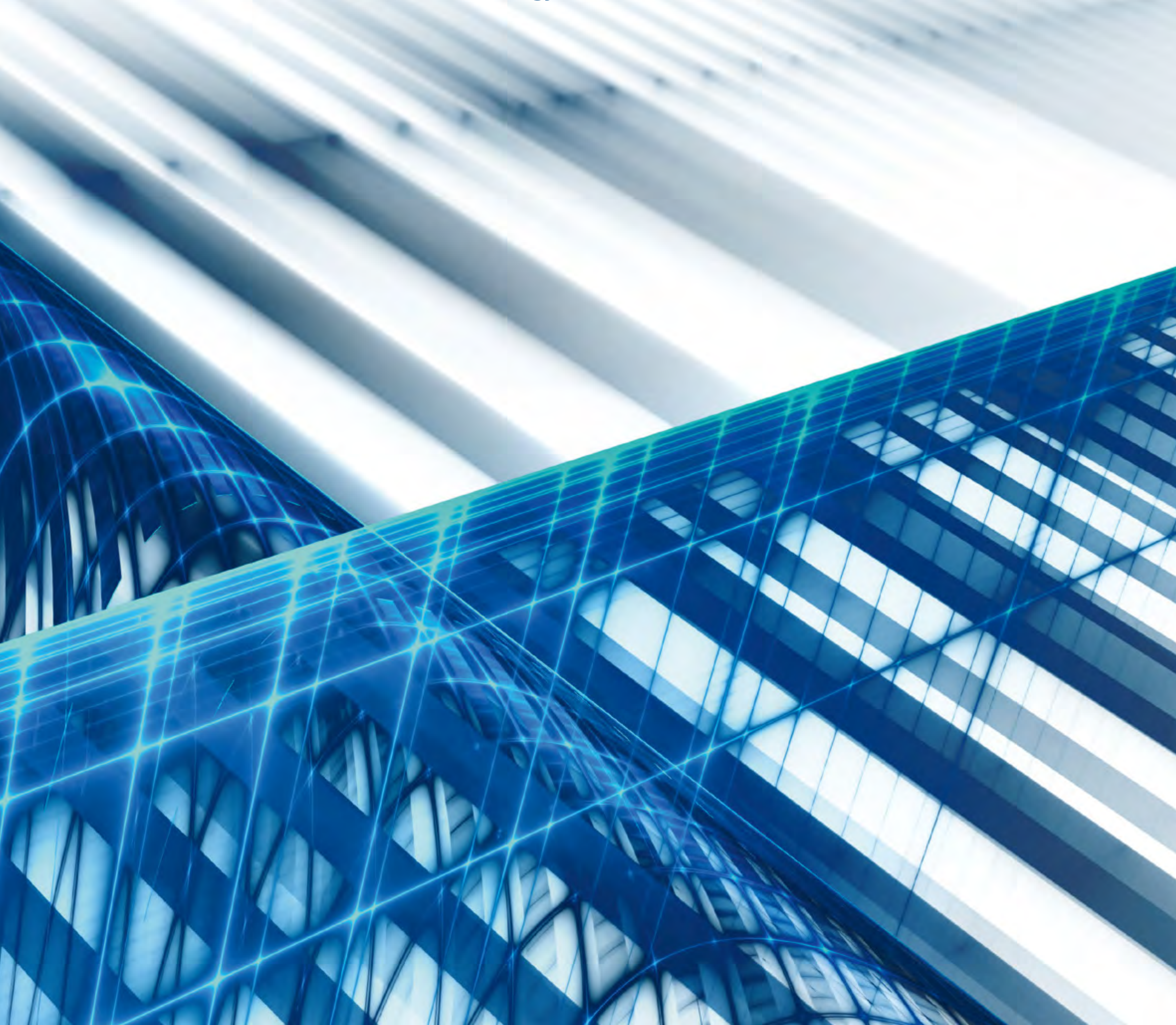
Austrian Research and Technology Report 2018

Report of the Federal Government to the Parliament (National Council) under Section 8(2) of the Research Organisation Act, on federally subsidised research, technology and innovation in Austria



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Preface

This 2018 government report presents a broad and positive picture of Austrian research, technology and innovation activities. Over the years since 2005, Austria has more than doubled its research expenditure, and increased its R&D intensity from 2.37% to 3.19%! In an international comparison, measuring research expenses in relation to gross domestic product (GDP), Austria has the second-highest R&D intensity in the EU after Sweden, and the seventh-highest worldwide. Key performance indicators of innovation have improved significantly for Austria, for example international patent applications and international co-publications. Venture capital investments have increased noticeably, although this area in particular used to be a weak spot in Austria. The high level of investment is not yet reflected in output across the board, but this is partly due to the long term nature of investments in science and research: it takes time to transform ideas into products.

A good basis for measuring a country's innovation activities is research expenditure, which according to the latest forecast from Statistics Austria will reach €12.34 billion in 2018 – €657.6 million higher than in 2017. This is an increase of 5.6%, which is well above the forecast GDP growth of 4.9%, resulting in a research intensity of 3.19% for 2018. This new record level is a clear indication that federal government measures are on the right track. In 2017 an amendment to the National Foundation Act (Nationalstiftungsgesetz) authorised the National Foundation for Research, Technology and Development to make additional funds available for research financing to the value of €100 million annually for the years 2018-2020. A further financial instrument, the Austria Fund, was created as part of the 2015/2016 Tax Reform Act, with €33.7 million to be allocated every year for five years, until 2020/21. The federal government expects to pay €610 million to firms in 2018 for the reimbursement of tax-deductible R&D expenditure. In January 2018 the government agreed to increase the research tax premium from 12 percent to 14 percent, but this will not take effect financially until 2019. Publicly funded research expenditure is expected to amount to €4.20 billion in 2018, which constitutes 34% of total R&D expenditure. The business enterprise sector, with €6.11 billion expenditure and growth of 6.9% compared to the previous year, is clearly the most important source of funds, providing around 50% of the total funding. International investors and international (subsidiary) companies investing in Austrian research make up the third most important source of funding, with €1.95 billion, a share of almost 16%.

The Research, Technology and Innovation Strategy approved by the federal government in 2011, covering the period up to 2020, has been adopted into the current government's legislative programme as an important policy framework. Numerous programmes and initiatives have been developed at government and ministerial levels with the aim of driving Austria forward into the group of European innovation leaders. This report provides an in-depth look at selected priority areas for university and non-university research, equal opportunities in research and development, future technologies in the context of digitalisation, and innovations in agriculture and food production – to name just a few of the topics. The report also provides a comprehensive overview of the latest developments and implementation projects in strategic RTI-relevant processes, programmes and initiatives.

The conclusion drawn from all these analyses is that Austria is on the right path to becoming one of the leading countries in innovation, although it will be essential to keep up our increased efforts and persevere with determination in order to build on this excellent basis and continue to improve innovation results in the coming years.

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Federal Minister for Education, Science and Research

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Federal Minister for Digitalisation and Economic Affairs

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Executive Summary

The Austrian Research and Technology Report 2018 is a report by the federal government to the Parliament (National Council) in accordance with Section 8(2) of the Research Organisation Act on the current status and needs of research, technology, and innovation in Austria. It was compiled by the Federal Ministry of Education, Science and Research (BMBWF), the Federal Ministry for Transport, Innovation and Technology (BMVIT), and the Federal Ministry for Digital and Economic Affairs (BMDW). The report looks at current data, analyses and findings to describe significant development trends and key themes in Austria's system of innovation and examine them in an international context.

The report includes the latest global estimate of trends in R&D expenditure in Austria for 2018, giving a picture of Austria's position in international rankings; it also describes recent developments in the implementation of the federal government's RTI strategy and other strategic initiatives in RTI policy. Current developments in universities and the business enterprise sector are also considered. The report outlines the demand for graduates in science, technology, engineering and mathematics (STEM subjects); the status of equal opportunities in R&D and decision-making bodies; and some characteristic features and areas of conflict in Open Science. It also discusses the contribution of universities to innovation in Austria, and, with specific reference to the life sciences and health, research priorities and interventions to support the transfer of academic discoveries into practical outcomes. Other important chapters present and discuss a comprehensive picture of current competition strategies and innovation practices by Austrian companies, explore trends and topics in digitalisation and give an insight into innovation activities in agriculture and the food industry.

Global estimate of R&D expenditure in 2018

According to Statistics Austria's current global estimate of April 2018, the expenditures forecast for research and development (R&D) carried out in Austria amount to €12.34 billion and are therefore €657.6 million higher than the value for 2017 (+5.6%). The projected growth in R&D expenditure is thereby also significantly above that for projected gross domestic product of 4.9% between 2017 and 2018. The estimated R&D intensity (gross domestic expenditure on R&D relative to gross domestic product) for 2018 is thereby expected to be 3.19% of gross domestic product, which would mean a slight increase on the previous year (2017: 3.16%, revised value compared with the 2017 global estimate) and a significant increase compared with the 3.05% in 2015 (the last year for which survey data are available). Overall the projected R&D intensity would therefore be above the European target value of 3% for the fifth year in a row.

R&D expenditure in the government sector is estimated at €4.20 billion in 2018, which would mean a rise of 4.3% or €172.3 million – slightly below the projected growth in nominal gross domestic product of 4.9%. The federal government accounts for the greatest proportion of expected public R&D expenditure at €3.56 billion (+4.1% or €140.9 million). This also includes the reimbursement of R&D expenditures by firms recognised for tax purposes (i.e. the research tax premium) as well as R&D funds from the National Foundation for Research, Technology and Development. R&D funding from the regional governments is estimated at €525.8 million for 2018, equating to an increase on 2017 of approx. 5.4% or €27 million. Other public institutions (municipal authorities, chambers, social insurance institutions) are expected to contribute €116.69 million towards R&D funding, equating to an increase of 4% (+€4.5 million). Public sector funding is thereby expected to account for 34.1% of Austrian R&D expenditure in 2018 (1.1% of GDP). The federal government is responsible for the largest proportion of this with 28.9%.

The biggest increase in R&D expenditure for 2018 is expected to come from the business enterprise sector, with an anticipated rise of 6.8% or €391.5 million as compared with 2017, which represents projected total funding of €6.11 billion. This means that in 2018 at 49.5% (approx. 1.58% of GDP), the proportion of funding from business enterprise R&D expenditure as a percentage of total expenditure is expected to be the second highest in the last decade (2015: 49.7%).

R&D funding from abroad is expected to amount to €1.95 billion in 2018, which represents an increase of 4.7% or €87.7 million. The expected funding for total R&D expenditure therefore amounts to 15.8%, which equates to 0.5% of projected nominal GDP. This amount predominantly includes funding for R&D from foreign firms to their Austrian subsidiaries as well as funds received from the EU research programmes. The private non-profit sector (private non-profit institutions whose status is predominantly private or under civil law, sectarian, or other non-public) continues to play a relatively minor role in Austrian R&D funding at an anticipated level of €70.8 million (+6.0 million) or 0.6% of total R&D expenditure.

According to Eurostat, Austria's research intensity of 3.09% in 2016 (the last year that international comparison values were published; value according to current global estimate 3.15%), was second behind Sweden (3.25%) in EU comparisons, and therefore ahead of Germany (2.94%), Denmark (2.87%) and Finland (2.75%). The average research intensity among the EU 28 in 2016 was 2.03%, and apart from the countries stated above, this was only exceeded by Belgium (2.49%) and France (2.25%).

Austria's position in international innovation rankings

Austria has progressed further towards becoming an Innovation Leader, measured in terms of the important RTI indicators. With a total R&D intensity of 3.09% in 2016, Austria achieved the second highest value in the EU 28 and the seventh highest value globally, making it one of the most research intensive countries in the world. There have also been distinct improvements recently in other key indicators of technological performance, such as international patent applications. The gap between Austria and the leading countries has reduced significantly. These developments are not, however, reflected in all international innovation rankings. While Austria was able to climb several places up the European Innovation Scoreboard in 2017, and reduce the gap between it and the leading countries, no corresponding improvement was observed in other international rankings, such as the Global Innovation Index and the innovation-related sections of the Global Competitiveness Index. In the case of the Global Innovation Index this is primarily due to the fact that it includes a large number of indicators that have little to do with a country's innovation performance. The results of the Global Competitiveness Index are based overwhelmingly on subjective management assessments which may differ from the indicators measured statistically.

Austria's advance towards the group of innovation leaders, at least in the key indicator of R&D intensity, shows that quantifiable successes can be achieved with a long-term strategy and continuous substantial efforts on the part of industry and the government. However this dynamic is not (yet) equally evident in all areas of the economic process of innovation at a national level. This means there is still the potential for further increases in innovation output. However it is important to keep in mind that it can often take a long time for higher inputs to bear fruit as higher innovation outputs. Moreover, in an international environment where all highly-developed industrial countries are focused on boosting their innovative potential, advancing to become one of the leading countries cannot be achieved rapidly, or necessarily on a permanent basis; instead this requires sustained effort and ongoing investment. Nevertheless, the successes in R&D intensity is an excellent basis for improvements in innovation results over the next few years.

Implementation of the Austrian government's RTI strategy

The RTI strategy agreed upon in 2011 has been adopted by the present Austrian federal government as an important policy framework for the 26th legislative period. A central aim of the strategy is to drive Austria forward to become one of the most innovative research countries in Europe by 2020. The RTI strategy is implemented at multiple levels with a broad-based and systemic approach to organising and supporting the innovation system. The RTI Strategy Task Force functions as an important coordinating tool for implementing strategy, and it supports the strategic and systems-oriented coordination efforts between ministerial departments. Led by the Federal Chancellery, it includes representatives of the Federal Ministry of Finance (BMF), the Federal Ministry of Education, Science and Research (BMBWF), the Federal Ministry for Transport, Innovation and Technology (BMVIT), and the Federal Ministry for Digital and Economic Affairs (BMDW). Intense and regular contact and exchange of information at a higher administrative level has made a crucial contribution to increasing the coordination between the RTI ministerial departments over the last few years.

Over the last year a series of initiatives have been launched which continue to be developed both at the federal government and ministerial department levels, with the aim of achieving the targets of the RTI strategy.

STEM university graduates

Universities play a key role in the further development of Austria as a location for innovation, amongst other things by imparting knowledge and skills in the fields of science, technology, engineering and mathematics (STEM). In light of the frequently mentioned impression that there is a lack of graduates in the STEM fields for the Austrian labour market, Chapter 3.1 discusses certain aspects of a comprehensive mapping of the supply and demand for academically trained STEM specialists in Austria. Technical vocational training in STEM subjects at middle and upper secondary school levels is also highly valued in the labour market, particularly in an international context.

This shows that the demand for some STEM qualifications exceeds supply. This applies in particular to the fields of computing and engineering. The demand is somewhat lower for graduates from other STEM fields of education such as life sciences, natural sciences or architecture. The current high demand for university graduates is likely to continue in the future. Even if future developments are difficult to predict due to disruptive technological changes (Industry 4.0, digitalisation), there is much to suggest that existing recruitment problems in the areas of information technology, mechanical engineering, electrical engineering and electronics could become even more acute in the coming years. To counteract the shortage of highly qualified STEM specialists, special attention must be paid to ensuring there are sufficient graduates in the fields of engineering and computing. A variety of projects and information campaigns are under way, with more being planned, targeting universities and schools, with the aim of increasing interest in STEM subjects and thus the number of students who choose and complete further education in this field.

Gender equality in R&D and decision-making bodies

A separate chapter in the report addresses the current situation and developments in equal opportunities in Austrian R&D. Particular attention is paid to the proportion of women in senior positions. It is noticeable that the number of women researchers working in R&D has seen significantly less dynamic improvement in recent years than previously. The growth rate in the number of women researchers is getting closer and closer to that of male researchers, meaning that the proportion of women researchers is only showing slight growth, or even approaching stagnation. In the business enterprise sector there is clear downward trend, which reflects the continuing small proportion of women in many STEM subjects that are in particularly high demand. While at least in the higher education sector the proportion of women researchers is approximately 40%, in the business enterprise sector this falls to a mere 17%. In scientific and technological non-university research the proportion of women researchers is around 27% – higher than in the business enterprise sector, but lower than at the universities. In basic non-university research institutes the proportion of women researchers varies significantly between different institutions and disciplines.

Survey findings also show that in most institutions and sectors the proportion of women researchers in lower level positions and in younger age groups is significantly above average. In senior positions, women are still underrepresented. However, developments in the university sector do show that quota regulations are helping to ensure progress in the representation of women. Around 28% of projects financed by the Austrian Science Fund (FWF) are attributable to women, although the gender ratio amongst funded doctoral and post-doctoral candidates is almost equally balanced. In terms of the Research and Technology Funding Act (FTFG) Section 4 (2), the committees of the Austrian Science Fund (FWF) were largely balanced in composition between men and women.

In Austria, various stakeholders in research, technology and innovation policy have launched initiatives to promote gender equality. In order to increase the number of women in senior positions, particular attention must be paid to the Universities Act (UG) Section 42 (8f), which governs gender-balanced membership of collegial bodies, and to the Equal Opportunities Act for Women and Men on the Supervisory Board (GFMA-G), which provides for a minimum proportion of 30% women on the supervisory boards of publicly listed firms and firms with more than 1,000 employees.

Open Science and Dark Knowledge

The opening up of scientific production processes and scientific output in the age of digitalisation is known as Open Science, and has been supported in recent years by European and Austrian policy. In the forefront here are activities to promote Open Access and Open Data, including the establishment of a range of infrastructures. The Open Access Network Austria (OANA) is a key element of this, and coordinates recommendations on Open Access activities from Austrian research institutes, research funding and research agendas, taking international developments into account. According to the Open Science approach, methodologies, data and findings from publicly funded research at universities and non-university research institutes should be made openly accessible. However there is also a trend for those involved in research not to make their findings available, or not to produce them at all. Currently this is sometimes described as "Dark Knowledge". It can lead to conflicting incentives, for example the choice of research topics may be influenced by third-party funding, and the evaluation of researchers may be affected by their output of publications in journals with the highest possible impact factor. The challenge for research policymakers is to create incentives and frameworks to reduce any possible gap between accessible knowledge and knowledge that is not made publicly available.

The contribution of universities to innovation in Austria

The potential contribution of universities to innovation is very large in an environment in which knowledge is becoming the most important production factor. This contribution finds its way into corporate innovation processes through various mechanisms, such as joint R&D projects, contractual research, consulting, technology licensing, university spin-offs, graduate participation in corporate R&D processes or by researchers in firms making use of university publications. International empirical studies emphasise the importance of graduates and publications as well as advisory activities, while the establishment of spin-offs or technology licensing for example, generally make up only a small part of the innovation contribution of universities. The data available for Austria indicate that universities play a similarly significant role in innovation. In the EU, Austria, together with Finland, is the leader in terms of the proportion of firms that cooperate with universities. Cooperation between science and industry is thus very well developed by international standards.

The effects of this cooperation in innovation confirm the influence of universities: firms that cooperate with universities develop technologically "radical" innovations more frequently than firms that do not cooperate with universities on innovations, although there are no data available that ascribe causality to the universities. University graduates – and thus university knowledge – are also used disproportionately in young, innovation-intensive firms. Moreover, industries with a high proportion of tertiary skilled workers are growing faster than industries with only a low or medium proportion of these skilled workers. Universities can thus play an important role in Austria's efforts to become one of the leading innovation countries.

Health research and its translation into medical practice

Life sciences and health research have developed rapidly over the past few years, against a background of growing social and health challenges. In Austria improved coordination processes and cooperation efforts between the stakeholders in science and industry, health policy and funding bodies have contributed significantly to a strategic positioning of these areas. National and international funding initiatives, research networks and strategic partnerships have also been central to this priority setting. This is reflected in the high level of successful participation and even project coordination by Austria in the health-related programmes of the EU's Horizon 2020 Research Framework Programme.

Despite increasingly better technical and financial circumstances, the translation of basic research into application remains a challenge. This translation process is characterised by complex interactions between different stakeholder groups along the entire value chain, from academic and clinical research through to the industrial sector. With the "Future Strategy Life Sciences and Pharmaceutical Location Austria", a further step has been taken to coordinate and orchestrate measures in the field of translating findings from basic research into medical practice. While there are already some instruments in place that promote cooperation between science and industry, further steps have been taken recently to improve infrastructures with the establishment of appropriate research institutes in universities, knowledge transfer centres and the nascent Translational Research Center.

Competitive strategies and innovative practices among Austrian firms

In order for firms operating in Austria to stay competitive they must make continuous adjustments given the growth in global competition and in particular digitalisation. Increased networking in innovation activities, shorter timeframes for product innovations, and new models for innovation such as Open Innovation, all present growing challenges for firms.

As a survey of Austrian industrial firms shows, businesses are gaining competitive advantages by developing and offering products with high technological content and premium quality, as well as adapting their products to customer preferences. On the other hand, competitive disadvantages are also evident, particularly in pricing and in the implementation of new production processes. Establishing new skills and broadening existing ones is perceived as key in dealing with the challenges of digitalisation. The necessary new knowledge and skills come partly from internal company R&D, but primarily from further training initiatives and networking with customers. Partnerships with other firms and universities and acquiring experts from abroad are becoming more and more important, particularly for the quality leaders and those firms that plan to broaden their skills significantly.

With regard to internal company organisation and innovation management in the business enterprise sector, a study at European level shows similar results. Innovation processes are frequently organised according to the "Stage-Gate" model; the customer-oriented "lean start-up" approach is less widespread, and is used more for radical innovation projects in (semi-) autonomous innovation units. The survey also shows that firms make use of their "innovation ecosystems" to generate knowledge and insights about technological possibilities, develop new knowledge through cooperation or to obtain information on future regulations. Innovation ecosystems are also used to communicate future requirements to policy decision-makers or regulatory authorities, develop common visions with external partners, and to establish new business models within the ecosystem. Today more than fifty percent of firms regularly use knowledge generated outside of the firm for their innovation activities and pursue Open Innovation as a fixed component of their business strategy.

The results indicate that the technical know-how and capabilities existing within Austrian (industrial) firms represent a good starting point for establishing new technological skills and developing new products and business areas from traditional strengths. Opening up innovation processes helps small open national economies such as Austria in particular to obtain new and effective forms of sharing knowledge, ideas and value and to exploit these within and outside of a firm. These firms face challenges, however, in the areas of training and telecommunications infrastructure. Digitalisation in particular – where the firms surveyed currently see Austria at a competitive disadvantage – requires corresponding trained expert staff.

Future technologies in the context of digitalisation

Some key technologies and applications play a particularly major role as part of the digitalisation of industry and society, and have the potential to transform individual or even multiple industries in a fundamental way. The spotlight is currently on automated driving, the "Internet of Things" and the "blockchain" transaction technology. Research stakeholders, commercial firms, public organisations, interest groups and policymakers in Austria are now exploring these developments and their potential applications. For all three of these digital technologies, policymakers need to address important legal, ethical and social issues alongside the traditional one of funding R&D, in order to initiate successful development projects.

The topic of "Automated Driving" (AD) is the focus of much attention in international and national dialogue on transport and technology policy. All well-known carmakers around the world are working intensively on achieving automated vehicles and launching these on the market. This potentially disruptive technology is of major significance for Austria, due to the importance of the automotive industry and its implications for transport policy. For this reason, an "Austrian research, development & innovation roadmap for automated vehicles" was drawn up, on the basis of which numerous test initiatives, pilots and development projects are already under way or being prepared in Austria.

The "Internet of Things" forms one of the technological cornerstones of the new production concepts operating under the label "Industry 4.0". In view of the above-average contribution of industry to the Austrian economy, these technological developments are also potentially highly significant for Austria. It is not currently possible to gain a comprehensive picture of the extent to which Industry 4.0 has permeated the Austrian business enterprise sector, but various indicators suggest that this is still in its early stages, and that any potential effects on the national economy (e.g. in the form of increased productivity) are not yet apparent.

The so-called "blockchain technology" and related applications are also still at a very early stage of development. In Austria there are now some initial pilot applications under way in the finance and energy sectors. Other fields of application such as public administration are currently being investigated though a series of studies and pilot schemes. The aim is to explore the potential and test out some innovative applications.

Investments in infrastructures (e.g. expansion of the broadband infrastructure), the funding of test environments (pilot production facilities, test tracks, trading platforms), the establishment of new qualifications and appropriate funding programmes are examples of the numerous initiatives which have recently been launched in these areas, and are designed to help harness the innovative potential of these technologies in Austria.

Innovations in the agricultural and food industries

Innovations play an important role in the (Austrian) agricultural and food business, and have a significant share in the competitiveness of the food industry. Aside from improving production and sustainability, agricultural innovations are regarded as essential to achieving the aims of balanced regional development and best use of the ecosystems. Combatting climate change, for instance, plays a major role in agriculture.

The majority of innovations in agriculture cannot be evaluated on the basis of the usual standard indicators (e.g. patents, publications). Innovations in agriculture are generally the result of activities along the entire value chain, e.g. in the form of products which are developed in cooperation with downstream businesses, or agricultural machinery (new production processes) from the engineering sector. Furthermore, the motives for developing innovations are different from those in other sectors, and international competition has a major influence on the possibilities for innovation in agricultural businesses.

The operational structure in the Austrian agricultural industry also limits the options available for achieving competitive advantages through economies of scale. Very small businesses in particular face some major challenges here. Increased cooperation, as well as innovations aimed at improving working conditions and saving labour, combined with innovations in diversification and activities which are complementary to agriculture, are what characterise the successful innovators amongst these businesses. By contrast, businesses with growing areas in regions with significant structural change (the eastern states, metropolitan areas) make use of new production methods which result in economies of scale. An innovation policy for agriculture must therefore consider regional patterns.

Aside from the regional differences, an innovation policy must take account of the specific features of the Austrian agricultural industry, and in particular the strong links with upstream and downstream industries in the innovation process. Consideration of operational objectives and of the competitive situation of the relevant business is also recommended for the promotion of operational innovation efforts. The strategy already established in Austria of promoting knowledge transfer and exchanges of best practice examples, as well as of improvements in training and the education and IT infrastructure is extremely successful in this regard. However, public financing of research and development in the agriculture and food production sector is below that of comparable countries.

The significance of microdata in supporting and assessing RTI policy

The quality and validity of the evaluations of research and technology policy measures –including the possibilities for developing and defining evidence-based policy measures – depend crucially on the data basis available. The options for recording as well as processing individual data sources have fortunately improved considerably in many countries over the last few decades. This also increasingly relates to business enterprise data as well as personal data records. The national statistical offices in the individual countries which record detailed information based on the statutory regulations serve as an essential source for these types of microdata records. These administrative data sources are often combined with information from additional surveys so that all necessary information can be brought together for the evaluation and quantitative assessment of specific industrial policy measures.

The legislative and organisational framework for the use of enterprise-specific microdata records for evaluation purposes vary significantly in different countries. A comparison of the Austrian legal situation with the access practices surrounding company-related microdata in the selected comparison countries – Germany, Denmark, France and the Netherlands – shows that there are still some significant obstacles to accessing microdata for scientific purposes in Austria. The country examples particularly show that data security and the use of business enterprise data for scientific purposes do not need to be mutually exclusive.

These examples of good practice provide valuable suggestions for Austria in terms of opening data access to individual data for assessment of the effects of research and technology policy measures. Adjustments to the statutory situation would be required in Austria, so that use of this data for research purposes can be made possible in principle, subject to clear conditions. One possibility would be to provide access to individual company-related data in Statistics Austria's existing Safe Center. Changes to data access and options for linking data could considerably improve the significance of quantitative ex-post impact evaluations of industrial policy programmes in general, and of research and technology policy measures specifically. This would contribute towards increasing the efficiency and effectiveness of policy measures for the purposes of evidence-based industrial and RTI policy.

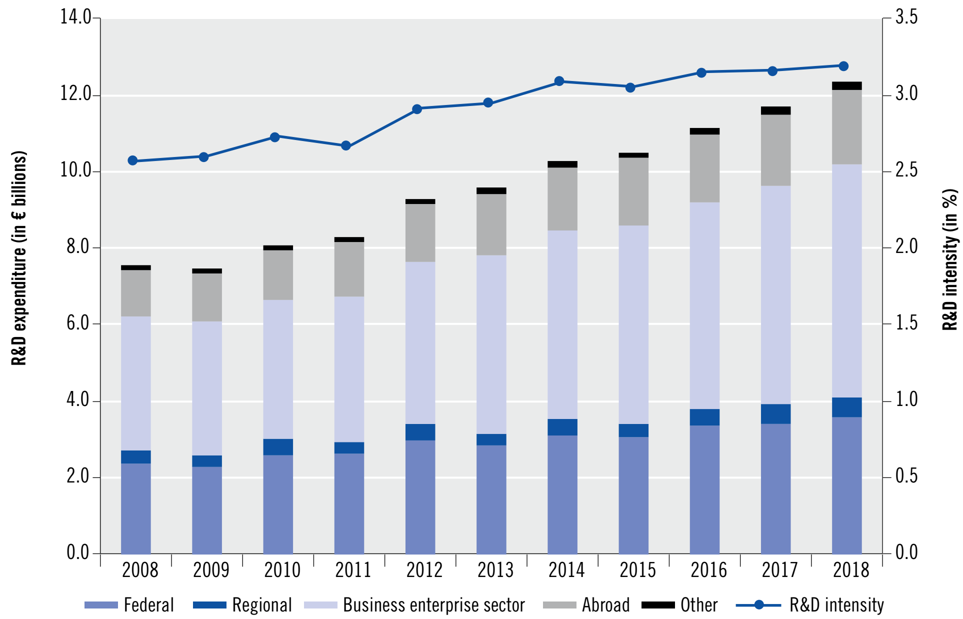
1 Current Trends

1.1 Trend of R&D expenditures based on the new global estimate

According to Statistics Austria's current global estimate of April 2018, the expenditures forecast for research and development (R&D) carried out in Austria amount to €12.34 billion and are therefore €657.6 million higher than the value for 2017 (+5.6%). The projected growth in R&D expenditure is thereby also significantly above that of projected gross domestic product of 4.9% between 2017 and 2018. The estimated R&D intensity (gross domestic expenditure on R&D relative to gross domestic product) for 2018 is thereby expected to be 3.19% of gross domestic product, which would mean a slight increase on the previous year by 0.03% points (2017: 3.16%, revised value compared with the 2017 global estimate) and a significant increase compared with the 3.05% in 2015 (the last reporting year of the Austrian R&D complete survey, see Chapter 1.2). Overall the projected R&D intensity would therefore be above the European target value of 3% for the fifth year in a row. Fig. 1-1 illustrates the long-term trend of a rise in overall R&D expenditure in Austria following slight falls or stagnation between 2008 and 2009.

According to Eurostat, with a research intensity of 3.09% in 2016 (the last year for which

Fig. 1-1: Expenditure on research and development in Austria by sources of funds



Source: Statistics Austria, Global Estimate as at 19 April 2018, nominal values.

internationally comparative values were published; value according to current global estimate 3.15%)[1], Austria was second behind Sweden (3.25%) in EU comparisons, and was therefore ahead of Germany (2.94%), Denmark (2.87%) and Finland (2.75%). The average research intensity among the EU 28 in 2016 was 2.03%, and with the exception of the countries stated above, this target was only overachieved by Belgium (2.49%) and France (2.25%).[2]

As shown in Fig. 1-2, all sources of funds contributed towards the projected growth in R&D expenditures. The biggest increase in 2018 is expected in R&D expenditure in the business enterprise sector, with an expected rise of 6.8% or €391.5 million as compared with 2017, which represents projected total funding of €6.11 billion. This means that in 2018 at 49.5% (approx. 1.58% of GDP), the proportion of funding from business enterprise R&D expenditure as a percentage of total expenditure is expected to be the second highest in the last decade (2015: 49.7%; see Fig. 1-3).

R&D expenditure in the government sector is estimated at €4.20 billion in 2018, which would mean a rise of 4.3% or €172.3 million – slightly below the projected growth in nominal gross domestic product of 4.9%. The federal government accounts for the greatest proportion of expected public R&D expenditure at €3.56 billion (+4.1% or €140.9 million). This also includes the reimbursement of R&D expenditures by firms recognised for tax purposes (i.e. the research tax premium) as well as R&D funds from the National Foundation for Research, Technology and Development. R&D funding from the regional governments is estimated at €525.8 million for 2018, equating to an increase on 2017 of approx. 5.4% or €27 million. Other public institutions (municipal authorities, chambers of commerce, social insurance institutions) are expected to contribute €116.69 million towards R&D funding, equating to an increase of 4% (+€4.5 million). Public sector funding is thereby expected to account for 34.1% of Austrian R&D expenditure in 2018 (1.1% of GDP). The federal government is responsible for the largest proportion of this with 28.9% (see Fig. 1-3).

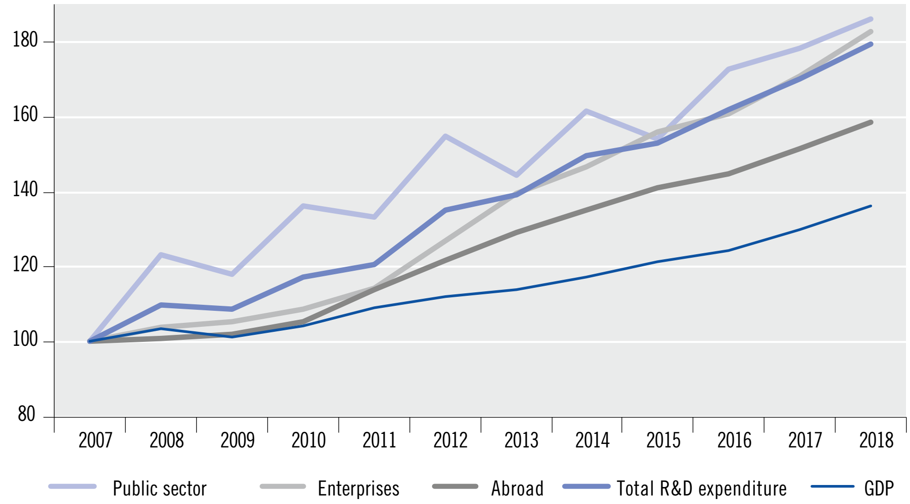
R&D funding from abroad is expected to amount to €1.95 billion in 2018, which represents an increase of 4.7% or €87.7 million. The expected funding for total R&D expenditure therefore amounts to 15.8%, which equates to 0.5% of projected nominal GDP. This amount predominantly includes funding for R&D from foreign firms to their Austrian subsidiaries as well as funds received from the EU research programmes. Given that a large part of the R&D funded from abroad originates from the business enterprise sector, the total sum of foreign and Austrian corporate funding results in a private funding share of approx. 65.4% of total R&D expenditure in Austria, which would meet the EU target of a 1/3 to 2/3 split between public and private R&D funding.

The private non-profit sector (private non-profit institutions whose status is predominantly private or under civil law, sectarian, or other non-public) continues to play a relatively minor role in Austrian R&D funding at an anticipated level of €70.8 million (+6.0 million) or 0.6% of total R&D expenditure.

1 The discrepancy between the data points is explained by the different data provision times. While Eurostat data on R&D intensity is provided with an 18-month delay following the end of the relevant calendar year, annual data is published as part of Statistics Austria's global estimate. Austria's ranking in 2016 (second behind Sweden) also remains unchanged with due regard to the more current data point in the global estimate.

2 See Eurostat (2018): Internal company R&D expenditure as a whole by sector of performance [rd_e_gerdtot].

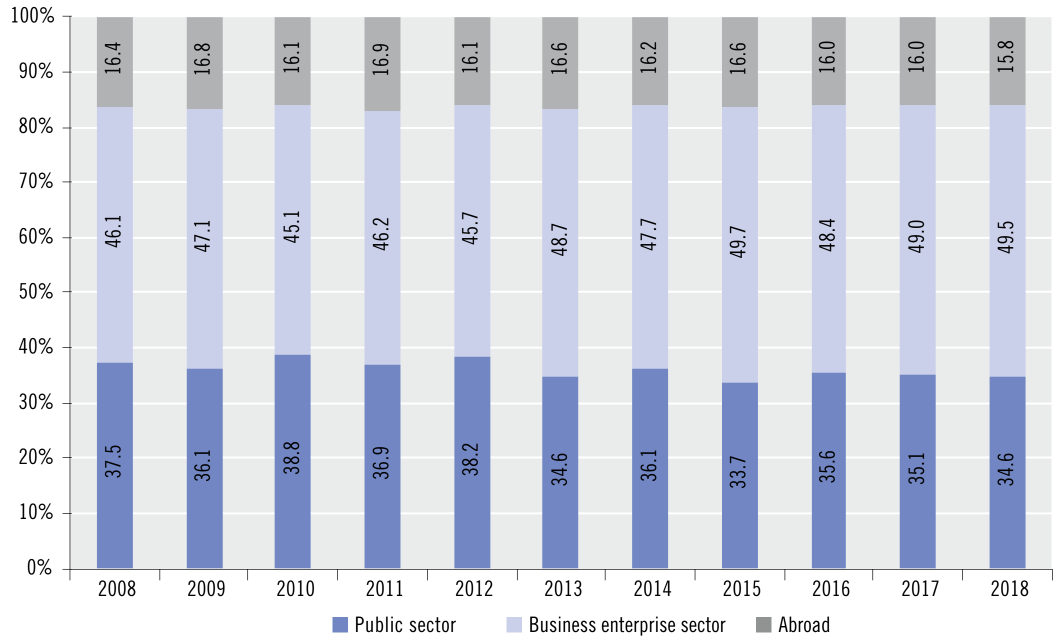
Fig. 1-2: Development of R&D expenditure in Austria by sources of funds (Index, 2007=100)



Note: The "Other public funding" sources of funds (which includes the municipalities and the social insurance institutions) as well as the private non-profit sector were counted under the "Public Sector" here.

Source: Statistics Austria, Global Estimate as at 19 April 2018.

Fig. 1-3: R&D funding shares in Austria by sources of funds (in %)



Note: The "Other public funding" sources of funds (which includes the municipalities and the social insurance institutions) as well as the private non-profit sector were counted under the "Public Sector" here.

Source: Statistics Austria, Global Estimate as at 19 April 2018.

1.2 Financing and performance of R&D in Austria

The financing and performance of research and development (R&D) from three different perspectives is outlined and discussed in this Chapter. The first part (Section 1.2.1) is dedicated to the 2015 R&D survey from Statistics Austria. As a complete survey it provides information on the development of R&D funding (firms, public sector, EU, etc.) and sectors of performance (primarily firms, universities, government sector), types of research (basic and applied research, experimental development) and R&D staff broken down for Austria.

The subsequent sections focus on the international comparison. Section 1.2.2 compares public R&D funding – not performance – from central government budgets (*GBARD*) based on a recent project for the EU. Indirect research funding via tax shortfalls or R&D funding by the EU or Austria's regions are not included in this. This budget information enables a current international comparison up to 2016, and specifically allows an analysis of how public direct funding is awarded on a project or institutional basis. This section is dedicated predominantly to funding in the higher education sector and non-university sector, since there is generally no institutional funding in the business enterprise sector, and public funding of the higher education sector is well above the funding of the business enterprise sector in all countries.

Section 1.2.3 also provides a comprehensive international comparison of public funding of the business enterprise sector, including tax incentives, EU and regions. Recent OECD data provides the basis for this. The study enables a detailed analysis of the two broad methods of awarding funding for business enterprise R&D, in the sense of direct vs. indirect R&D funding.

1.2.1 Research and experimental development in Austria: Results of the 2015 R&D survey

Statistics Austria collects data on research and development (R&D) every two years.[3] The current version of the R&D survey for 2015 was released in 2017 and was carried out as a full survey on the basis of the OECD's[4] Frascati Manual's methodology, standards, and definitions, which facilitates the international comparison of data[5]. R&D is defined as an activity undertaken on a systematic basis to increase the stock of knowledge ... and the use of this stock of knowledge to devise new applications. The elements of novelty and originality (new findings, new knowledge, new knowledge systems, and new applications) are therefore the most important criteria for distinguishing R&D from other scientific and technological activities. In addition, R&D includes natural science and technical research as well as research in the social sciences and the humanities.

There are four distinct sectors of performance: firms (cooperative sub-sector and company R&D sub-sectors), universities, the state, and the private non-profit sector. The cooperative sub-sector of the business enterprise sector includes research service institutions that regularly conduct R&D for firms.[6] By contrast, the company R&D sub-sector includes public and private firms that produce goods for the market due to the attainment of a profit or other economic advantage.

The "higher education" sector includes public and private universities, universities of applied sciences, pedagogical universities, the University for Continuing Education Krems, the Austrian Academy of Sciences, the testing institutes at technical federal colleges, and other university institutions summarised together.

3 The years 2006 and 2007 are an exception as the frequency of the surveys was moved to odd calendar years.
4 See Schiefer (2017).
5 See OECD (2002).
6 The sector primarily consists of members of the Association of Austrian Cooperative Research (ACR), JOANNEUM RESEARCH Forschungsgesellschaft mbH, the Austrian Institute of Technology GmbH (AIT), and since 2009, the competence centres from the COMET programme lines.

Table 1-1: R&D expenditures broken down by sector of performance and sources of funds, 2015

Sector of performance	in € millions	Share in %	Sources of funds	in € millions	Share in %
Business enterprise sector	7,498	71.4	Business enterprise sector	5,222	49.7
Institutes' sub-sector ("kooperativer Bereich")	825	7.9	Public sector	3,485	33.2
Company R&D sub-sector ("firmeneigener Bereich")	6,673	63.6	Private non-profit sector	54	0.5
Higher education sector	2,468	23.5	Abroad	1,738	16.6
Government sector	481	4.6	company R&D sub-sector abroad (not including EU)	1,539	14.7
Private non-profit sector	51	0.5	EU	198	1.9
Total	**10,499**	**100**	**Total**	**10,499**	**100**

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

The federal government, local governments, chambers of commerce, social insurance institutions, and other private non-profit institutions that are financed or controlled by the public sector, together comprise the "government" sector.[7] The private non-profit sector includes private non-profit institutions whose status is predominantly private or under civil law, sectarian or otherwise non-public. Distinctions are made with regard to financing between the business enterprise sector, the public sector, the private non-profit sector, and financing from abroad.[8]

R&D in Austria

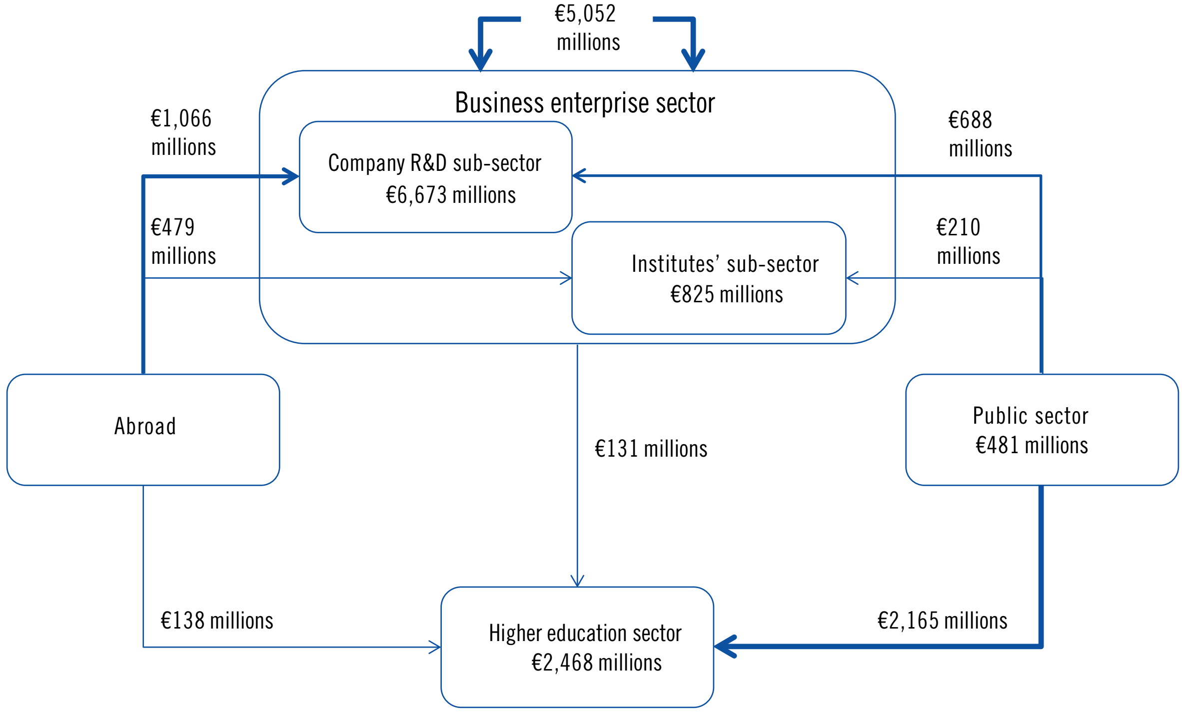
Compared with the 2013 R&D survey, R&D expenditures increased from by 9.7% to €10,499 million in 2015 (2013: €9,571 million). The business enterprise sector accounted for the highest share (71.4%) of total R&D expenditures on R&D performance with €7,498 million (see Table 1-1). The higher education sector and government sector featured far lower shares with 23.5% (€2,468 million) and 4.6% (€481 million) respectively. The private non-profit sector played a minor role with 0.5% (€51 million). By contrast, a more subtly differentiated image emerges on the financing side. Although the (Austrian) business enterprise sector also contributes the largest proportion (49.7%) to all R&D financing with €5,222 million, the gap with the public sector (33.2% or €3,485 million) is significantly lower. Funding from abroad contributed 16.6%, of which the largest portion (€1,539 million) comes from foreign firms and international organisations. The EU provided a share of 1.9%, or €198 million.

Fig. 1-4 shows financing flows between the different sectors: the boxes show the scope of R&D expenditures among the sectors of performance, while the arrows symbolise the funding streams. In the business enterprise sector, 97% of €5,222 million is invested in R&D within the sector itself; 67.4% (2013: 66.7%) is financed from the sector's own funds. 89% of funding from abroad (primarily firms and the EU) went to the business enterprise sector. 25.8% (€898 million) of R&D funds from the public sector go to the business enterprise sector, thereby funding 12% of business enterprise R&D, a high proportion when compared internationally. At 62% of public R&D expenditure (€2,165 million) the public sector primarily funds the higher education sector (87.7% of R&D expenditures in the higher education sec-

7 Unless otherwise stated, the data includes Federal institutions (not including those combined in the higher education sector), regional government, local government and chamber institutions, R&D institutions of the social insurance carriers, public sector-financed and/or controlled private non-profit institutions as well as R&D institutions of the Ludwig Boltzmann-Society, including regional hospitals. The regional hospitals were not surveyed by questionnaire, but instead Statistics Austria prepared an estimate of the R&D expenditures based on the reports of the offices of the provincial governments.

8 Unless otherwise stated, the term "abroad" includes foreign firms in the data including international organisations. The EU is stated separately.

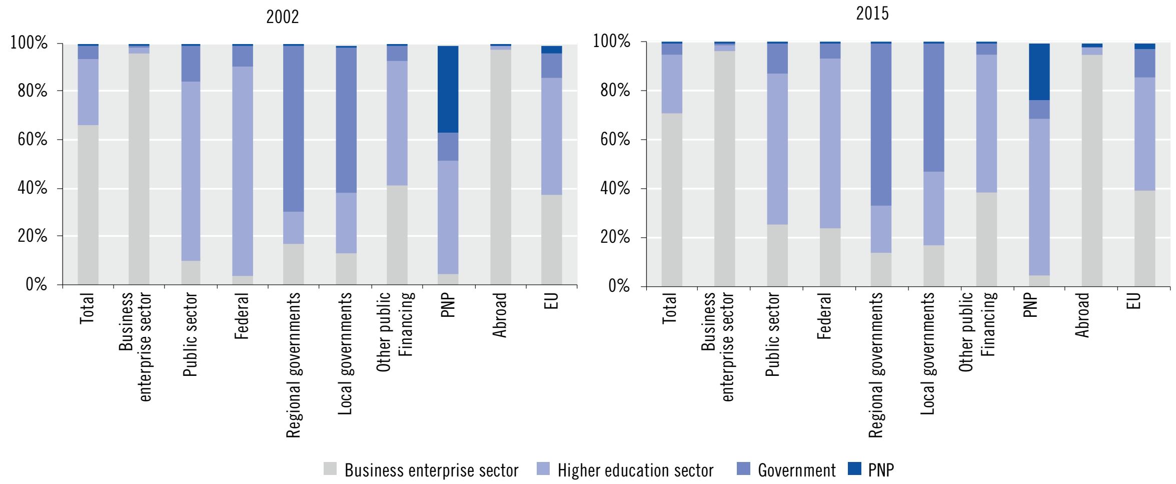
Fig. 1-4: Performance and funding of R&D, 2015



Note: The private non-profit sector was not shown in the interest of clarity. abroad including EU

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO). Presentation based on JOANNEUM RESEARCH.

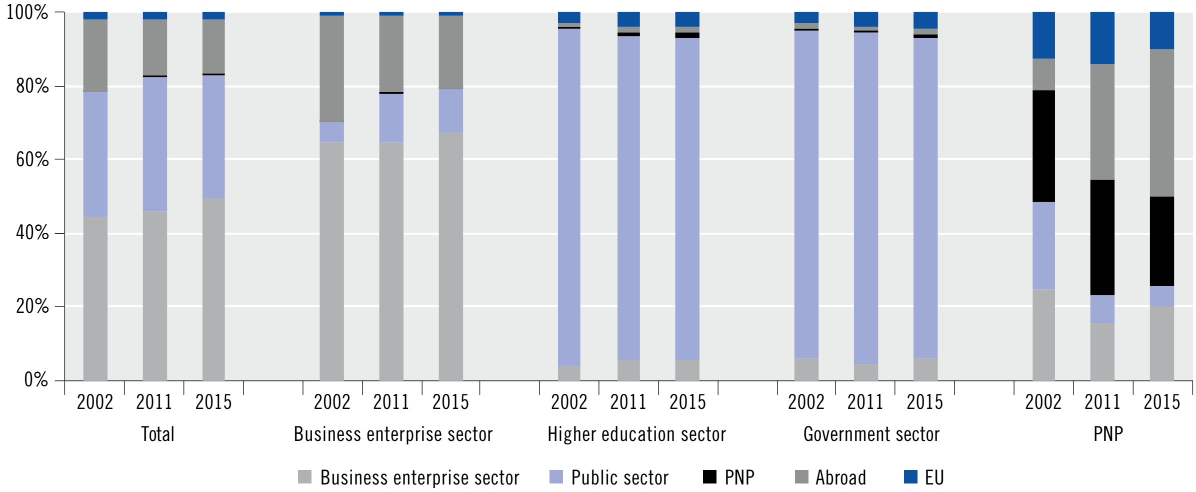
Fig. 1-5: Distribution of funding by sectors of performance



Note: The figure shows the distribution of the sources of funds (horizontal axis) among the different sectors of performance (vertical axis). PNP = private non-profit sector

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

Fig. 1-6: R&D expenditure by sources of funds



Note: The figure shows the origin of the funds (vertical axis) within sectors of performance (horizontal axis).
PNP = private non-profit sector

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

tor are financed by the public sector). It receives a further €131 million from the business enterprise sector, which consequently invests 2.5% of its funds in the higher education sector.

Financing streams have scarcely changed since 2002 (see Fig. 1-5). Only the public sector, or more specifically the federal government, awarded more funds to the business enterprise sector in 2015 (and correspondingly less to the higher education and government sectors) than was the case in 2002 (2002: 11%; 2011: 25%; 2013: 26%; 2015: 26%). The increase by 15% points shows the growing significance of public financing for the business enterprise sector. The reason for this increase can be found in increases to the direct and indirect research funding, i.e. the research tax premium, which is allocated to federal funding.[9] The research tax premium is an indirect research-funding instrument that firms can apply for to cover expenditures for internal research and experimental development. The funding ratio has been 10% since 1 January 2011, 12% since 1 January 2016 and 14% since 1 January 2018. Since 2013, in order for the premium to be granted, an expert opinion for R&D conducted since 2012 has to be obtained from the Austrian Research Promotion Agency (FFG).

Trends in the R&D funding structure

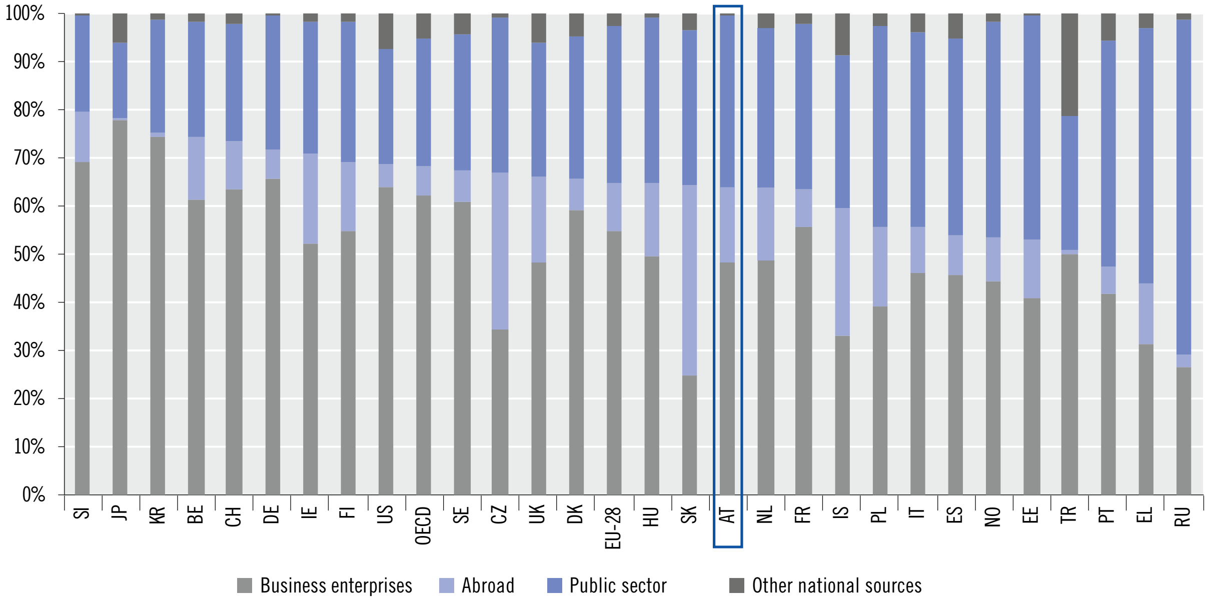
Contrary to Fig. 1-5, Fig. 1-6 shows the financing structure within the sectors of performance for the years 2002, 2011, and 2015. Financing from the business enterprise sector climbed from 44.6% of total R&D financing in 2002 to 49.7% in 2015. While little changed in the university and government sectors, the business enterprise sector has enjoyed an increase in the share of public financing (2002: 5.6%; 2015: 12.0%) and self-financing (2002: 64.5%; 2015: 67.4%) at the expense of foreign funding (2002: 28.9%; 2015: 19.6%).[10]

One of the key objectives of European RTI

9 Corporate funding through the research tax premium is indirect funding according to the new Frascati Manual 2015. In international comparisons it is consequently no longer allocated to public funding as of the complete survey 2017, but rather to the business enterprise sector's own funding.

10 Refers to results data, not including the EU.

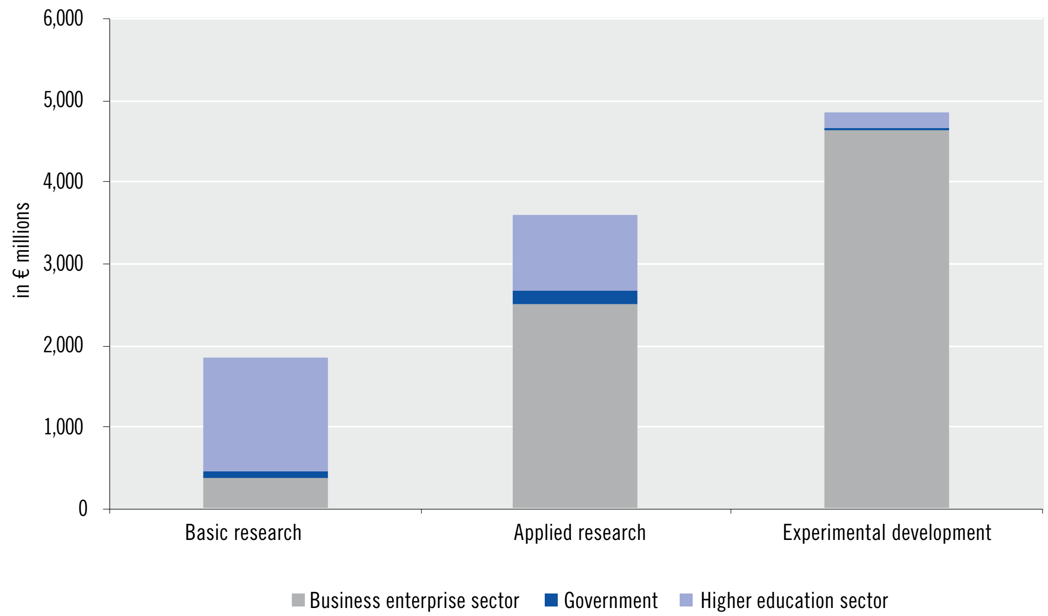
Fig. 1-7: Funding structure in an international comparison, 2015



Note: some countries with estimates.

Source: OECD – MSTI, Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

Fig. 1-8: Expenditure for the different types of research by sectors of performance, 2015



Note: The private non-profit sector was not included due to its minor share.

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

policy, and thus of the national RTI strategy, is to increase the business enterprise sector's share in overall funding to 66%, and ideally even to 70%, by 2020.[11] The financing share of firms currently amounts to 48.4%[12], which is low by international comparison (OECD average: 62.2%). Austria, however, showed a high proportion of funding from abroad (15.4%; OECD: 6.2%), most of which came from firms. If we view domestic and foreign corporate financing together (see Fig. 1-7), Austria comes close, at about 63.8% (2013: 62.8%) in overall research financing to the OECD and EU-28 average (OECD: 68.5%; EU-28: 65%), whereby additional efforts are still required.

Statistics Austria's R&D survey differentiates R&D expenditures by the type of research (basic research, applied research, and experimental development) and the type of expenditure. In 2015, experimental development was pursued above all else (2015: 47%), which took place almost exclusively in the business enterprise sector (see Fig. 1-8). Most applied research was also conducted in this sector (69% of €3,624 million). By contrast, the higher education sector is the most important sector of performance for basic research (with a share of 73.8% compared with 20.3% basic research for firms), for which the comparatively lowest amount was spent overall at €1,852 million.[13] Expenditure for all three types of research has more than doubled since 2002 (basic research: 2002: €819 million, 2015: €1,852 million; applied research: 2002: €1,727 million, 2015: €3,624 million; experimental development: 2002: €2,051 million; 2015: €4,854 million), with experimental development posting the greatest growth at 57.7%. While the share of experimental development in total expenditures has risen slightly (2002: 44.6%, 2015: 47%), spending on basic research has remained constant, while the figure for applied research fell slightly (2002: 17.8% vs. 37.6%; 2015: 17.9% vs. 35.1%). By international comparison, Austria has caught up with the group of leading countries in spending for basic research: with a share of 0.54% (2015), Austria is level with France (2014: 0.54%) and ahead of the USA (2015: 0.48%), but behind South Korea (2015: 0.73%), Switzerland (2015: 1.3%) and Czechia (2015: 0.62%).[14]

In R&D expenditures by type of expenditure (see Table 1-2), both expenditures for equipment investments as well as land and buildings have changed relatively evenly over time. One striking change is the increase in ongoing material expenses by almost €1,151 million from 2011 to 2015. These can be explained primarily by the increase in business financing for ongoing material expenses (2011: €2,250 million; 2015: €3,253 million). Despite the increase in current costs, half of expenditure (€5,207 million) was spent on staff in 2015.

R&D in the higher education sector

Depending on the scientific discipline, R&D expenditures in the higher education sector were between €83 million (agricultural science) and €764 million (natural science), whereby financing from the public sector was over 80% in all fields of science (see Table 1-3). Federal financing comprised the largest portion of public financing here and oscillated between 62.9% for the technical sciences and 84.7% for agricultural sciences. In the technical sciences, the business enterprise sector, together with public financing, made an above-average contribution of 12%.

11 See BKA et al. (2011, 7).
12 The figures relate to OECD data (MSTI, 1/2017 edition) and differ slightly from the national data from Statistics Austria. They were used in order to enable an international comparison.
13 However, this is just over half of the entire research in the basic research higher education sector (55.4%), the rest is split between applied research (36.5%) and experimental development (8.1%).
14 Any international comparison for basic research expenditure is only possible to a certain extent, because many countries such as Germany, Finland and Sweden do not distinguish between types of research in their R&D surveys.

Table 1-2: Type of expenditure over time

Type of expenditure	2002		2011		2015	
	[in € millions]	[in %]	[in € millions]	[in %]	[in € millions]	[in %]
Labour costs	2,322	50	4,186	51	5,207	50
Other current costs	1,965	42	3,423	41	4,574	44
Expenditure for instruments and equipment	316	7	502	6	582	6
Land and buildings	81	2	165	2	137	1
Total	**4,684**	**100**	**8,276**	**100**	**10,499**	**100**

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

Table 1-3: Financing of R&D in the higher education sector by financing sector, 2015

Fields of science	Number of units conducting R&D	Total	Business enterprise sector	Public sector					PNP	Abroad (not including EU)	EU
				Federal government	Regional governments	Local governments	Other	Total			
		[in € millions]	[in %]	[in %]	[in %]	[in %]	[in %]	[in %]	[in %]	[in %]	[in %]
1.0 to 6.0 Total	**1,265**	**2,468,207**	**5.3**	**72.7**	**2.7**	**0.1**	**12.3**	**87.7**	**1.4**	**1.8**	**3.8**
1.0 to 4.0 Subtotal	719	1,888,883	6.4	69.4	2.9	0.1	13.8	86.1	1.1	2.1	4.4
1.0 Natural sciences	257	764,352	3.0	70.0	2.3	0.1	15.8	88.1	0.5	2.1	6.4
2.0 Engineering	221	460,445	12.0	62.9	4.0	0.2	13.7	80.8	1.0	1.8	4.4
3.0 Human medicine, health sciences	182	580,683	6.9	71.5	3.1	0.0	11.9	86.5	1.9	2.5	2.1
4.0 Agricultural sciences, veterinary medicine	59	83,403	2.5	84.7	0.6	0.0	8.6	93.9	0.8	1.0	1.9
5.0 and 6.0 together	546	579,324	1.7	83.7	1.9	0.1	7.3	93.0	2.5	1.0	1.7
5.0 Social sciences	344	363,524	2.3	83.3	2.2	0.1	5.7	91.3	3.4	1.1	1.8
6.0 Humanities	202	215,800	0.7	84.4	1.5	0.1	9.9	95.9	1.0	1.0	1.4

Note: PNP = private non-profit sector

Source: Statistics Austria, calculations: Austrian Institute of Economic Research (WIFO).

R&D in the business enterprise sector

In 2015, 62% (€4,617 million) of total R&D expenditures went to firms in the manufacturing industry, meaning that this industry's share has fallen by 10% points since 2004 (2004: 71.7%) (see Table 1-4). R&D expenditures on services have risen by about the same percentage (2002: 27.4%; 2015: 36.9%). There was also a shift in the share of employment in R&D in full-time equivalents (FTEs) from the manufacturing industry (2004: 72%; 2015: 61%) to services (2004: 26.9%; 2015: 38.3%).[15]

In contrast, the R&D intensity (share of R&D expenditures as part of gross value added, GVA) increased in both industries (manufacturing: 2004: 6.1%; 2015: 8.1%; service industry: 2004: 0.7%; 2015: 1.3%). Taxonomies[16] offer a nuanced view of economic structure by grouping

15 Attention must be paid at all times to classification problems with this, as for instance a firm involved in trade and production activities and with R&D expenditure based around manufacturing can e.g. be allocated to the service sector if the revenues for the trade segment predominate. Additionally, individual firms may also be reclassified over time.

16 See Peneder (2010). In this taxonomy, goods and service sectors are divided at the NACE 2 2-digit level according to their innovation intensity. The innovation intensity is measured based on microdata from the European Community Innovation Survey (CIS) and includes e.g. the introduction of product innovations. It supplements taxonomies such as the high-tech taxonomy of the OECD, which is based narrowly on R&D intensity in manufacturing.

Table 1-4: R&D expenditure and employees in the business enterprise sector by economic sub-sectors and knowledge intensity, 2004 and 2015

sector	2015					2004				
	Units conducting R&D	Employees in R&D, FTEs (full time equivalents)	R&D expenditure	Gross value added (GVA)	R&D as component of GVA	Units conducting R&D	Employees in R&D, FTEs (full time equivalents)	R&D expenditure	Gross value added (GVA)	R&D as component of GVA
		Share of all sectors [in %]			[in %]		Share of all sectors [in %]			[in %]
Agriculture and forestry, fisheries	6	0.0	0.0	1.2	0.1	5	0.1	0.1	1.7	0.1
Mining	14	0.1	0.1	0.4	0.9	11	0.1	0.1	0.4	0.4
Manufacturing	1,483	60.7	61.6	18.6	8.1	1,229	72.0	71.7	19.5	6.1
Electricity, gas and water supply	55	0.2	0.4	2.8	0.3	25	0.3	0.3	3.4	0.1
Building	74	0.7	1.0	6.3	0.4	65	0.6	0.5	7.3	0.1
Services	1,979	38.3	36.9	70.6	1.3	788	26.9	27.4	67.7	0.7
Other services	1,124	14.7	15.9	67.5	0.6	444	11.5	11.9	64.4	0.3
Economic sub-sectors by type of innovation										
low	8	0.1	0.0	0.2	0.6	20	0.4	0.4	0.3	2.4
medium-low	99	0.9	0.7	2.2	0.8	90	1.2	0.9	2.6	0.6
medium	339	6.7	5.5	4.9	2.8	283	6.5	5.1	5.0	1.7
medium-high	407	16.9	18.3	5.6	8.0	320	20.4	20.7	6.0	5.7
high	623	36.0	36.9	5.7	15.7	514	43.3	44.2	5.2	13.9
Material goods sectors by type of technology										
high technology	204	11.3	13.6	1.7	20.1	160	25.7	28.6	2.2	21.7
medium-high technology	561	34.7	34.9	6.5	13.1	466	30.1	28.9	5.8	8.3
medium-low/low technology	718	14.8	10.4	10.4	2.4	603	16.2	21.9	19.6	1.8
Services by knowledge intensity										
high-tech knowledge intensive services	855	23.7	21.0	3.1	16.5	344	15.4	15.5	3.2	8.0

Note: Economic sub-sectors according to ÖNACE 2008; innovation types: low (14, 15), medium-low (10–12, 18), medium (16, 17, 25, 31–33) medium-high (13, 19, 20, 22–24, 29, 30), high (21, 26– 28); technology types: high technology (21, 26), medium-high technology (20, 27–30) medium-low/low technology: miscellaneous; knowledge intensity: high-tech knowledge intensive (59–63, 72); 61–63 & 72 were used as the sectors 58–60 are stated as aggregates in the R&D survey; other services: miscellaneous.

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

sectors according to certain features, which summarises the goods and services industry by their innovation intensity, or classifications by the OECD that divide manufacturing and service sectors into groups based on their research and knowledge intensity. All classifications – for example, according to broader innovation intensity that includes non-technological innovation, as well as more narrowly defined R&D intensity – reveal high concentrations of R&D expenditures on classification segments that are most intensive in technology, innovation, or knowledge, whereby innovation activity is more broadly scattered than pure R&D activity.

Concentration tendencies are also revealed depending on firm size (see Table 1-5): companies with 1,000 or more employees make up the largest share of internal R&D expenditures in the business enterprise sector. Although these firms only constitute 2.2% of all surveyed units conducting R&D, they are responsible for 42.1% of internal R&D expenditures. In the same class of large firms, there was a very high proportion of foreign funding revealed in the financing structure (31.8%), which underscores Austria's international attractiveness as a place to carry out R&D activities. The significance of the research tax premium increases with the size of the firm, from 4% for the smallest category of size to 7.3% for the largest category of firms.

Table 1-5: Financing of R&D expenditure by employment size category, 2015

Categories of company size	Units conducting R&D		R&D expenditure		Proportions by sources of funds [as a %]										
						Public sector									
	Number	Share [in %]	[in € millions]	Share [in %]	Business enterprise sector	Federal government	Research tax premiums	Regional governments	FFG	other public financing	Total	PNP	Abroad (not including EU)	EU
Less than 10 employees	1,283	35.5	192	2.6	70.2	1.6	4.0	2.0	12.0	0.8	20.3	0.7	5.5	3.4
10–49 employees	1,038	28.7	626	8.4	73.0	1.7	5.4	2.1	6.3	0.9	16.4	0.2	7.7	2.8
50–249 employees	833	23.1	1,350	18.0	70.3	3.2	5.8	1.3	2.3	0.3	12.9	0.0	15.8	1.1
250–999 employees	379	10.5	2,170	28.9	80.7	0.2	7.2	0.5	2.0	0.1	9.9	0.0	8.7	0.7
1,000 and more employees	78	2.2	3,161	42.1	55.7	2.1	7.3	0.2	1.9	0.1	11.6	0.0	31.8	0.8
Total	**3,611**	**100.0**	**7,498**	**100.0**	**67.4**	**1.7**	**6.8**	**0.7**	**2.6**	**0.2**	**12.0**	**0.0**	**19.6**	**1.1**

Note: PNP = private non-profit sector

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

Internal and external R&D in the business enterprise sector

External R&D expenditure includes the contractual research allocated externally to third parties; internal R&D expenditure on the other hand includes own R&D, R&D commissioned by third parties and current costs that are incurred on account of the R&D project implemented. The distinction between internal and external R&D is not always a clear one. Only the internal R&D expenditure is stated in the R&D statistics in order to avoid duplicate payments.

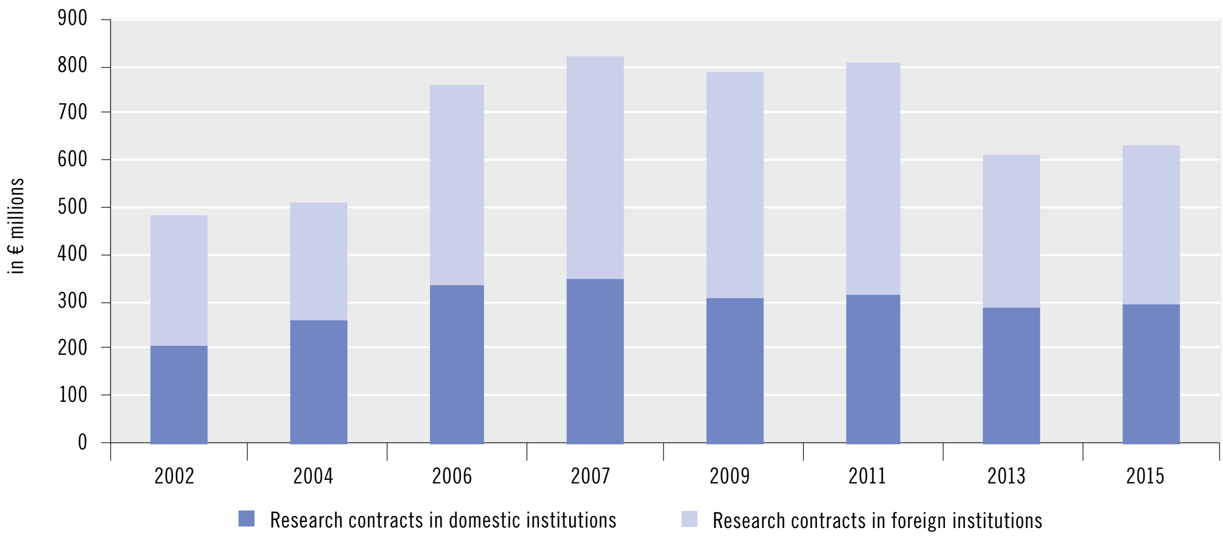
While external R&D expenditure increased by 67.6% between 2002 and 2011, there was a 22% reduction between 2011 and 2015 (2002: €483.5 million; 2011: €810.4 million, 2015: €632.4 million) caused primarily by a decrease in the research contracts to foreign institutions (see Fig. 1-9). The heavy fall in external funding for R&D has been accompanied by a significant increase in internal R&D expenditure for current costs in the business enterprise sector. These increased by 45% from €2,250 million in 2011 to €3,252 million in 2015. This could be as a result of a change in reporting behaviour by firms in response to the expert reports introduced by the Austrian Research Promotion Agency (FFG) for research tax premiums in 2013, e.g. through internal group shifts.[17] In addition, clinical studies commissioned externally are also no longer considered intramural R&D expenditure of the implementing research institute by the financial authorities, but rather as current costs incurred by a pharmaceutical company. Given that the fall in external R&D expenditure was only €178 million between 2011 and 2015, while the increase in current costs was around €1,003 million, any potential change in the interpretation of the allocation to internal or external R&D expenditure is only able to explain part of the increase in corporate funding.

Employees in R&D

Table 1-6 shows the increase in R&D staff since 2002, both in terms of headcount (2002: 65,725; 2015: 126,171) and of full time equivalents (FTEs) (2002: 38,893; 2013: 71,396). Most of the staff are employed in the business enterprise

17 See Schiefer (2015).

Fig. 1-9: Development of external R&D expenditures in the business enterprise sector, 2002–2015



Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

Table 1-6: Employees in R&D, 2002 and 2015

Sector of performance	Employees in R&D						R&D expenditures (in € millions)			R&D expenditure per FTEs		
	Headcount			FTEs								
	2002	2015	Change 2002–2015	2002	2015	Change 2002–2015	2002	2015	Change 2002–2015	2002	2015	Change 2002–2015
Total	**65,725**	**126,171**	**92%**	**38,893**	**71,396**	**84%**	**4,684**	**10,499**	**124%**	**120**	**147**	**22%**
Business enterprise sector	34,020	71,008	108.7%	26,728	50,534	89.1%	3,131	7,498	139.5%	117	148	27%
Higher education sector	25,072	47,562	90%	9,879	17,682	79%	1,266	2,468	95%	128	140	9%
Government	6,010	6,632	10%	2,060	2,674	30%	266	481	81%	129	180	39%
PNP	623	969	56%	227	507	123%	21	51	146%	92	101	10%

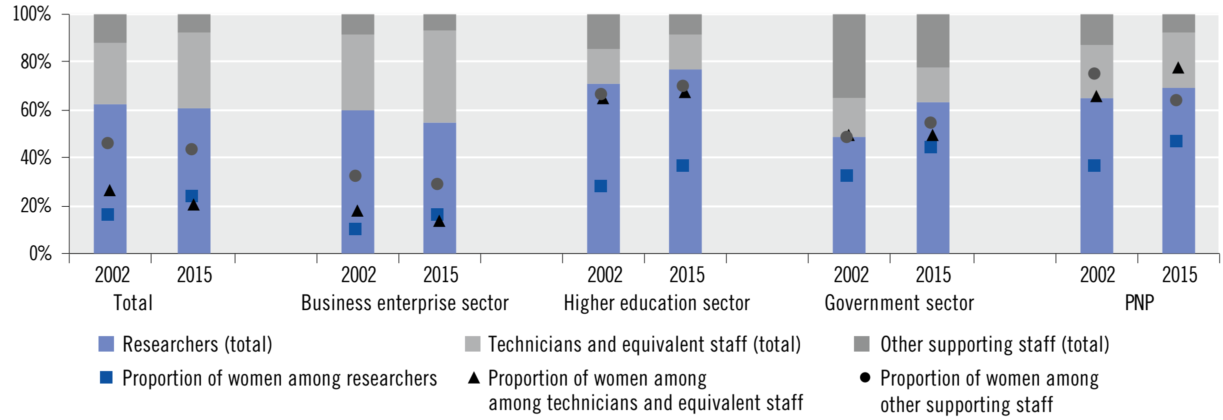
Note: PNP = private non-profit sector

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

sector (2015: headcount: 56.3%; FTEs: 70.8%), at which this sector also recording the strongest growth (change 2002–2015: headcount: +108.7%; FTEs: +89.1%). The increase in R&D expenditure per employee in FTEs is attributable to the increase in R&D expenditure, which has increased much more significantly than the R&D staff. In the business enterprise sector, R&D expenditure has risen by 139.5% as compared with 2002, with FTE employees rising by 89.1%.

Employees in the R&D sector can be divided into three groups: researchers, technicians and equivalent and other supporting staff (see Fig. 1-10). The higher education sector has the highest proportion of researchers (in full-time equivalents) at 77.2%, while the business enterprise sector has the lowest (55.2%). The proportion of women among researchers has increased considerably since 2002 (2002: 15.8%; 2015: 23.2%), although the figure generally remains well below 50% in all sectors. The pri-

Fig. 1-10: Employment structure of R&D staff (in FTEs), 2002 and 2015



Note: PNP = private non-profit sector

Source: Statistics Austria. Calculations: Austrian Institute of Economic Research (WIFO).

vate non-profit sector has the highest proportion at 46.3% (2002: 36.3%), while the business enterprise sector has the lowest at just 15.5% (2002: 9.7%). The proportion of women among technicians and equivalent and other supporting staff was above 50% in all sectors apart from the business enterprise sector in 2015.

In summary the 2015 R&D survey shows an on-going positive trend in the individual finance sectors and sectors of performance as compared with the 2013 R&D survey. Overall the rise in R&D expenditure was less than the rise between 2011 and 2013, yet the 2015 R&D survey bears witness to the continuing engagement of Austrian universities, research institutes and firms in R&D activities. This must be seen as a positive development both for industry as well as for society.

1.2.2 Methods for awarding public R&D budgets in an international comparison

GBARD (Government Budget Allocations for R&D) measures direct, budgeted R&D expenditure by central or federal government and is the central statistic for total government R&D expenditure for international comparisons. The data relates solely to a part of the government expenditure stated in the R&D survey (see Section 1.2.1). While research-related payments to international organisations are included in GBARD irrespective of the R&D location, R&D funding by international organisations (e.g. EU) in Austria does not form part of GBARD. Indirect R&D funding, such as the R&D premium and R&D financed by the states, local authorities and foundations are equally not recorded as part of GBARD.[18]

According to the funding proposal for 2017 the GBARD amounted to €2.85 billion, an increase of 2.7% on 2016. Of this amount, €101 million or 3.5% was attributed to research-related contributions to international organisations, with the remaining €2.75 billion (96.5%) in research-related funds from the federal government attributable primarily to direct payments to national R&D operators (e.g. universities, non-university research institutes), budget allocations to national research-promoting institutions (e.g. Austrian Science Fund (FWF), Austrian Research Promotion Agency (FFG)) as well as intramural R&D expenditure of the fed-

18 See Frascati Manual (2015).

eral government (e.g. downstream agencies such as the Central Institute for Meteorology and Geodynamics (ZAMG)).[19]

International comparison

Based on more recent studies[20] the allocation of the research funding recorded via the GBARD can be characterised in an international comparison and the proportion of any project-based vs. institutional financing analysed on a comparative basis. The composition of the total public research funding can also be presented by different categories of funding channels (universities, public research organisations, etc.) in a country comparison.

Fig. 1-11 presents first of all the GBARD in a country comparison, per inhabitant and as a proportion of total government expenditure in 2016. With public research funding of €320 per inhabitant (left axis), Austria is well above the corresponding value for the entire EU-28 of €186 per inhabitant, and ranked sixth within the EU-28. Only the Nordic countries of Norway, Denmark, Sweden and Finland, along with Switzerland, Luxembourg, the USA and Germany feature higher public R&D funding per inhabitant. As such Austria is directly ahead of South Korea (€297) and the Netherlands (€296), and features a considerably higher value than some other countries, including Belgium (€226), France (€209) and the UK (€189).

A similar picture is revealed when the GBARD is viewed as a proportion of total government expenditure (right axis): Austria is ranked seventh within the EU-28 with a share of 1.56%, and is well above the value for the overall EU-28 of 1.38%. This share of public R&D financing as a percentage of government expenditure has risen over the last ten years by around 0.3% points despite the financial crisis, whereas a fall of 0.1% can be seen for the entire EU-28. Within the EU, Germany, Denmark and Sweden once again featured higher proportions of GBARD as a percentage of government expenditure in 2016, along with three other countries with lower spending per capita, i.e. Portugal, Estonia and the Netherlands. Finland and Luxembourg with higher GBARD per capita spend a lower amount on R&D as a proportion of entire government expenditure as compared with Austria. Overall therefore, a GBARD can be determined for Austria that is above the EU average and within the range of the Innovation Leaders.

Fig. 1-12 compares the proportion of project-based and institutional R&D funding as a share of GBARD. Project-based R&D funding is not equivalent to competitive R&D funding here: while project-based R&D funding is also generally awarded based on a competition, institutional R&D funding can be awarded both competitively as well as non-competitively. Austria featured a share of 29% of project-based funding in 2015, leaving it within the range of the two innovation leaders Netherlands (29%) and Switzerland (28%). Germany and Sweden feature a somewhat higher proportion of project-based R&D funding at 35%, while Denmark has a slightly lower proportion at 25%.[21]

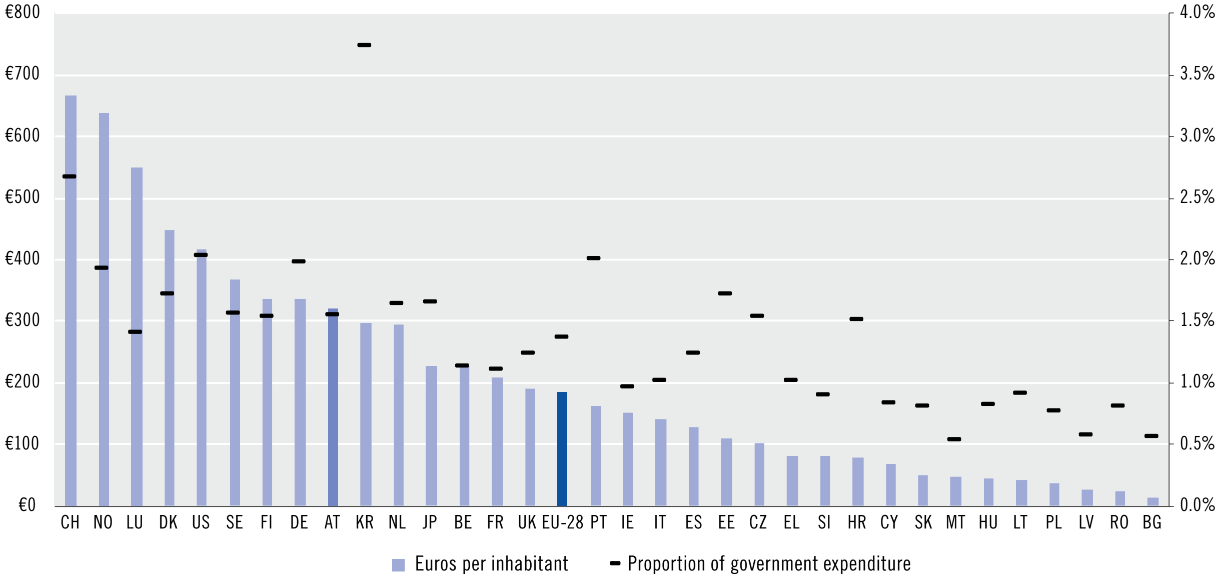
The English-speaking countries of Ireland (67%), the USA (64%) and the UK (53%) feature considerably higher proportions of project-based R&D funding. Norway and Finland also feature disproportionally high shares of project-based funding with 44% each. Some of the newer EU countries such as Estonia (75%) and Poland (60%), whose research funding landscape has changed fundamentally in recent years, have also largely been providing funds on a project ba-

19 The "Detailed overview of research-related appropriation of federal funds" (see Table 4 in the statistics appendix) of the R&D Annex to the relevant Federal Finances Act 2017 contains a summary of the expenditure budgeted by the federal government for research and research promotion, which includes both the payments by the federal government to international organisations whose objective is (at least partly) research and research promotion (Part a), as well as the national expenditure by the federal government for research and research promotion (Federal Research Budget; Part b).

20 See Reale et al. (2017).

21 See Reale et al. (2017).

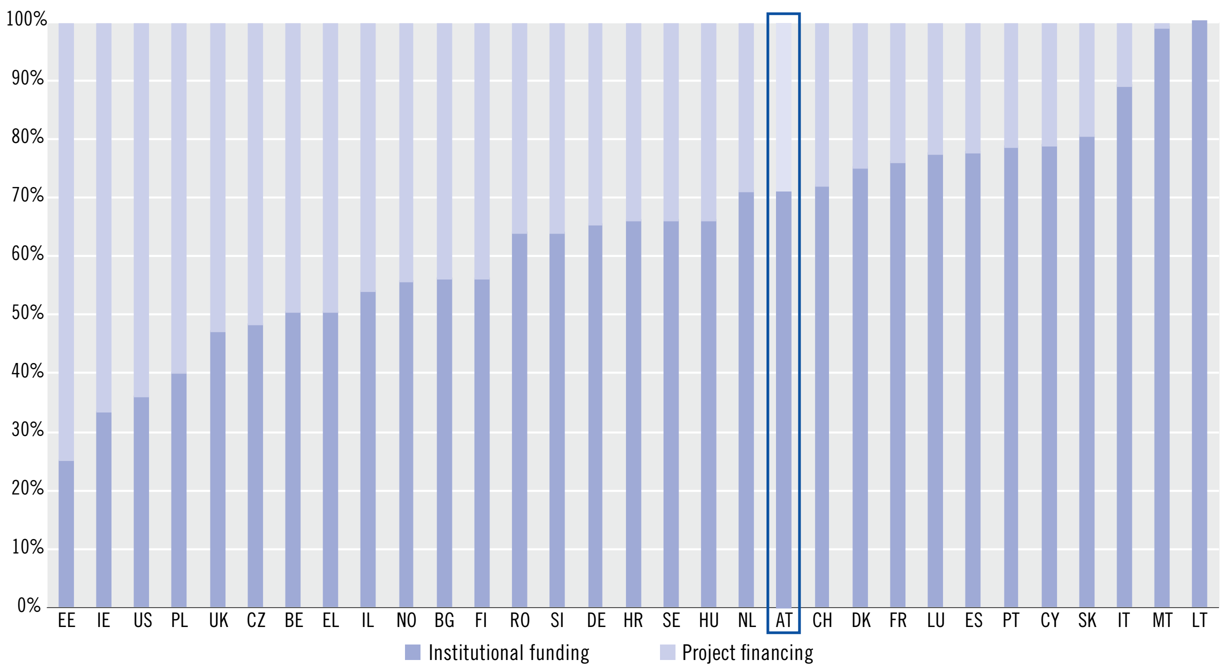
Fig. 1-11: GBARD per inhabitant and as a proportion of government expenditure, 2016



Note: HR and CH 2015 instead of 2016; US and JP 2015 instead of 2016 (proportion of government expenditure). For country codes see Table 8.1 in Annex I.

Source: Eurostat (2017). Total GBARD as % of total government expenditures [gba_nabste]. Calculations: AIT.

Fig. 1-12: Project-based vs. institutional funding



Note: The latest year with data available is provided in each case; DE, NL, LU, SK 2016 (Eurostat), EE 2016 (PREF), IE, CZ, BE, EL, NO, AT, PT 2015 (Eurostat), FR 2015 (PREF), US, PL, IL, BG, FI, RO, SI, HR, SE, HU, CH, DK, CY, IT, MT, LT 2014 (PREF), UK, ES 2013 (PREF). For country codes see Table 8.1 in Annex I.

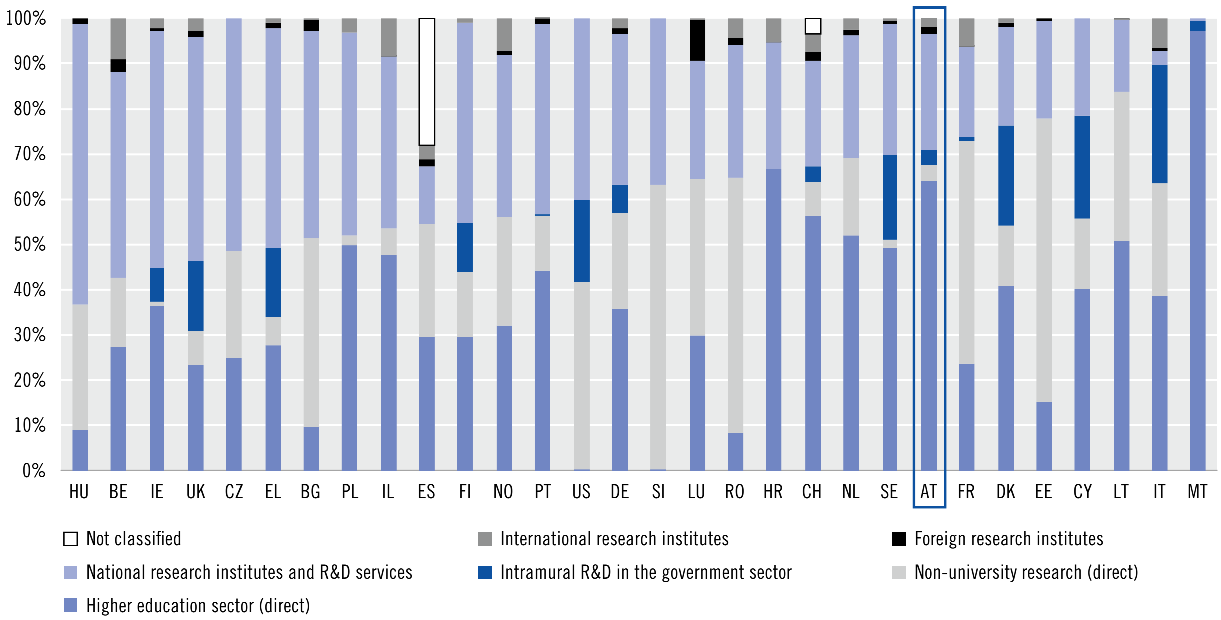
Source: Eurostat (2017). Total GBARD by funding method [gba_fundmod]; Reale et al. (2017). Calculations: AIT.

sis most recently. In contrast, some of the large older EU member states in particular have featured significantly lower proportions of project-based funding. This group includes France (24%), Spain (22%) and Italy (11%).[22]

Fig. 1-13 illustrates the GBARD divided into six major funding channels. A distinction is made on the one hand between funds that a) flow directly[23] to the Austrian higher education sector, and b) flow directly to the Austrian non-university sector, or c) are used for intramural R&D in the government sector[24] and d) project-based funding via national research[25] and innovation financiers[26] or directly for R&D services[27]. On the other hand, the funds to transnational R&D institutions (e.g. CERN) and research promotion agencies (e.g. ESA) are also presented as additional components of the GBARD.

In examining the breakdown of the GBARD by funding channels, it is evident that the largest share is attributable to the higher education sector at 64%. Together with the funding for national research promotion agencies (25%), both of these funding channels represent by far the most significant funding channels with a cumulative share of almost 90%, while the direct allocation to non-university research (3%) and intramural R&D in the government sector (4%) play a subordinate role in Austria. Approx. 2% of Austrian GBARD is attributable to R&D-related funds to foreign R&D institutions (e.g. CERN) and research promotion agencies (e.g. ESA).[28]

Fig. 1-13: GBARD by funding channels, 2013



Note: ES 28% not allocated (regional). For country codes see Table 8.1 in Annex I.

Source: Reale et al. (2017). Calculations: AIT.

22 See ibid.
23 No distinction is made here between funds awarded competitively and non-competitively.
24 Among other items includes the funds for downstream agencies such as the Central Institute for Meteorology and Geodynamics (ZAMG).
25 Includes in particular funds for science promotion agencies such as the Austrian Science Fund (FWF).
26 Includes in particular funds for innovation promotion agencies such as the Austrian Research Promotion Agency (FFG).
27 Includes in particular R&D services awarded directly by ministries.
28 See Reale et al. (2017).

The distribution of the GBARD across funding channels in Austria is most similar to that in Switzerland,[29] Sweden and the Netherlands in the international comparison. In the larger countries there is generally a considerably higher proportion of funding for non-university research (e.g. France 49%, USA 41%, Spain 25%, Italy 25% and Germany 21%) and/or intramural R&D in the government sector (Italy 26%, USA 18%, UK 16%). The share of around 25% of public funding awarded in Austria via research promotion agencies roughly equates to the international average. The UK and Ireland feature significantly higher shares of around 50%, as do newer member states such as Czechia and Poland, where the research promotion systems have been reorganised in recent years. Italy is at the other end of the international scale with a share of just 3%. Non-EU countries that take part in the EU Framework Programme, such as Israel and Norway, feature significantly higher payments to international research promotion agencies at 9% and 7% respectively, as these payments are only visible explicitly for non-EU countries and are not part of the general non-GBARD payments to the EU budget.

While the funds awarded on a project basis via research promotion agencies are always competitive and are primarily used for R&D funding in the business enterprise sector (with the exception of the Austrian Science Fund), the direct institutional R&D funding for the higher education sector and non-university research can be awarded competitively or can include competitive elements (e.g. via performance agreements), but is used almost exclusively for R&D funding in the public sector. A trend towards greater competitive components can also be seen in institutional R&D funding in Austria as well as internationally. While some of the EU countries in Central and Eastern Europe with comparatively low total funds for R&D funding have implemented huge reorganisations in their research funding systems in this direction over recent years, the changes aimed at increasing competitive R&D funding have been more gradual and incremental among the Innovation Leaders (although these are already consistently at a higher level), with the situation similar in Austria.

National Foundation for Research, Technology and Development

The National Foundation for Research, Technology and Development (FTE) is independent of the federal budget and therefore not captured in the GBARD. It provides funds for research funding and is aimed at making a contribution towards a visible positioning and internationalisation for Austrian research excellence, without creating additional administrative and processing structures in the process. The Foundation Council decides on the use of National Foundation funds based on the recommendation of the Council for Research and Technology Development. The amendment to the FTE National Foundation Act[30] implements the federal government's decision to provide additional funds to the Foundation over the next three years (2018–2020). The Austrian National Bank is authorised in this to contribute up to €100 million each year.

The funds of the National Foundation for Research, Technology and Development, amounting to a total of €107 million in 2018, are distributed to promotion agencies supported by the federal government (Austrian Science Fund, Austrian Research Promotion Agency, Austria Wirtschaftsservice, Austrian Academy of Sciences, Christian Doppler Society and Ludwig Boltzmann Society). These funds represent additional project-based R&D funding in Austria which are not taken into account in the share stated previously of 29% of project-based funding in 2015. Table 1-7 shows the use of

29 The share of international research promotion agencies is higher as a result of the Swiss contributions to the EU Framework Programme which are allocated to the GBARD.

30 See Federal Law Gazette I no. 81 (2017).

Table 1-7: Use of funds from the National RTD Foundation in 2018

Beneficiaries	Initiatives/programmes	Amount granted
Austria Wirtschaftsservice (aws)	aws Creative Catalyst, Licence.IP, expansion of the Global Incubator Network (GIN)	€5.7 million
Christian Doppler Society (CDG)	11 CD laboratories	€7.0 million
Austrian Research Promotion Agency (FFG)	BRIDGE, R&D infrastructure funding, quantum research (together with the Austrian Science Fund) and quantum technology, development of the Austrian quantum computer, research partnerships on industry-related PhD theses, Ideas Lab 4.0, Laura Bassi Centres 4.0-women design digitalisation, Impact Innovation, R&D innovation partnerships, expansion of the Global Incubator Network (GIN)	€47.6 million
Austrian Academy of Sciences (ÖAW)	go!digital Next Generation	€3.0 million
Ludwig Boltzmann Society (LBG)	Digital Health meets Social Needs-LBI for Digital Health, Sustainable establishment of Open Innovation in Science Research and Competence Centres	€9.0 million
Austrian Science Fund (FWF)	Special research areas (SRA) and doctoral programmes, research groups, matching funds initiative, TRANSFORM pioneer laboratories as a nucleus for programmes of excellence, quantum research (together with the Austrian Research Promotion Agency)	€34.7 million

Source: National RTD Foundation.

funds of the National Foundation for Research, Technology and Development for 2018.

The Austria Fund (from the Tax Reform Act 2015/2016)[31] is an additional funding instrument in the national innovation system. The Austria Fund is endowed with €33.7 million each year until 2020. These funds are not received by the National Foundation for Research, Technology and Development, as this Foundation merely processes the funds for the Austria Fund. Of these funds in 2017, €11 million is attributable to the endowment for the Austrian Research Promotion Agency (FFG), €6 million to the Austrian Science Fund (FWF), €2 million to the Christian Doppler Society (CDG), €8.7 million to the Austria Wirtschaftsservice (aws), and €6 million to the *Young Independent Researcher Groups* project (Austrian Academy of Sciences (ÖAW) and the Austrian Science Fund, FWF).

Overall Austria has experienced a moderate increase in direct R&D funding in recent years, which has recently been well above the EU average. The funds from the federal budget for direct R&D funding are awarded institutionally at a rate of 64% (primarily to the higher education sector) and include competitive and non-competitive components. The second national funding channel, which is exclusively awarded competitively, runs via the research promotion agencies, in particular the Austrian Science Fund (FWF) and the Austrian Research Promotion Agency (FFG). This R&D funding is not only supplied from funds from the federal budget captured in the GBARD, as significant funds are also provided from the National Foundation for Research, Technology and Development and the Austria Fund. In addition to these national funds for direct R&D funding, particularly in the public sector, funds awarded competitively at the international level, particularly the EU, form a third central pillar for R&D funding. Overall these different funding streams have resulted in stable R&D funding that rises slightly and with increasingly competitive components in line with international trends.

1.2.3 Public funding for business enterprise R&D in an international comparison

This section compares the international and national development of public funding for R&D activities in the business enterprise sector of performance over time using recent data from the OECD and Statistics Austria. The data includes both budgetary and tax funding sourc-

31 See Federal Law Gazette I no. 118(2015).

es as well as funding from international organisations such as the EU and sub-national administrative units (regional governments in Austria). The data depicts the funding for the business enterprise sector more comprehensively than the GBARD data (see Section 1.2.2.), although the data only extends to 2015.

Public funding for business enterprise R&D activities attempts to remedy various market and system failures in the area of private R&D.[32] According to this, firms invest too little in R&D from a social perspective, as the return on R&D investments also benefits other firms and not just them. The knowledge generated through R&D does not wear out through use, and instead can potentially be used again and again by all market participants. The "positive externalities" often result in firms investing too little in their own R&D. Public funding for R&D can combat this market failure by reducing the costs of R&D investments, and thereby also increasing the return specific to the particular firm.

Additional reasons for public research funding[33] make reference to the observable cumulative nature of firms' R&D activities, which generally results in path dependencies: processes for searching out new applications that can be commercialised generally build on existing skills and expertise within a firm. This can result in a "lock-in" with respect to efforts by firms to promote innovation, i.e. a failure to develop new technological options that are further removed from a firm's traditional areas of expertise. Public funding should accordingly not only offer incentives by reducing the costs of R&D activities, but should also offer incentives for different R&D activities that are e.g. closer to basic research, or take place in cooperation with universities or other public research institutes.

A third approach towards justifying public research promotion originates from the impact of the spatial density of firms and other research institutes to the success of R&D activities.[34] The higher this density, the more positive effects can be expected in terms of exchanging knowledge, e.g. through researcher mobility or the rapid diffusion of innovations among firms that are in competition. Public support for R&D is therefore also seen here in the context of locational competition, with the promotion of regional cluster policies or boosting of the regional effects of universities taking place in particular in addition to general cost reductions for R&D activities.

A large number of different instruments have been established in funding practice for financial support of business enterprise R&D which are generally divided into direct funding of R&D and indirect or tax funding of R&D, and feature different intervention logics.[35] Direct funding can e.g. be awarded as a grant or as a discounted loan in accordance with an application process, potentially with very different funding criteria depending on the funding objective. The technological or commercial risk, collaboration with external partners or a certain topic-based orientation for the research project may for instance be a condition for funding. Indirect funding is also broken down into many different forms, e.g. into tax allowances or deductions, or divided into deductible cost formats (e.g. all R&D expenditure types or staff costs only, total R&D for a year or increase on previous year only, etc.).

Direct research funding is largely characterised by support for projects that are technologically sophisticated and which feature a convincing industrial potential in the peer review process. This tends to mean medium to lon-

32 See Arrow (1962); Nelson (1959).
33 See Malerba (2009); Soete et al. (2010).
34 See Steinmueller (2009).
35 For a brief overview see e.g. https://www.oecd.org/sti/outlook/e-outlook/stipolicyprofiles/competencestoinnovate/financingbusiness-rdandinnovation.htm

ger-term effects, depending on the detail of the intervention logic of the funding programmes.

Tax funding cannot, however, generally discriminate between research projects, i.e. cannot be awarded for instance solely for a certain topic-based focus or only for collaborative projects.[36] Direct funding can therefore be targeted towards certain research projects, but does require corresponding administrative costs; the use of indirect funding on the other hand cannot be managed by administrative processes, but is entirely subject to the firms, with administrative costs incurred in return (indirect funding is therefore also described as being "market-based"). With respect to the options for using the different instruments, a consensus has developed[37] whereby direct funding is most suitable in principle for supporting longer-term risky R&D, and for mission-oriented R&D on a specific topic, whereas indirect funding tends to be used to support the development of applications that can be launched on the market within the foreseeable future.

Direct business enterprise research promotion by the federal government in Austria is primarily administered via the Austrian Research Promotion Agency (FFG), which looks after lots of different funding programmes. Additional funds, albeit at a lower level, originate from another federal promotion agency, the Austria Wirtschaftsservice (aws), the funding agencies of the regional governments and from EU funding programmes. Indirect research funding is provided via the research tax premium, which is paid out by the Federal Ministry of Finance (BMF). The Austrian Research Promotion Agency reviews the applications for payment of the research tax premium in order to verify that these conform with the official definition of R&D activities in the Frascati Manual.

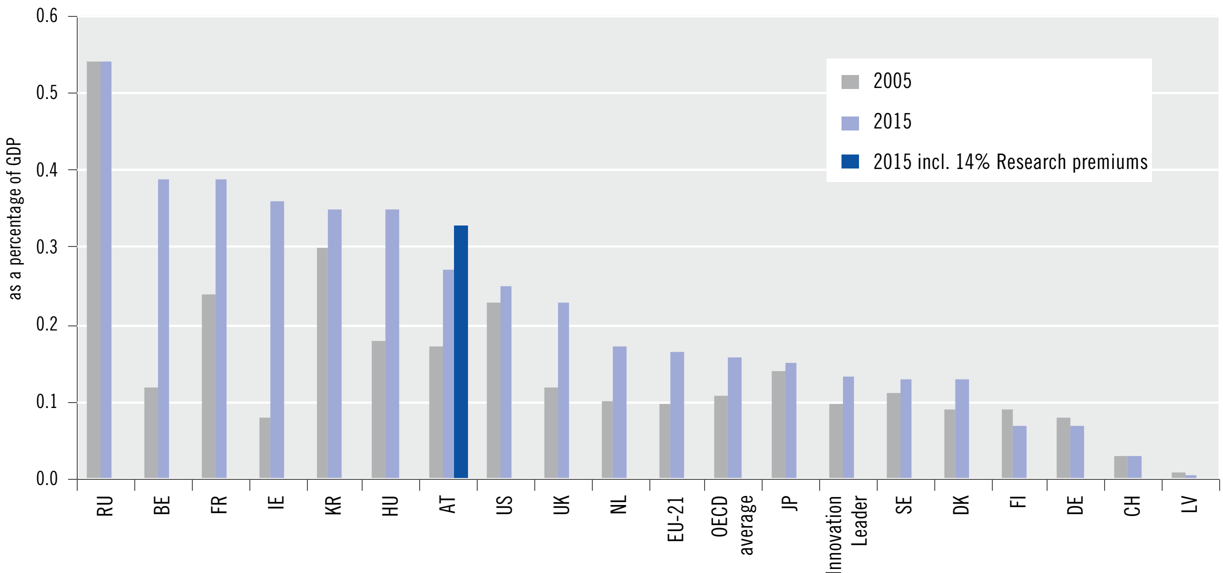
Development of funding for business enterprise R&D in the OECD

In order to capture the financial dimension of these different R&D support instruments across the whole OECD, the OECD has been surveying its member states for some years on the formats and endowment procedures for their tax research funding instruments, which are then stated together with the direct research funding.[38] Publication of the data as of July 2017 provides a breakdown of the public funding for business enterprise R&D into direct and indirect funding instruments relative to GDP for the period between 2009–2015, as well as the total funding for the period between 2005–2015 for 34 OECD and six additional countries.

Fig. 1-14 shows the most recent data for selected countries: in addition to Austria for the six leading innovation countries in the EU according to the European Innovation Scoreboard (Germany, Denmark, Finland, the Netherlands, Sweden, UK) on average and individually, the average for the EU countries available (EU-21), the average for the 34 OECD countries available, countries outside the EU that feature high levels of innovation (Switzerland, Japan, South Korea, USA), the country with the highest public corporate funding (Russia) and the lowest (Latvia) along with all other countries that are ahead of Austria with respect to the total amount of public funding (Belgium, France, Hungary, Ireland).[39] In addition to the OECD data for 2015 the increase in the research tax premium to 14% is also simulated for Austria as of 1 January 2018, i.e. a third bar shows the Austrian research funding for the business enterprise sector if the research tax premium had been at 14% in 2015 instead of 10%. This helps to make this comparison of the research fund-

36 See Appelt et al. (2016).
37 See ibid.
38 See http://www.oecd.org/sti/rd-tax-stats.htm
39 The data for all available countries can be found in Table 8.3 in Annex I.

Fig. 1-14: Public research promotion for the business enterprise sector, 2005–2015



Note: The third bar for Austria (AT) simulates the development of research promotion for the business enterprise sector if the research tax premium had already been at 14% in 2015. The Figure does not account for potential changes in other countries after 2015. For country codes see Table 8.1 in Annex I.

Source: OECD (2017). R&D Tax Incentive Indicators, July 2017. Calculations: Austrian Institute of Economic Research (WIFO).

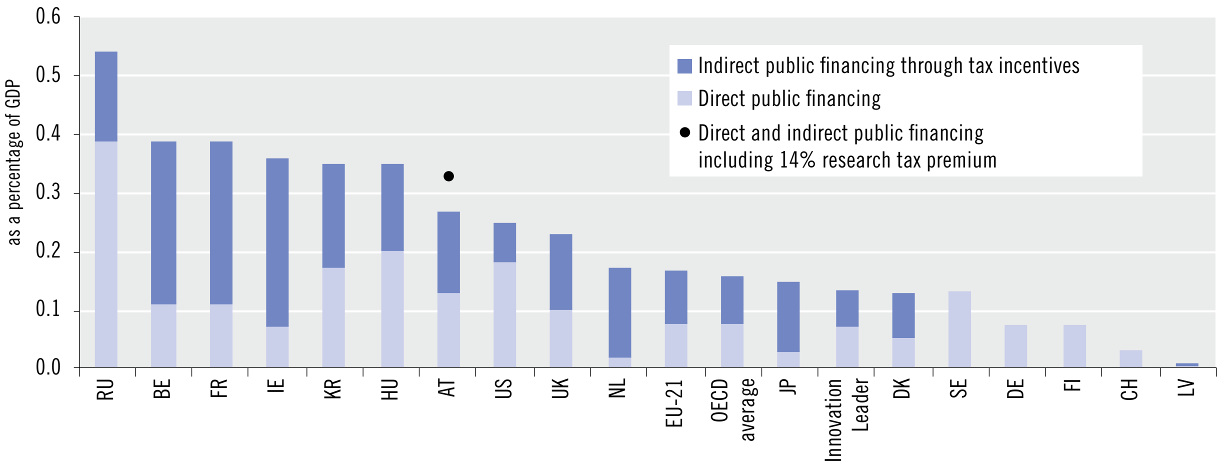
ing more current and enables a more effective assessment of its scope in Austria. However, there may be potential changes enacted into law in other countries that are not reflected in the data and are not therefore considered. Austria's relative gap with the other countries may accordingly change, yet the research funding's absolute dimension can be estimated more effectively by considering the increase in the research tax premium by 4% points since 2015.

Fig. 1-14 shows that public funding for business enterprise R&D in Austria is above the level for the highly innovative European countries, and above the average level for the available OECD and EU countries. Belgium, France, Hungary and Ireland are above the level for Austria within the EU, and South Korea and Russia feature higher levels outside the EU. Austria is also one of the countries that has significantly expanded public funding for business enterprise R&D since 2005, i.e. by more than 0.1% points of GDP (behind Ireland, Belgium, Hungary, France and the UK). Only nine countries out of 40 have reduced their support (including Finland, Germany and Israel).

Fig. 1-15 shows the public research funding for the business enterprise sector by direct and indirect funding instruments. All countries have direct R&D funding instruments, a total of OECD 30 countries also have indirect funding instruments or tax concessions for research activities. Direct and indirect funding were roughly equally high in Austria for 2015, in a situation similar to the average for the leading innovative countries and the available EU and OECD countries. However, clear differences in emphasis can be identified in the OECD data at the country level: countries with very low or non-existent tax concessions for research activities include e.g. the Innovation Leaders Switzerland, Germany, Finland and Sweden. Countries where the tax concessions for research activities achieve a high share (more than 70%) of total public funding include Australia, Belgium, France, Ireland, Japan and the Netherlands.

Fig. 1-16 finally compares the change in di-

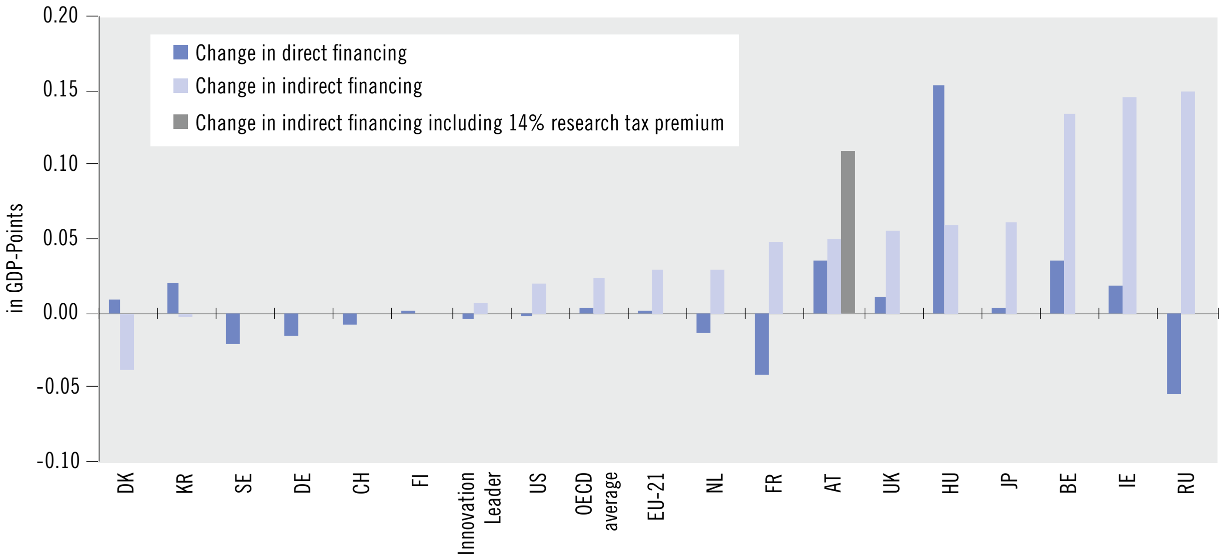
Fig. 1-15: Public direct and indirect research promotion for the business enterprise sector, 2015



Note: The point for Austria (AT) shows the development of research promotion for the business enterprise sector if the research tax premium had already been at 14% in 2015. The Figure does not account for potential changes in other countries after 2015. For country codes see Table 8.1 in Annex I.

Source: OECD (2017). R&D Tax Incentive Indicators, July 2017. Calculations: Austrian Institute of Economic Research (WIFO).

Fig. 1-16: Change in public direct and indirect research promotion for the business enterprise sector, 2009–2015



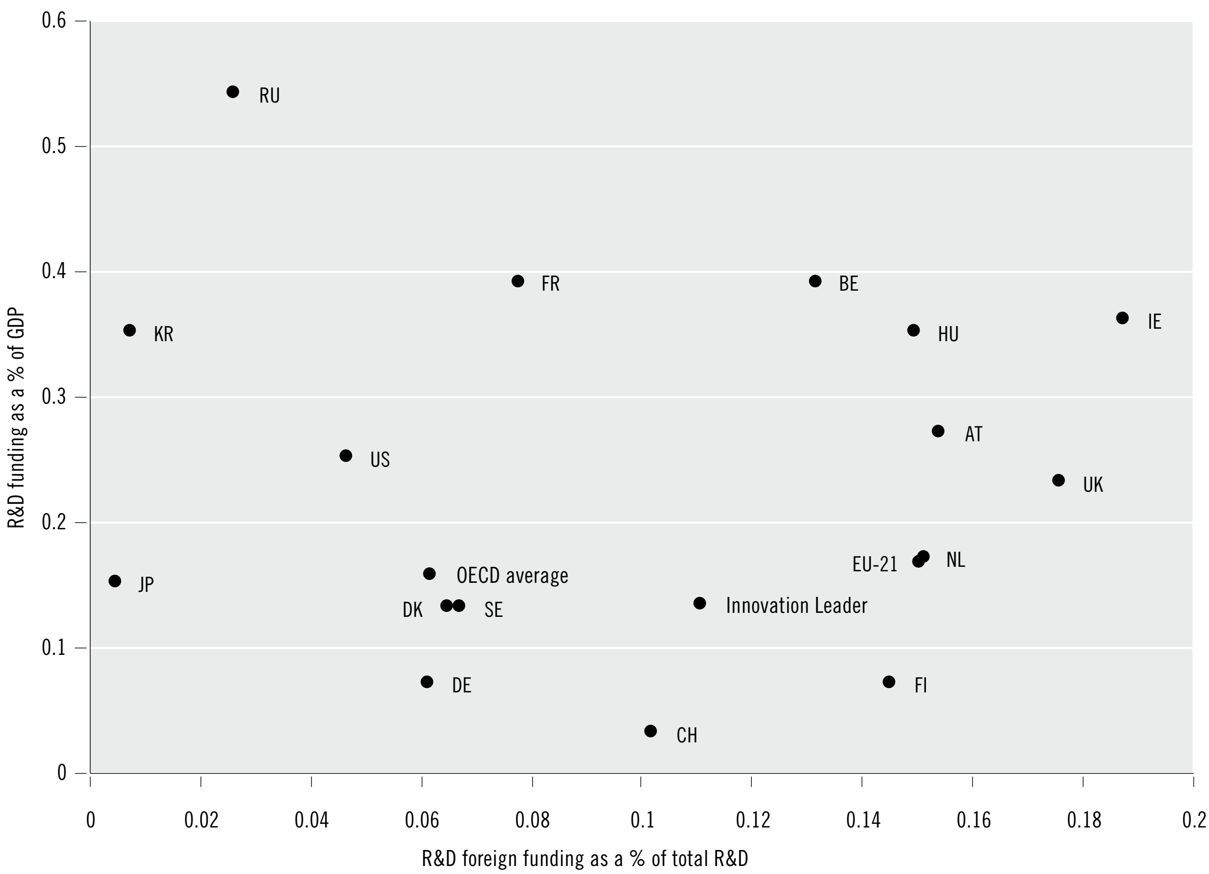
Note: The third bar for Austria (AT) simulates the development of research promotion for the business enterprise sector if the research tax premium had already been at 14% in 2015. The Figure does not account for potential changes in other countries after 2015. For country codes see Table 8.1 in Annex I.

Source: OECD (2017). R&D Tax Incentive Indicators, July 2017. Calculations: Austrian Institute of Economic Research (WIFO). 2010 for the following countries: CH, DE, EE, FI, EL, IS, IT, LU, MX, RU, SK.

rect with indirect funding between 2009 and 2015. It is clear that indirect funding grew significantly more as a % of GDP than direct funding on average in the available EU and OECD countries. Direct funding even fell slightly on average among the leading innovative countries. Direct funding increased significantly in Austria compared internationally, with only Hungary, Mexico and Belgium achieving greater or comparable increases. However, indirect funding increased even more significantly, even before the increase in the research tax premium to 14% is taken into account. Countries that experienced similar or even greater increases in indirect funding include Australia, Belgium, France, the UK, Hungary, Ireland, Iceland, Japan and Norway, while Russia, Belgium and Ireland saw an even greater increase than Austria when the increase to 14% is taken into account. There are also some countries that reduced their indirect funding in the period examined, most notably Canada and Denmark.

As already mentioned, public funding for R&D is also viewed from locational aspects, since the spatial density of R&D activities can have a positive impact on the results of these. One measure for the close international integration of R&D activities is the funding for R&D provided by foreign parent companies. OECD data within the scope of the Main Sci-

Fig. 1-17: Proportion of R&D funded from abroad (as a % of total R&D) in comparison with the public funding for business enterprise R&D (as % of GDP), 2015



Note: For country codes see Table 8.1 in Annex I.

Source: OECD (2017). R&D Tax Incentive Indicators. July 2017, OECD MSTI. Calculations: Austrian Institute of Economic Research (WIFO).

ence & Technology Indicators (MSTI) also enables a comparison of this funding from abroad, with the overwhelming proportion (87%) originating from firms and only a very small proportion from public international funding sources (e.g. EU research programmes). Fig. 1-17 compares public funding of business enterprise R&D with funding from abroad. A simple correlation even produces a slightly negative result, and a comparison of the growth dynamic between foreign funding and public business enterprise R&D shows an even more pronounced negative correlation. This does not mean that public funding would have no impact on funding from abroad, but there must obviously be other factors that have a significant impact on the extent of funding from abroad; econometric calculations would need to be carried out based on corporate microdata in order to be able to verify these other factors.[40]

Development in Austria

Next the development is shown for Austria in public funding of the business enterprise R&D sector of performance and by different public sources of funding (federal government, federal states, EU) as well as in comparison with the public funding of the government and universities sectors of performance. This analysis enables an assessment of the dynamic for different components in public R&D funding, and therefore of the significance of public funding for business enterprise R&D in the Austrian research promotion system. Based on the global estimate from Statistics Austria for 2017 and the latest calculations available on the issue of achieving the federal government's R&D intensity target for 2020 (3.76%)[41], projections of the different funding types by 2020 within Austria can also be shown. These are essentially based on the trends in the period between 2005–2017, the current federal funding framework for 2017–2020, and further laws enacted, such as the increase in the research tax premium to 14% and increase to university budgets by €1.35 billion for the 2019–2021 performance agreement period. Minimum and maximum scenarios were also calculated for the development of business enterprise expenditure for R&D; an average scenario was selected for the calculations provided. Based on the current economic boom and the procyclicality of R&D expenditure (i.e. R&D expenditure grows more strongly in times of economic boom than in a recession), this average scenario is very likely to be exceeded.

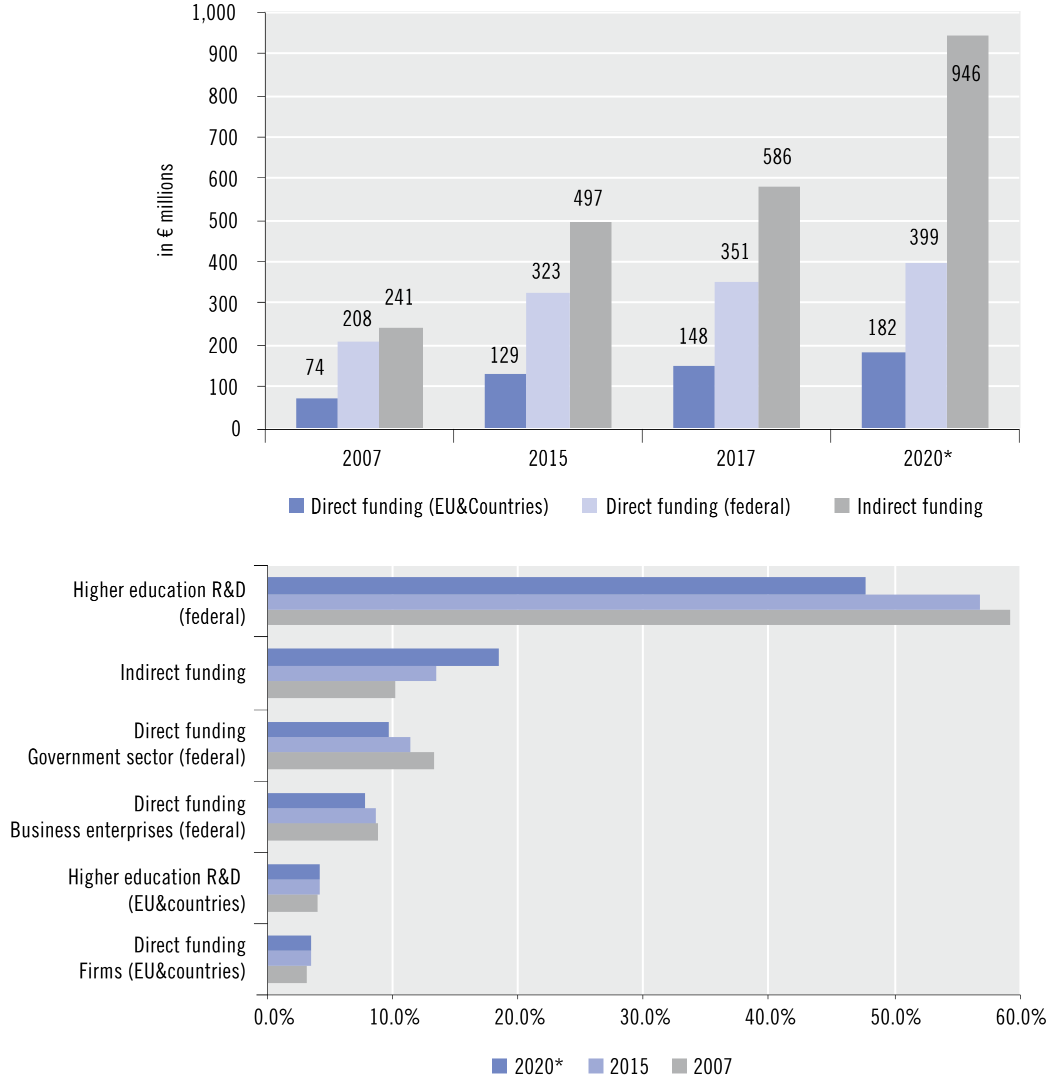
Fig. 1-18 (top panel) shows how the volume of direct and indirect funding of business enterprise R&D by the federal government, federal states and EU had developed by 2017, and projects developments until 2020. As already shown in the international comparison, growth in indirect funding was slightly stronger from 2007 until 2015 than total direct funding (by €86 million). From 2015 indirect funding grew significantly more rapidly, and this situation should also persist until 2020 given the existing federal funding framework and current growth trends. This results in a shift in emphasis in the balanced distribution up until now between direct and indirect funding in Austria by approx. 10% points towards indirect funding. With just over 60%, however, Austria would still remain below the 70% mark that is exceeded by countries in the international comparison that rely very heavily on indirect funding.

Fig. 1-18 (bottom panel) shows how this different dynamic impacts the different funding categories as a share of total public funding by 2020. Public funding for university R&D essentially remains the dominant category within public R&D funding, although the share of this has fallen by just under 10% points, which are

40 Data on the overall R&D activity of firms under foreign ownership and not just that activity funded from abroad would be even more suitable for an analysis of the significance of foreign firms for Austrian R&D activities. However, this data on foreign affiliates is only available for a few countries and only extends to 2013. A comparison with the amount of public funding also only shows a slight positive correlation in this case.

41 See Janger and Strauss (2018).

Fig. 1-18: Development of direct and indirect funding for business enterprise R&D, 2007–2020 (top) or proportions of the different categories of public funding, 2007–2020 (bottom)



Note: * projected value, for calculation details see Janger and Strauss (2018).

Source: Statistics Austria, Federal Ministry of Finance (BMF). Calculations: Austrian Institute of Economic Research (WIFO).

made up primarily by indirect funding of business enterprise R&D. As already outlined, the universities budget continues to rise in absolute terms, meaning that public funding for university R&D will also continue to rise. It should be noted that no distinction is made between budget expenditure and receipts in the statistical examination of the public R&D funding: firms, universities, etc. receive direct funding via budget expenditure, while indirect funding for business enterprise R&D is effectively a tax deficit. Simply examining the budget expenditure would therefore mean that the distribution of public funding for R&D among the different categories would remain roughly stable.

The shift in emphasis for public funding for business enterprise R&D from direct funding instruments towards indirect funding raises questions regarding its effect on firms' innovation performance. The issue of the interaction between direct and indirect research has also not been clarified in its entirety internationally, since heterogeneous innovation systems influence the impact of the funding in each country. Both substitutive as well as complementary effects can be found between direct and indirect funding in the international comparison. The benefits of direct funding certainly only seem to be for financing R&D at young R&D-intensive firms, since these find it especially difficult to obtain external finance, and direct funding for R&D projects for small firms can be significantly higher in volume terms than obtaining tax concessions.[42]

The interaction between direct and indirect research could only be reviewed to a limited extent in the recent evaluation of the research tax premium due to a lack of data.[43] As a result of the Federal Statistics Act it is difficult to link corporate data from different data sources in Austria in order to determine the interaction between different funding instruments (see Chapter 5.1). A separate assessment of the 2013 R&D survey by Statistics Austria performed as part of the evaluation revealed that firms that only make use of direct R&D funding are smaller on average and feature a higher share of basic research than firms that only receive the research tax premium or direct and tax-related funding. The corporate survey for evaluation of the research tax premium also revealed that direct research funding has a greater impact on smaller firms, whereas tax-related funding has a greater impact on large firms. A described, this is connected with the amount of the types of funding relative to the firm's size.

In summary it can be stated that public funding for business enterprise R&D is rising on average in the OECD and EU countries, driven by an increase in indirect funding. However, this does not affect all countries; a high degree of heterogeneity can still be observed in relation to the amount and use of direct vs. indirect funding instruments. Austria is among the group of countries that strongly support R&D activities in the business enterprise sector in the international comparison, and that have continued to expand this support in the periods between 2009–2015 or 2009–2018 as relevant. The costs of R&D activities in firms have therefore fallen considerably in Austria in the international comparison, with the incentives for R&D activities by firms remaining high. Incentives are also provided in the international comparison for off-shoring R&D activities to Austria from abroad, with this off-shoring also impacted by many other factors. There is no evident link between the amount of the corporate funding and funding from abroad, at least based on the descriptive statistics; obviously a large number of additional factors play an essential role in the establishment of foreign R&D units, such as the quality and predictability of the regulatory environment, the availability of qualified employees and premium technological infrastructures.

The strong rise in indirect funding, which is expected to continue until 2020 given the existing federal funding framework and the increase in the research tax premium to 14%, results in a shift in emphasis in the Austrian funding landscape. The balanced ratio between direct and indirect funding from 2015 will shift by around 10% points in favour of indirect funding if existing trends continue. The impact of the increase remains to be seen.

1.3 Austria's position in an international context

This Chapter looks at Austria's position in research, technology and innovation in an international comparison. One key issue involves

42 See Appelt et al. (2016).
43 See Ecker et al. (2017).

the extent to which Austria is coming closer to the target set out in the federal government's RTI strategy of advancing into the group of Innovation Leaders. Three data sources are used for any such assessment:

- **European Innovation Scoreboard (EIS):** The EIS is an initiative of the European Commission for comparison of innovation performance and capabilities between member states. Austria's most current position in the European Commission's EIS cannot be shown in this Austrian Research and Technology Report, as the EIS 2018 will not be published until after the Report is printed. The same situation existed in the previous year, meaning that this report examines the results from the EIS 2017.
- **Key RTI indicators:** The R&D intensity, patent intensity and publication activity reveal the extent to which funds are made available for R&D and the extent to which this R&D expenditure has led to results in the form of patentable new technology and published scientific findings.
- **International innovation rankings:** The Global Innovation Index 2017 (GII) and innovation-related elements of the Global Competitiveness Index 2017/18 (GCI) from the WEF compare a large number of countries using numerous indicators, with consideration both of quantitative indicators and also expert assessments.

Countries with an industrial and technological level of development similar to Austria are used as the reference group here in order to assess progress in achieving this objective of being part of the Innovation Leaders, since Austria is primarily engaged in innovation competition with these countries. This reference group includes all countries that feature at least half of Austria's per capita GDP (calculated at current exchange rates) and have a population of at least half of Austria's population. Oil-exporting countries are excluded due to their very specific conditions. The reference group includes a total of 22 countries, including 13 from Europe, eleven of which are EU Member States. The criteria for advancing into the group of innovation leaders for the individual indicators and rankings is the gap between Austria and the five leading countries on the one hand, and the difference between Austria's position and the average value for the reference group on the other. The assumption is that a position among the best five countries or a clear gap between the mean value for the reference countries indicate that a leading position has been attained or is within reach.

1.3.1 European Innovation Scoreboard 2017

The European Innovation Scoreboard (EIS) is aimed at comparing innovation performance by the EU member states and categorising the EU's innovation performance in a global context. It also has the objective of monitoring implementation of the Innovation Union flagship initiative in the EU's 2020 Strategy. The EIS allocates the member states to different groups with this, which also include a group of Innovation Leaders. As such the EIS is a central reference point in assessing Austria's progress in achieving the target from the RTI strategy of guiding Austria into the group of Innovation Leaders.

The most recent EIS edition that was available at the time this report has been finalised was from 2017.[44] Austria's position is summarised below based upon this EIS edition. One of the main focal areas is the development of the individual indicators. For the EIS 2017 it should be noted that the selection and definition of the indicators have been changed, which makes any comparison with the results from previous years more difficult. The methodological changes and their impact on Austria's position are summarised in an overview at the end of this section.

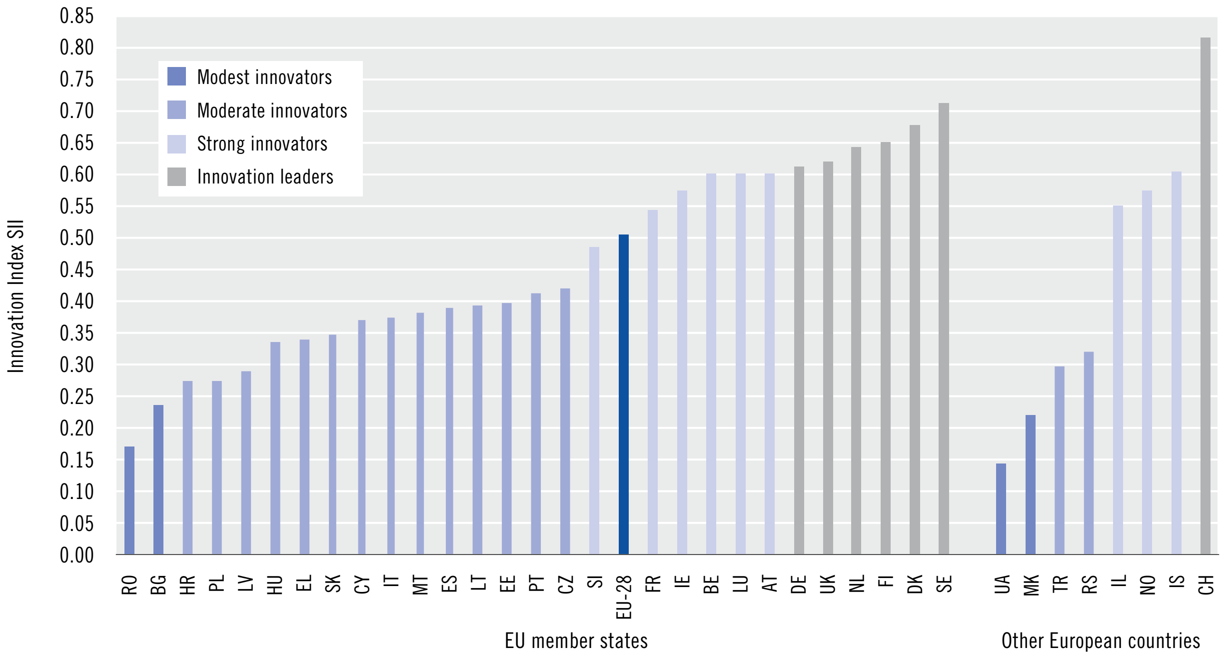
44 As the EIS 2017 was only published in the summer of 2017, its results could not be presented in the Austrian Research and Technology Report 2017. The EIS 2018 will also only be published in the summer, meaning that its results cannot be used for this Report.

Austria is ranked seventh among the 28 EU member states in the EIS 2017 (see Fig. 1-19). This is a significant improvement on Austria's ranking in the EIS 2016 when it was ranked in tenth position. Austria now leads the group of "Strong Innovators" and is thereby directly behind the countries that are part of the Innovation Leaders. The gap with the next Innovation Leader (Germany) is just 1.6% points. It is therefore very close to the federal government's target of joining the group of Innovation Leaders.

The close approximation to the group of Innovation Leaders is also due to the fact that this group now includes seven countries (including Switzerland) in the EIS 2017 instead of six countries previously. If the gap between Austria and the country ranked fifth were to be used as a criterion for catching up with the Innovation Leaders, then at approx. 6% in the EIS 2017 (with Switzerland also taken into account), Austria would be behind the next Innovation Leader (the Netherlands). Austria was also able to move ahead of Luxembourg and Belgium in the current ranking with a very small gap (0.3%). Austria would have been ranked ninth instead of seventh if its figures had been just slightly worse in a few individual indicators.

In the longer-term comparison, Austria has almost reached the ranking from the period before the financial and economic crisis as a result of the improvement in the EIS (2017), which refers to the reference years 2014 or 2015 depending on the relevant indicator (see Fig. 1-20). Austria was ranked sixth within the EU in the EIS 2008 and 2009, which essentially related to data from the reference years between 2005 and 2007. The gap in the Summary Innovation Index (SII) for Austria with the EU average was very high in the EIS 2010 at 15%, but had fallen to a healthy 5% by the EIS 2015. In the last two EISs Austria was once again able to extend the gap with the EU average significantly. It was 19% above the EU value in the EIS

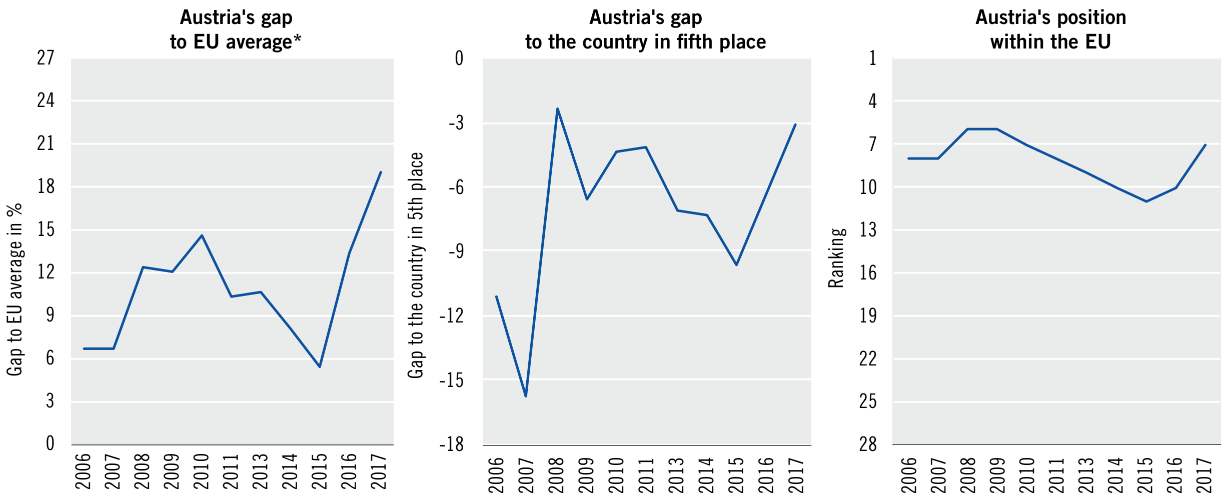
Fig. 1-19: EIS 2017: Summary Innovation Index (SII)



Note: For country codes see Table 8.1 in Annex I.

Source: European Commission (2017).

Fig. 1-20: Austria's position in the EIS between 2006 and 2017



Note: * 2006: EU-26, 2007–2013: EU-27, 2014–2017: EU-28. Years stated relate to the number of years under which the EIS has appeared. Between 2006 and 2011 the name for the EIS referred to the reference year, from 2013 onwards it referred to the year of publication. Gap with the EU average, gap with the fifth best ranked country, and ranking within the EU in accordance with the methodology applied in the EIS for the relevant year in all cases.

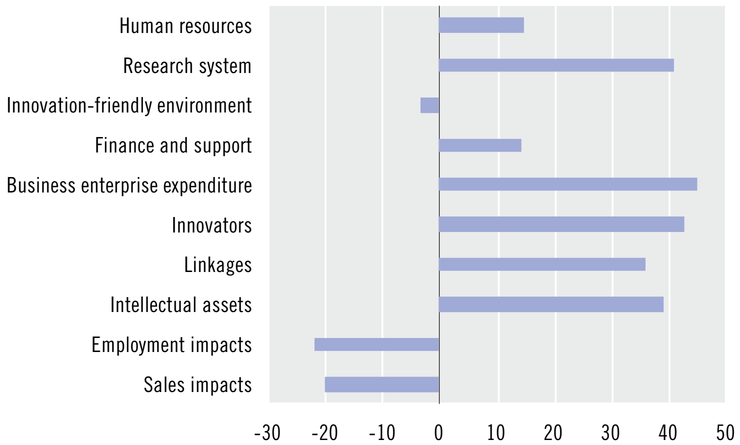
Source: European Commission (2006, 2007, 2008, 2009, 2010, 2011, 2013, 2014, 2015, 2016, 2017).

2017. The gap with the country ranked fifth in the EIS 2017 was around 3%. This is the lowest value since the EIS 2008.

The EIS 2017 makes a distinction between ten fields of innovation performance, ranging from human resources and scientific performance capability to various innovation framework conditions, along with investment by firms in R&D and innovation through to the innovation results and their direct and indirect impact. Austria's performance is well above average in five fields, which are each around 40% above the EU average (see Fig. 1-21). These include the areas of business enterprise expenditure, innovators, research system, industrial patents and networking. Austria's performance is average in the area of innovation-friendly environments, which does in fact only include broadband supplies and readiness for creating new enterprises, and slightly above-average in human resources and the area of finance and support. Austria's performance is well below the EU average in two fields: employment impacts and industrial results. Austria would succeed in its mission of joining the group of Innovation Leaders if it could manage to make significant improvements in these two fields in particular.

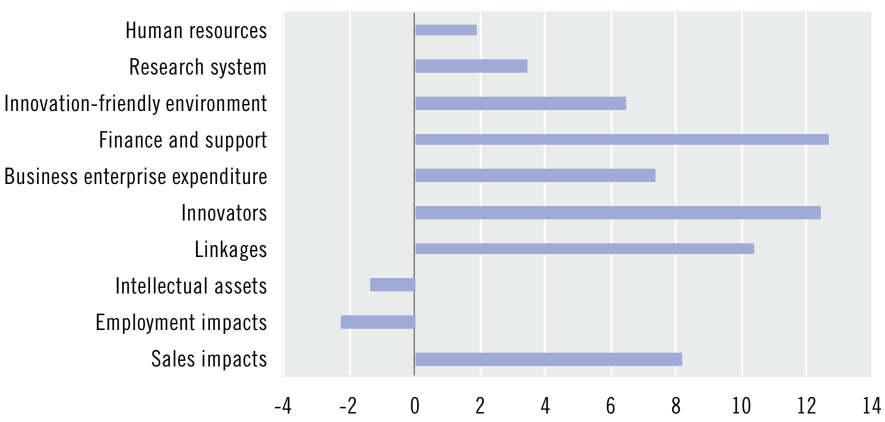
Austria improved significantly in the EIS 2017 in one of the two areas featuring below-average performance (see Fig. 1-22). The average indicator value in the area of industrial results (exports of research-intensive goods and knowledge-intensive services, revenues with new products) rose by around 8%. In employment impacts through innovations (employment in knowledge-intensive industries, employment in fast-growing firms) on the other hand the average indicator value worsened by 2%. In the area of innovation-friendly environments, in which Austria was also below the EU average in the EIS 2017, the indicator value rose a good 6% as compared with the EIS 2016. Austria was able to make particular improvements in the three areas of finance and support (R&D in the public sector, venture capital investments, +13%), innovators (SMEs with innovations, +12%) and linkages (SMEs with innovation co-operation, public/private co-publications, industrial funding for public R&D, +10%). Slight

Fig. 1-21: Austria's performance in the EIS 2017 in comparison with the EU average by fields



Source: European Commission (2017). Calculations: ZEW.

Fig. 1-22: Change in Austria's performance between the EIS 2016 and 2017

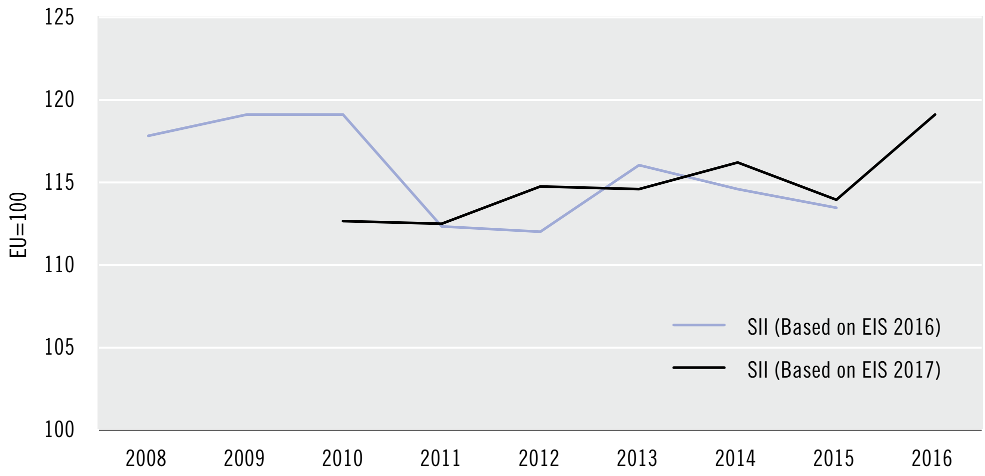


Source: European Commission (2016, 2017). Calculations: ZEW.

increases were recorded in the areas of human resources and research system. A slight decline can be observed in the area of industrial patents and employment impacts.

The improvements in most fields of the EIS result in a clear leap forward in the *Summary Innovation Index* (SII) for Austria in the EIS 2017 compared with the previous year from 0.566 to 0.599 points (see Fig. 1-23). Austria was able to increase its gap with the EU average from 14% to 19%. This means that Austria has once again achieved the performance levels from 2008 to 2010, when Austria's SII was between 17% and 19% above the EU average.

Fig. 1-23: Summary Innovation Index (SII) for Austria in the EIS based on the earlier (EIS 2016) and revised (EIS 2017) methodology



Source: European Commission (2016, 2017). Calculations: ZEW.

Detailed analysis of the individual indicators

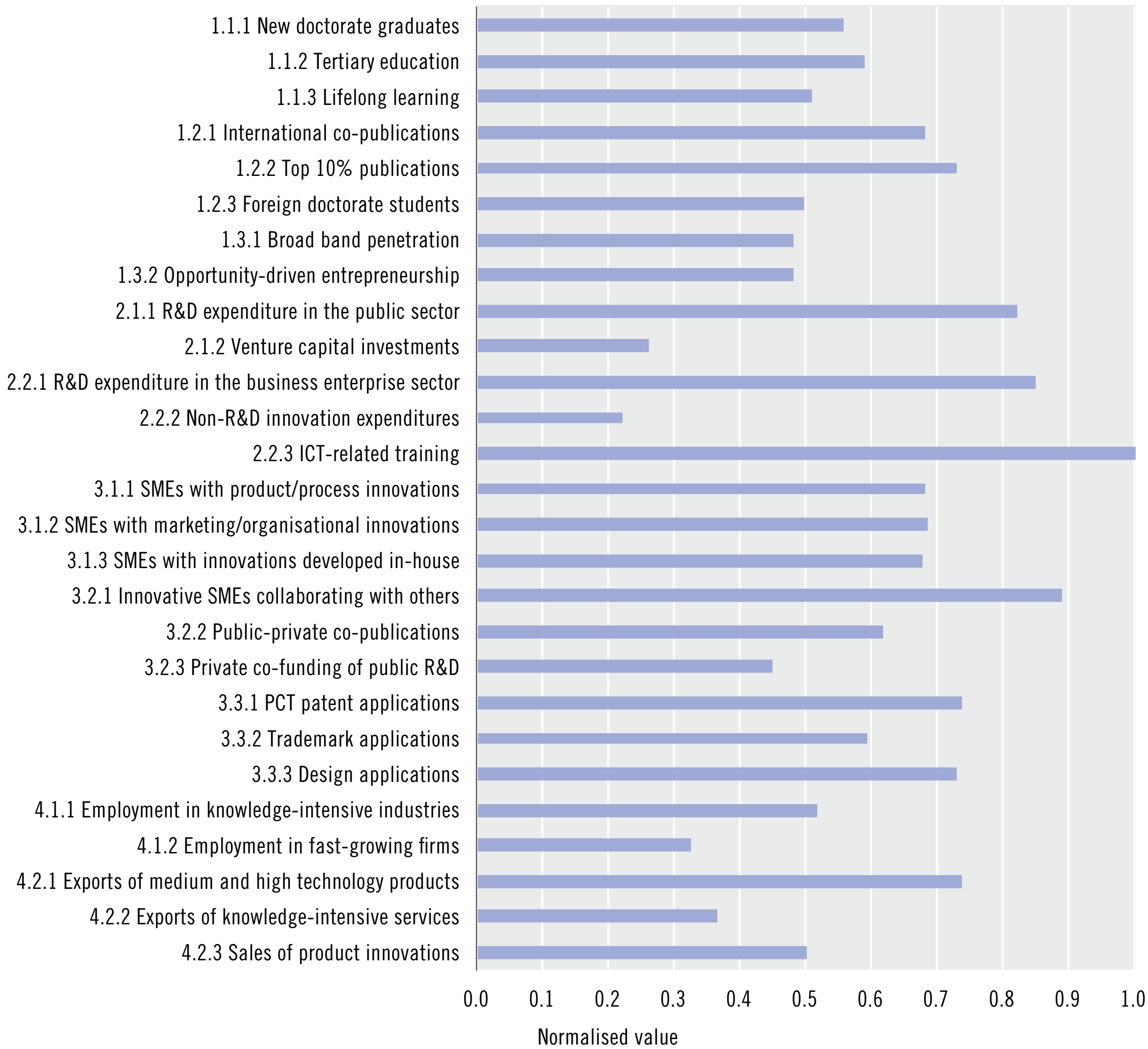
A country's position in the EIS is determined by 27 individual indicators. Each indicator has the same weighting with this. The individual indicators are "standardised" in order to merge them with the SII, meaning that they are placed in a value range between 0 (= country with the lowest value) and 1 (= country with the highest value). The SII corresponds with the average value for the standardised individual indicators. Since the countries in the group of Innovation Leaders feature a SII of more than 0.6, each individual indicator with a standard value greater than 0.6 contributes towards the efforts to close the gap with the Innovation Leaders.

In the EIS 2017 a total of 13 of Austria's 27 standardised individual indicators were above the value of 0.6 (see Fig. 1-24). Austria achieved its highest value in ICT-related training in enterprises (2.2.3). It also achieved very high values in innovative SMEs collaborating with others (3.2.1), R&D expenditure in the business enterprise sector (2.2.1) and R&D expenditure in the public sector (2.1.1). Values above 0.6 were also achieved in the publication indicators (1.2.1, 1.2.2, 3.2.2), SME indicators of innovation (3.1.1, 3.1.2, 3.1.3), patent and registered design applications (3.3.1, 3.3.3) and export of medium and high technology products (4.2.1). Austria features low standardised indicator values of below 0.4 in non-R&D innovation expenditure (2.2.2), venture capital investments (2.1.2), employment in high-growth enterprises (4.1.2) and export of knowledge-intensive services (4.2.2). These indicators were also among Austria's weakest in the EIS in previous years.

In examining the change to the original values for the individual indicators (see Fig. 1-25), it is evident that the biggest increase was in venture capital investments (2.1.2), and SMEs with innovation cooperation (3.2.1). There were also distinctly positive changes in further indicators from the CIS[45] (3.1.1, 3.1.3, 4.2.3), broadband penetration (1.3.1), ICT-related training (2.2.3), foreign doctorate students (1.2.3) and international scientific co-publications (1.2.1). The heaviest decline for one single indicator re-

45 European Community Innovation Surveys (CIS) coordinated by Eurostat.

Fig. 1-24: Standardised indicator values for Austria in the EIS 2017

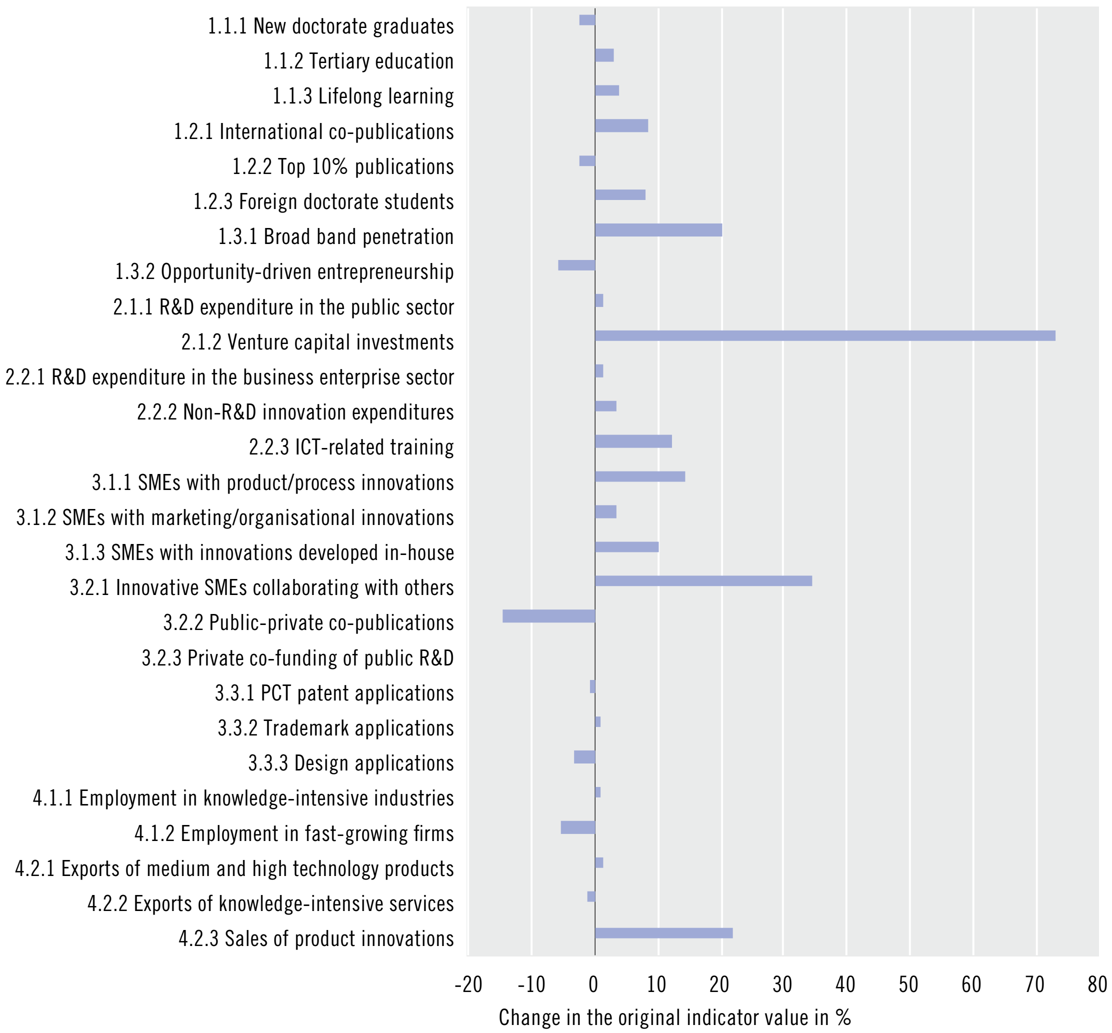


Source: European Commission (2016, 2017). Calculations: ZEW.

lated to the public/private co-publications (3.2.2), with significant declines also observed in employment in fast-growing firms (4.1.2) and opportunity-driven start-ups (1.3.2).

The significance of individual indicators for the improvement in the EIS 2017 by 0.033 points (i.e. by around 6%) is influenced both by the change to the original indicator value as well as by the changes in other countries, as these co-determine the standardised value for an individual indicator. If the overall change in the Austrian index value is broken down into the contributions of the standardised individual indicators (see Fig. 1-26), then SMEs with innovation cooperation (3.2.1) make the biggest contribution to Austria's improved position. Additional larger contributions were provided by ICT-related training (2.2.3), sales of product innovations (4.2.3), SMEs introducing product/process innovations (3.1.1) as well as venture capital investments (2.1.2). Overall the six CIS indicators made a contribution of two-thirds to the overall increase in the Austrian SII in the EIS 2017.

Fig. 1-25: Change to the original values for Austria with the individual indicators in the EIS 2017



Note: The change relates to the two latest available reference years. This is frequently the change between the reference year 2014 and reference year 2015. In the case of the CIS indicators (2.2.2, 3.1.1, 3.1.2, 3.1.3, 3.2.1, 4.2.3) this is the change between the reference years 2012 and 2014.

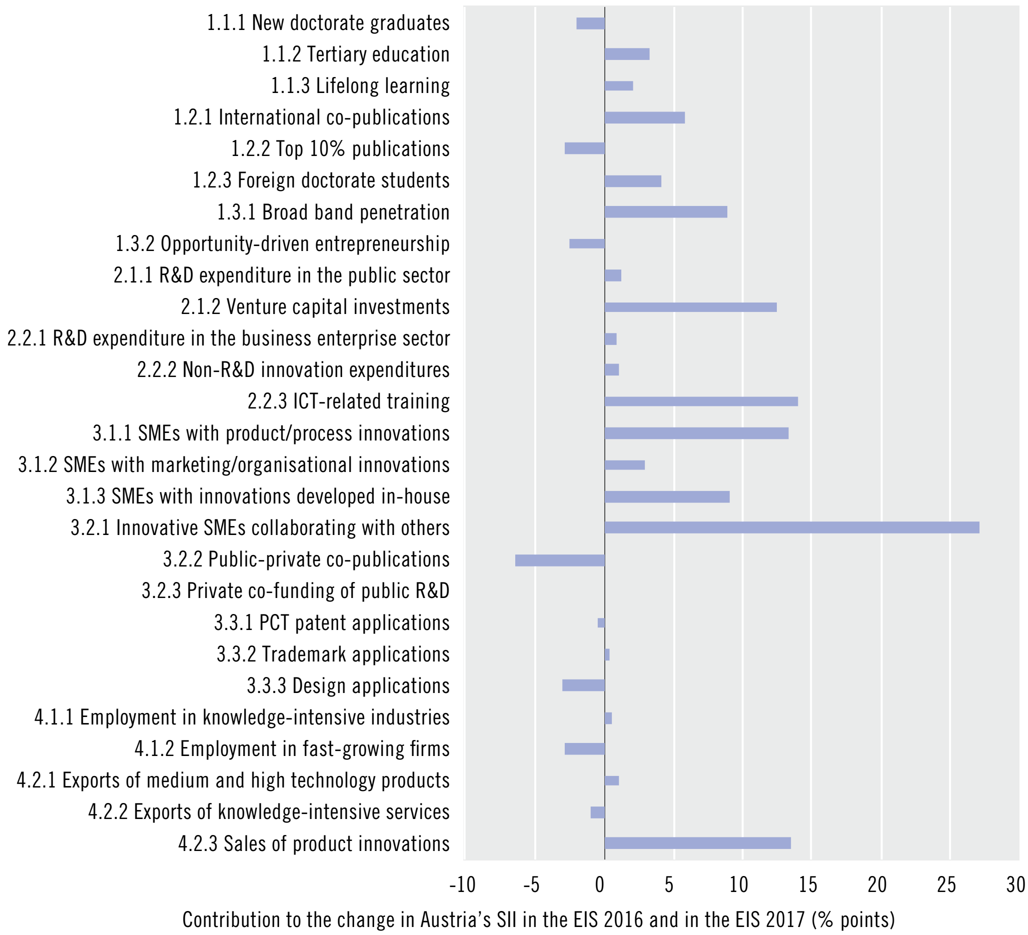
Source: European Commission (2016, 2017). Calculations: ZEW.

Changes in the EIS 2017 compared with the EIS 2016:
Indicators removed

- Higher secondary education: percentage of 20-24 year olds with a college degree in higher secondary education (ISCED 3)
- Patents on societal challenges: number of PCT patent applications[46] in the areas of the environment and health relative to GDP
- Licence and patent income from abroad: amount of income from abroad from industrial patents (licences, sale, etc.) as well as R&D and technical services relative to GDP

46 PCT stands for "Patent Cooperation Treaty" and designates the procedure whereby a patent application may be submitted for an invention in many countries at the same time in the form of one single "international" patent application instead of multiple separate national patent applications, as is the case for instance with the triadic patents.

Fig. 1-26: Contribution of the individual indicators to the change in the overall index value for Austria between the EIS 2016 and EIS 2017



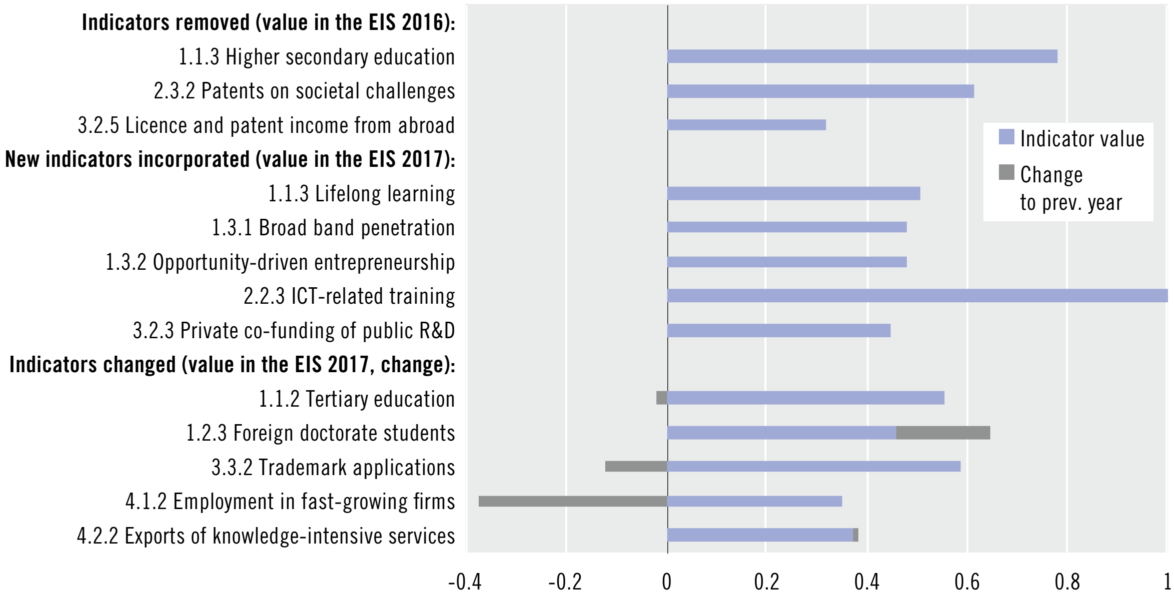
Note: The total sum for the values stated adds up to 100%.

Source: European Commission (2016, 2017). Calculations: ZEW.

Changes in the EIS 2017 compared with the EIS 2016:
New indicators incorporated:

- Lifelong learning: percentage of 25-64 year olds who have taken part in further education or training over the last four weeks
- Broad band penetration: percentage of firms with an internet connection of 100 mbps or higher
- Opportunity-driven entrepreneurship: proportion of people who wish to start a business or recently founded their own firm in order to improve their income situation or achieve greater independence, and those people who wish to start a business or recently founded their own firm because they have no other option of earning an income
- ICT-related training: percentage of firms that have provided further training on ICT skills to their employees
- Industrial funding for public R&D: amount of R&D expenditure by universities and the government sector funded by the business enterprise sector relative to GDP

Fig. 1-27: Indicator values for Austria for individual indicators that have been removed, newly incorporated and revised



Source: European Commission (2016, 2017). Calculations: ZEW.

Changes in the EIS 2017 compared with the EIS 2016:
Revised indicators:

- Tertiary education: percentage of 25-34 year olds who have completed tertiary education *[previously: 30–34 year olds]*
- foreign doctorate students: percentage of doctorate students from abroad (students with prior education abroad) *[previously: percentage of doctorate students from non-EU countries]*
- Trademark applications: Number of trademark applications with the EUIPO and the WIPO relative to GDP *[previously: not including WIPO applications]*
- Employment in fast-growing firms: percentage of employees in fast-growing firms (with at least ten employees) from particularly innovative industrial sectors (beverage, tobacco, chemical, pharmaceutical and electrical industries, mechanical engineering and vehicle construction, electricity supplies, petroleum processing, other manufacturing, elimination of environmental pollution, mining services) *[previously: weighting of the percentage of employees in fast-growing firms with a sector-specific innovation index]*
- Export of knowledge-intensive services: proportion of exports of knowledge-intensive services (including fees for the use of intellectual property) as a percentage of all service exports *[previously: not including fees for the use of intellectual property]*

Impact of changes on Austria's performance in the EIS 2017

Incorporation of the five new indicators with simultaneous removal of three indicators had a slightly positive impact on the SII in the EIS 2017. It increased by 0.011 points as a result of this, i.e. 2% of the Austrian SII. Austria features the highest value of all countries for one new indicator: ICT-related training. For all other new indicators, Austria features standardised values that are slightly below its SII of 0.599, i.e. these indicators pushed Austria's overall result down slightly. Of the three indicators removed, one – i.e. higher secondary education – featured a value that was well above average, and another – i.e. licence and patent income from abroad – a value that was well below average.

Austria's performance deteriorated significantly by 0.064 points, i.e. by around 11% of the Austrian SII, as a result of the revision of five indicators. The indicator of employment in fast-growing firms is pivotal to this. The restriction to innovation-oriented industrial sectors means that employment growth in fast-growing firms of knowledge-intensive services is no longer evaluated. The revision also resulted in a lower indicator value for trademark applications and a higher indicator value for doctorate students from abroad.

Potential developments in the EIS 2018

No results from the EIS 2018 (which relates to the reference year 2016) were available at the time of preparing the Austrian Research and Technology Report 2018. No data updates had taken place either for some of the individual indicators that are based on separate assessments. Austria's performance in the EIS 2018 cannot therefore be depicted in advance. At the same time, some possible developments can be estimated using the trends for individual indicators for which more current values are already available. The change in the original values of the indicators is compared with the changes in the EU-28 for this (see Table 1-8).

A considerably more favourable development can be expected for Austria for four of the individual indicators than in the EU-28. This relates first of all to the proportion of R&D expenditure at universities and government research institutes funded by firms as a percentage of GDP (3.2.3), which has increased considerably in Austria for the reference year 2015. Secondly the percentage of doctorate students from abroad (1.2.3) also increased. Thirdly the number of trademark applications (3.3.2) remained consistent, whereas a significant decline was recorded for the EU-28. Fourthly R&D expenditure in the public sector (2.1.1) increased slightly, although it fell slightly in the EU-28.

It is likely that six of the indicators will contribute towards a deterioration in Austria's position: with broadband penetration in firms (1.3.1) Austria's position will be worse despite an increase in the indicator value in the EIS 2018, since a significantly greater increase was recorded in the EU-28. The other five indicators are: opportunity-driven start-ups (1.3.2), venture capital investments (2.1.2), ICT-related training (2.2.3), PCT patent applications (3.3.1) and registered design applications (3.3.3). Progress with the developments in the indicators of new doctorate graduates (1.1.1) and R&D (2.2.1) are expected to be parallel for Austria and the EU-28. There are not expected to be any data updates in the EIS 2018 for the six indicators based on CIS data (2.2.2, 3.1.1, 3.1.2, 3.1.3, 3.2.1, 4.2.3).[47]

A worsening in Austria's position in the EIS 2018 is more likely than an improved position based on the trends for the indicators for which updated values are already available. The heavy decline in venture capital investments in the reference year 2016 in particular as compared with reference year 2015 (the values for which are used in the EIS 2017) should have a noticeable impact on Austria's SII value. However, there were no updated values available yet for nine of the indicators at the time of reporting. Improvements in these indicators, which map performance in scientific publications, employment in knowledge-intensive sectors and/or fast-growing firms and export activities could balance out any unfavourable developments overall.

47 The European Commission plans to incorporate any provisional trends from the CIS 2016 into a brief “Outlook” chapter. However, this outlook is not used in the SII for the EIS 2018.

Table 1-8: Current development in the indicator values for the EIS in Austria and the EU-28

	Value in the EIS 2017	Current value	Change for AT as a %	Change for EU-28 as a %
1.1.1 New doctorate graduates	1.90	1.90	0	0
1.1.2 Tertiary education	39.7	39.7[b)]	0	0
1.1.3 Lifelong learning	14.9	14.9[b)]	0	0
1.2.1 International co-publications	1,336	n.a.	-	-
1.2.2 Top 10% publications	11.7	n.a.	-	-
1.2.3 Foreign doctorate students	27.0	28.3	+5	0
1.3.1 Broadband penetration	12	13	+8	+23
1.3.2 Opportunity-driven entrepreneurship	3.21	3.00	-6	+8
2.1.1 R&D in the public sector	0.89	0.90	+1	-1
2.1.2 Venture capital investments	0.051	0.022	-56	-8
2.2.1 R&D in the business enterprise sector	2.18	2.21	+1	+1
2.2.2 Non-R&D innovation expenditures	0.47	0.47[a)]	0	0
2.2.3 ICT-related training	37	31	-16	-5
3.1.1 SMEs with product/process innovations	40.7	40.7[a)]	0	0
3.1.2 SMEs with marketing/organisational innovations	46.1	46.1[a)]	0	0
3.1.3 SMEs with innovations developed in-house	35.0	35.0[a)]	0	0
3.2.1 SMEs with innovation cooperation	20.5	20.5[a)]	0	0
3.2.2 Public-private co-publications	57.6	n.a.	-	-
3.2.3 Industrial funding for public R&D	0.042	0.049	+15	+2
3.3.1 PCT patent applications	4.95	4.93	0	+7
3.3.2 Trademark applications	12.9	12.8[c)]	-1	-17
3.3.3 Registered design applications	7.10	5.82[c)]	-18	-8
4.1.1 Employment in knowledge-intensive industries	14.6	n.a.	-	-
4.1.2 Employment in fast-growing firms	2.90	n.a.	-	-
4.2.1 Export of research-intensive goods	57.6	n.a.	-	-
4.2.2 Export of knowledge-intensive services	44.4	n.a.	-	-
4.2.3 Revenues with product innovations	12.0	12.0[a)]	0	0

a) No update in the EIS 2018 as data is only collected every two years.
b) Not yet updated at the time of reporting.
c) Preliminary values.
n.a.: not available/applicable

Sources: Eurostat. Processing and calculations: ZEW.

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

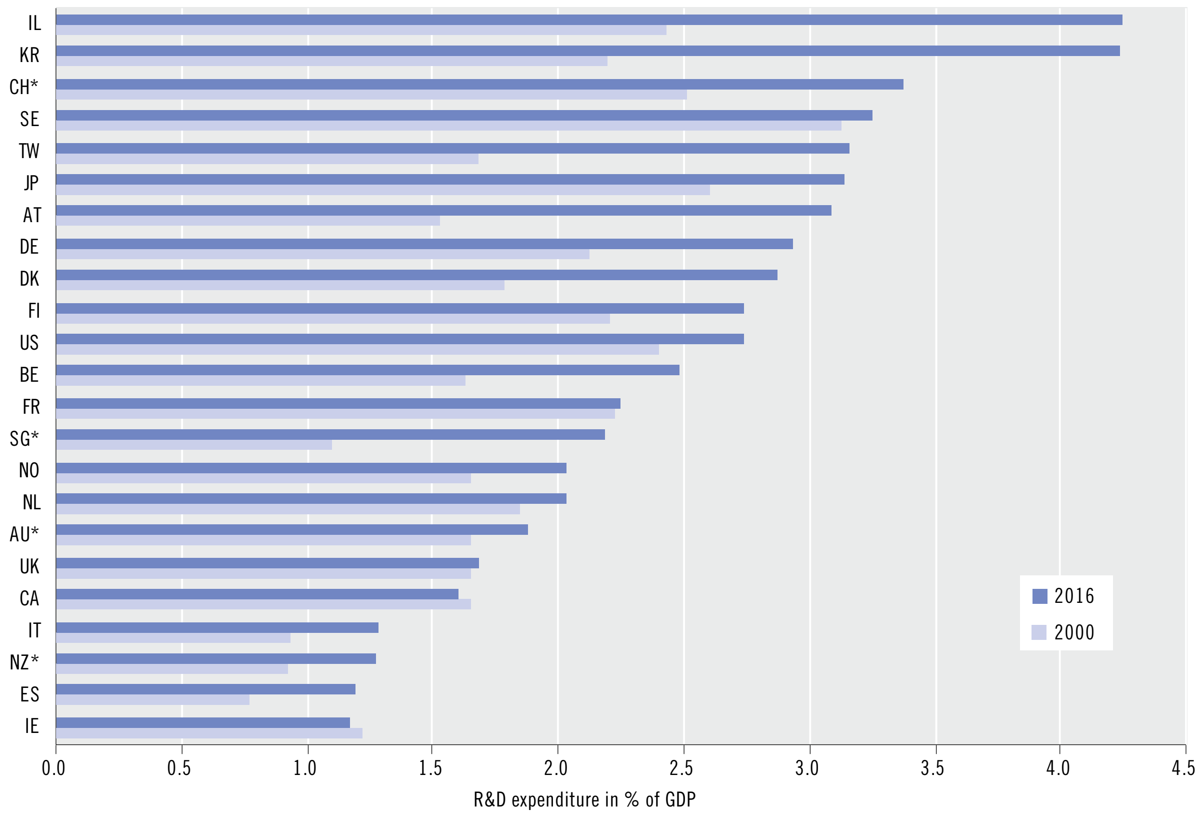
The key performance indicators for research, technology and innovation include the overall economic R&D intensity as a key input indicator along with patent applications and scientific publications, which depict the direct results of R&D activities.

Total R&D intensity

Austria was in seventh place among the reference countries for total R&D intensity in 2016 with a value of 3.09%.[48] Austria was in second place within the EU-28 behind Sweden. Israel, South Korea, Switzerland, Taiwan and Japan were also ahead of Austria in 2016 (see. Fig. 1-28). Austria was only ranked eleventh in 2011 (not including Switzerland, for which a ratio of

48 Fifth place was stated for Austria for 2015 in the Austrian Research and Technology Report 2017, Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017). Switzerland is now ahead of Austria for 2015 as a result of the data update for Switzerland.

Fig. 1-28: Austria's total R&D intensity and that of the reference countries 2000 and 2016



Note: * Values estimated for 2016. For country codes see Table 8.1 in Annex I.

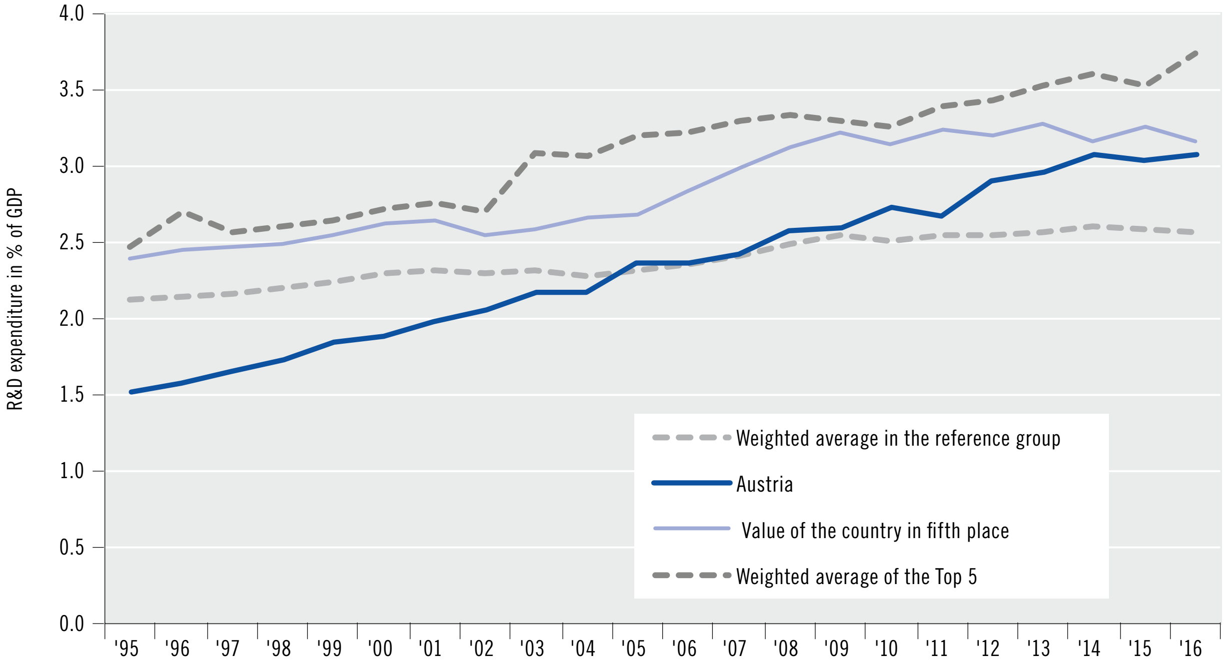
Source: OECD: MSTI, edition 2/2017. Calculations: ZEW.

3.19% is stated for 2012) with R&D intensity of 2.67%. In addition to the increase in the Austrian R&D intensity the improvement in the rankings was also attributable to the heavy decline in Finland's R&D intensity and the stagnation of the R&D intensity in Denmark and the USA, which were all still ahead of Austria in 2011.

Austria's R&D intensity has seen a significantly greater increase compared with the average for the reference group based on the trends over the last 20 years (see Fig. 1-29). Austria's R&D intensity exceeded this average value for the first time in 2005, since 2008 it has been persistently above this value. The gap with the average value of the top 5 countries on the other hand only began to reduce from 2012. This is because individual larger countries among the top 5 increased their R&D intensity even more than Austria (mid 2000s: Japan, most recently South Korea).

Austria's R&D intensity has increased by 1.56% points over the last two decades. Only two countries feature higher increases (South Korea: +2.04% points, Israel: +1.82% points). Austria was the country with the most dynamic development in its R&D intensity by far within the EU-28. Only Denmark comes closer to the development dynamic in Austria with an increase of 1.08% points.

Fig. 1-29: Development of total R&D intensity in Austria and in the reference group, 1995–2016



Note: Estimated or preliminary values for some countries for 2016.

Source: OECD: MSTI, edition 2/2017. Calculations: ZEW.

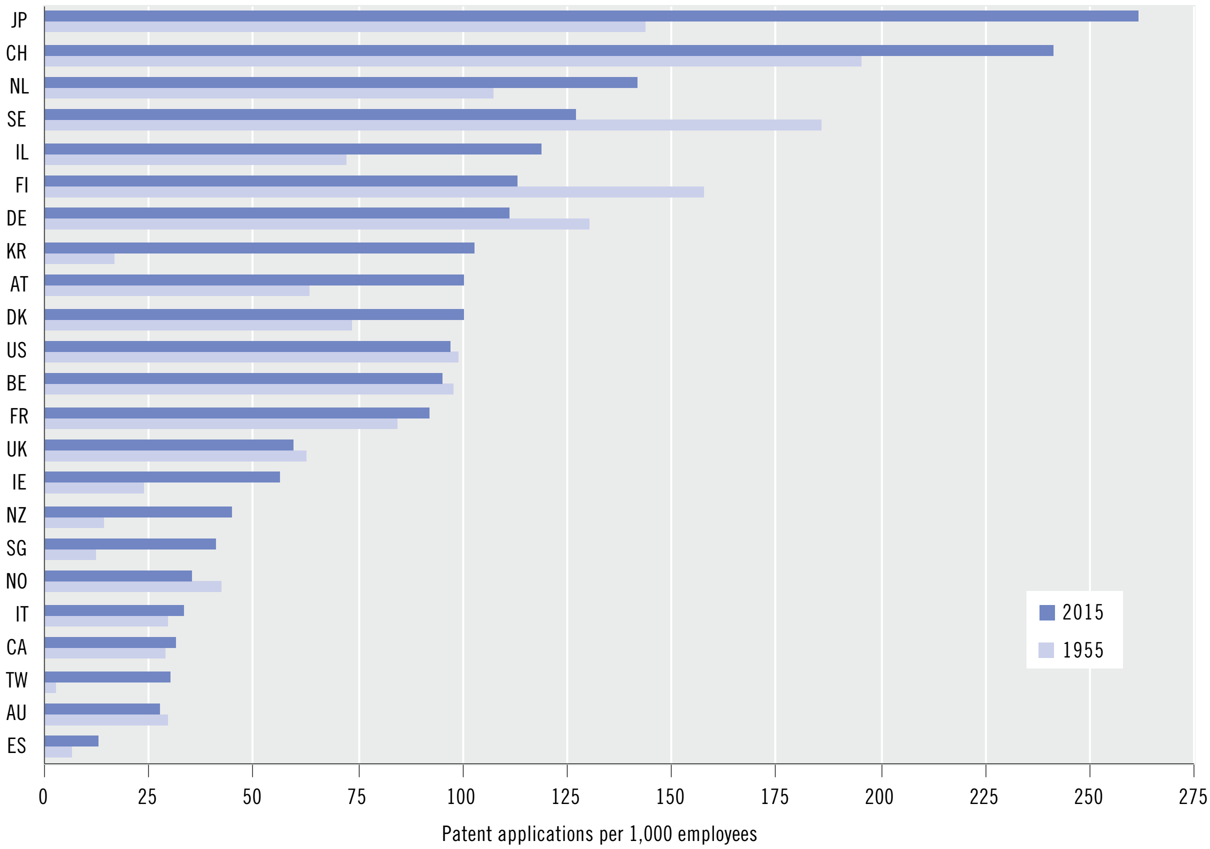
Patent applications

Patent applications are an indication that new technical knowledge is being generated. Only the latest technical knowledge that is or may (at least in principle) be relevant for industrial applications can generally be patented. Since there are costs associated with patent applications there is an assumption that patent applications are only made if there is a prospect that the patent will subsequently be granted, i.e. that the case actually involves a technical invention with application potential. In terms of comparing patent applications at the international level it should be noted that an invention can be registered with different patent offices. At the same time it has been shown that inventions that are only registered at one single national patent office often feature a low level of invention. Only patent applications that are registered internationally, i.e. in different countries, are therefore examined for international comparisons. The OECD[49] has established the concept of "triadic patents" for this. These are patent families that have been registered with the US, European and Japanese Patent Offices.

In 2015 Austria patent intensity, i.e. the number of triadic patent applications per 1,000 people in gainful employment, was 100. This is the ninth highest value among the reference countries (see Fig. 1-30). Austria was only ranked at 13th position in 2011. Japan and Switzerland feature the highest patent intensity. This is followed at a significant distance by Sweden, the Netherlands, Israel and Finland. Austria was able to increase its patent intensity by 37 compared with the figure in 1995. Only two countries feature a significantly stronger increase (Japan, South Korea). Patent intensity increased in Switzerland, Israel and the Nether-

49 See OECD (2009).

Fig. 1-30: Patent intensity in Austria and the reference countries, 1995 and 2015 (triad patents)



Note: For country codes see Table 8.1 in Annex I.

Source: OECD: MSTI, edition 2/2017. Calculations: ZEW.

lands to roughly the same extent as it did in Austria. Patent intensity even fell considerably between 1995 and 2015 in Finland, Sweden and Germany.

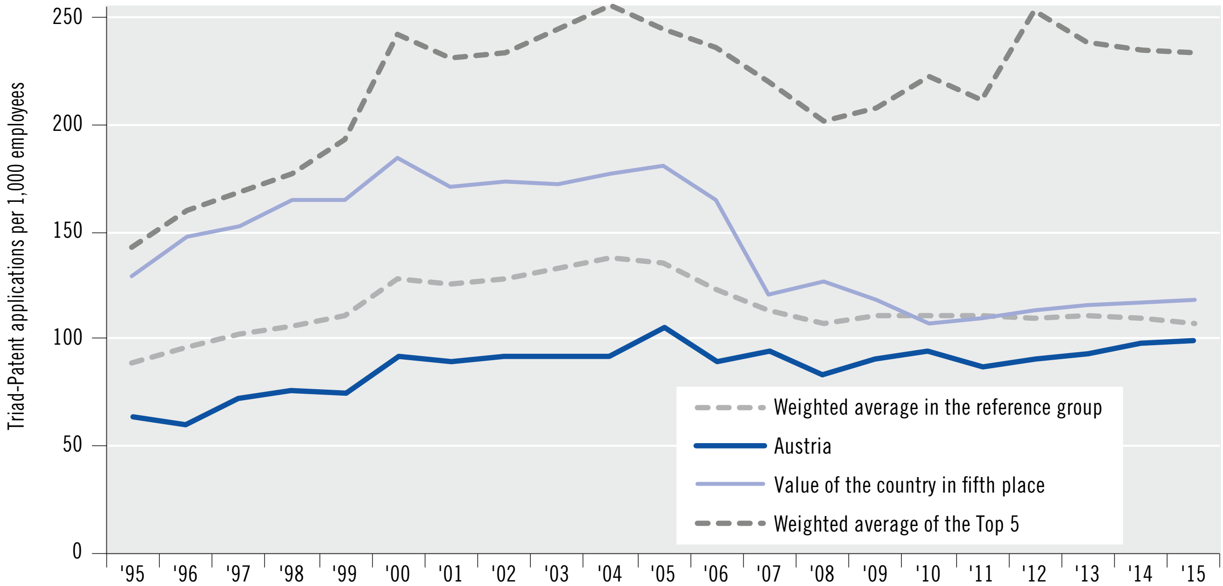
As a result of the strong growth in triadic patent applications, in 2015 Austria was able to come close to the average value for the reference group. The gap with the country ranked fifth (Israel) has, however, hardly reduced at all following the significant reductions between 2005 and 2010 (see Fig. 1-31). While this average value has experienced a downward trend since 2005, Austria was able to maintain a consistent patent intensity and started to increase it again from 2012 onwards.

Scientific publications

The number of scientific publications is a further indication of the scope of scientific research. There is also a certain control of the relevance since many publications in scientific periodicals and numerous conference papers undergo prior quality control (in the form of a *peer review*). Publication indicators from SCImago[50] are referred to below as based on the Scopus database and as also used by the OECD[51] for international comparisons on scientific output. This includes all publications of magazine articles, reviews and conference papers recorded in Scopus. Allocation to countries takes place via the authors' institution (main affilia-

50 See http://www.scimagojr.com
51 See OECD and SCImago (2016).

Fig. 1-31: Development of patent intensity (triadic patents) in Austria and in the reference group, 1995–2015



Source: OECD: MSTI, edition 2/2017. Calculations: ZEW.

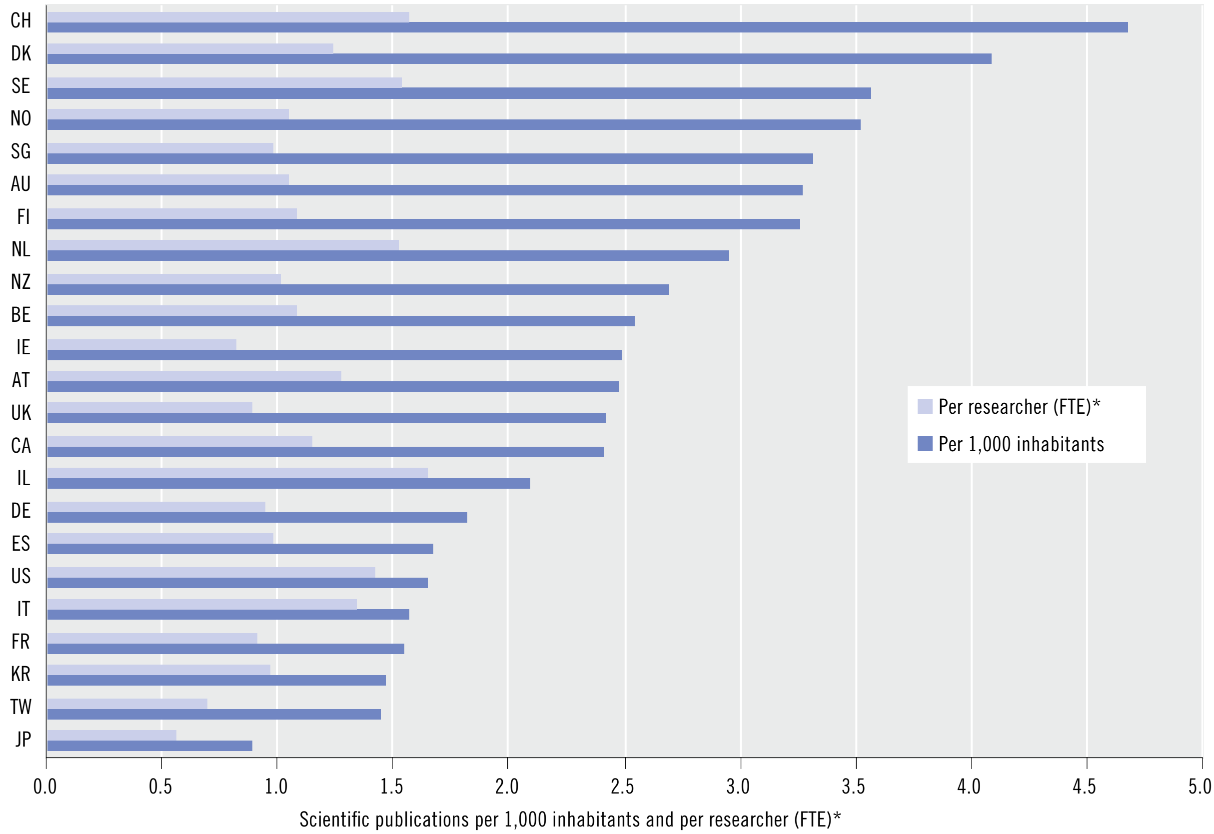
tion), with publications by authors from multiple countries counted multiple times (i.e. *full counting* is applied and not *fractional counting* in order not to devalue publications arising from international cooperation). The number of publications increases simply as a result of the increase over time in the number of technical periodicals recorded in Scopus.

In 2016 researchers operating in Austria published just under 22,000 scientific publications recorded in Scopus. This is around 2.48 per 1,000 inhabitants. As such, Austria is ranked in 12th place among the reference countries (see Fig. 1-32). This is an improvement on the period between 1996 and 2011 when Austria was ranked either 14th or 15th. At 4.68 the publication intensity in Switzerland in 2016 was almost double the amount in Austria. All four Scandinavian countries, Australia, Singapore, the Netherlands, New Zealand, Belgium and Ireland are also ahead of Austria. If the number of publications is scaled in terms of the number of researchers (calculated as full-time equivalents)[52] instead of in terms of the number of inhabitants then Austria comes closer to the group of leaders. It was ranked 7th in 2016 with a value of 1.30. Switzerland, Israel, the Netherlands, Sweden, the USA and Italy are ahead of Austria. However, Austria has not been able to improve its position in this indicator in longer-term comparisons; on the contrary, it was ranked either 4th or 5th in the years between 2001 and 2003.

The increase in Austria's publication inten-

52 All researchers at universities and government research institutes and a certain proportion of researchers in the business enterprise sector are taken into account, as authors from the business enterprise sector also publish items in scientific periodicals and at technical conferences. This proportion is determined as follows: the number of publications by authors from the business enterprise sector as a proportion of all publications is taken from an OECD analysis (OECD and SCImago 2016, 53) for each country (average for the years 2003 to 2012). This number has been between 0.2 and 6.4%. This number is divided by the number of researchers in the business enterprise sector as a proportion of all researchers in a country (average between 2003 and 2012), i.e. the proportion for the business enterprise sector that would be expected if business enterprise researchers would publish items at the same rate as researchers from universities and government research institutes. The number of business researchers taken into account in determining the publication intensity for each researcher is between 0.7% (Germany) and 14.1% (Switzerland). This is 6.0% for Austria, attributable in particular to the publication activity by researchers in the institutes' sub-sector.

Fig. 1-32: Publication intensity in Austria and the reference countries, 2016



Note: * Number of researchers at universities and government research institutes as well as proportion of researchers in the business enterprise sector in the previous year. Data for 2016 updated in part. For country codes see Table 8.1 in Annex I.

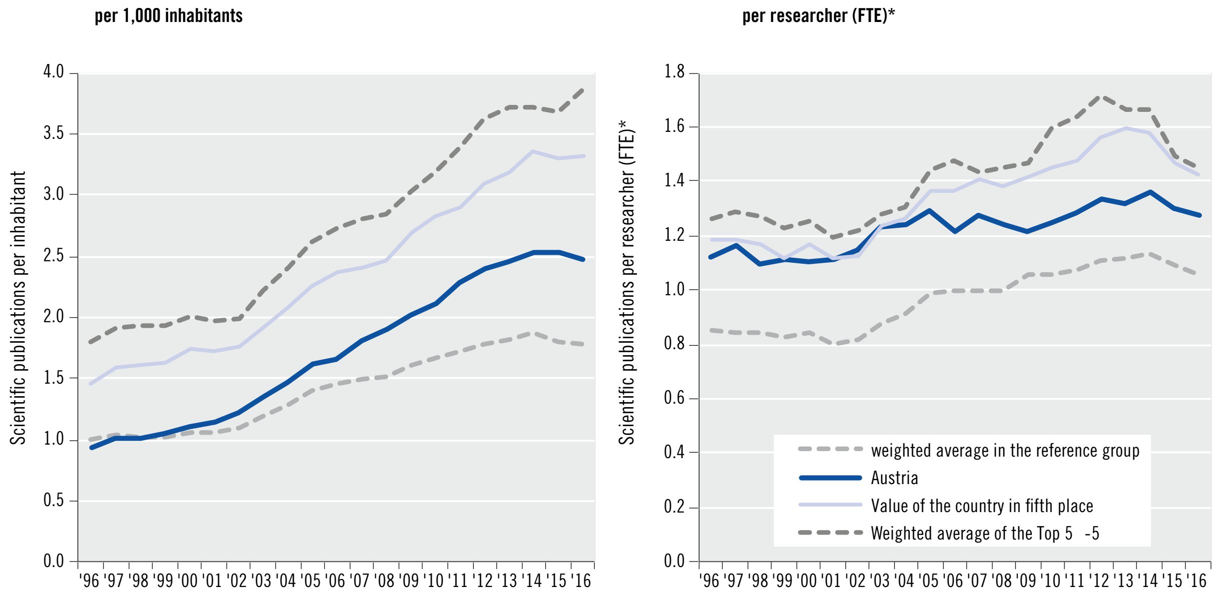
Source: SCImago Journal & Country Rank; OECD: MSTI, edition 2/2017. Calculations: ZEW.

sity per inhabitant has been disproportionately high over the last 20 years. Austria's publication intensity was still slightly below the average for the reference countries in 1996. It has increased each year since 2000 and was 40% above the average value in 2016 (see Fig. 1-33, left chart). The gap between the average for the five leading countries actually increased, however, as the group of leaders also expanded their publication activities intensely.

In terms of the number of scientific publications per researcher the increase in the value for Austria was considerably weaker and lower than the average for the reference countries (see Fig. 1-33, right chart). Compared with the relevant five best-ranked countries the gap increased noticeably between 2005 and 2013, but has started to reduce again in recent times. Austria was one of the five highest ranked countries between 2001 and 2003. The decline using this indicator can be interpreted as a sign that the strong expansion in research capacities in the Austrian scientific sector – the number of researchers (as FTEs) increased by more than 150% between 1995 and 2015 – was essentially responsible for the increase. Publication activities did not increase at the same time to the same extent as the average for the reference countries.

In addition to the number of scientific publications, their reception by the science community also plays a major role, as this reveals the

Fig. 1-33: Development of publication intensity in Austria and in the reference group, 1996–2016



Note: * Number of researchers at universities and government research institutes as well as proportion of researchers in the business enterprise sector in the previous year. Data for 2016 updated in part.

Source: SCImago Journal & Country Rank; OECD: MSTI, edition 2/2017. Calculations: ZEW.

extent to which the research results achieved are seized upon and pursued further by other researchers and academics. The number of times that a publication is cited in other scientific publications serves as an indicator of this. Austria's citation intensity[53] performed more favourably than the reference group average. Austria achieved the average number of citations in 2002, since then the gap has increased every year (see Fig. 1-34). At the same time Austria has been gradually getting close to the value for the fifth-ranked country, although the gap remains a large one. In 2012 Austria achieved 14th place among the reference countries in terms of citation rates. This corresponds with Austria's ranking in most of the years prior to this. Switzerland, Denmark, Sweden, Singapore and the Netherlands occupied the top spots.

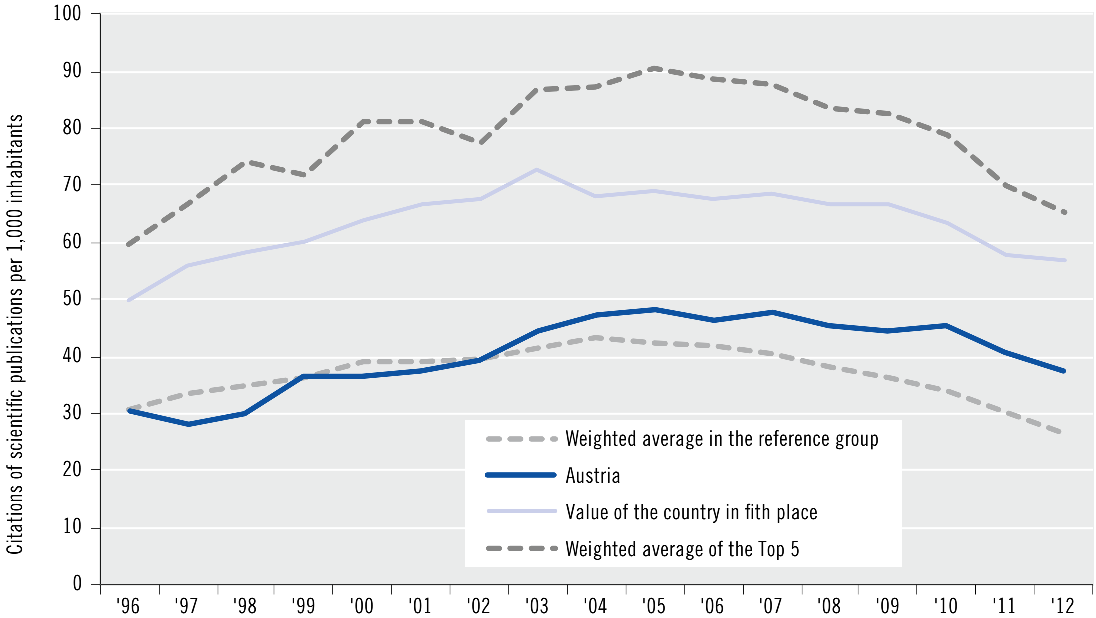
1.3.3 Austria's position in other international innovation rankings

Two innovation rankings that are highly respected internationally and are updated annually are the *Global Innovation Index* (GII) and the *Global Competitiveness Index* (GCI), which also partly includes innovation-related indicators.[54] The GII uses 82 individual indicators for more than 120 countries. The innova-

53 The citation intensity states the total number of citations that have been made on scientific publications in a country from a particular year relative to the population. Both citations from the same country as well as those from all other countries are taken into account with this. The number of citations received for a publication year generally increases over time since many publications are also cited years after they were published. The number of citations from current publication years is therefore not very significant. This is why here only citations up until publication year 2010 are examined.

54 Unlike the earlier Austrian Research and Technology Reports, this year's Report does not include an account of the "Innovation Indicator" which is published by the Federation of German Industries (BDI) and the German National Academy of Science and Engineering, as there has been no update to the "Innovation Indicator" published since last year's Austrian Research and Technology Report.

Fig. 1-34: Development of citation intensity in Austria and in the reference group, 1996–2012



Source: SCImago Journal & Country Rank; OECD: MSTI, edition 2/2017. Calculations: ZEW.

tion-related parts of the GCI include 30 individual indicators for more than 150 countries.

Austria is ranked between position 13 (GCI) and position 16 (GII) in the latest editions of both rankings, which essentially reflect the data from 2016 (see Table 1-9). Austria has been able to improve by one position in the GII compared with the previous year's editions of the rankings. Austria's position remained unchanged within the reference group in the innovation-related sub-indicators. Austria was able to improve in both rankings measured against the index value. Austria's value in the GII improved by 1% from 52.6 to 53,1. Austria also improved in the GCI's innovation-related sub-indicators by around 1% from 5.50 to 5.56 points.

Switzerland was in first place by a clear margin in both innovation rankings. Sweden, the Netherlands, USA and UK follow behind it in

Table 1-9: Austria's rank and index value in international innovation rankings for 2008–2017 within the reference group

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Global Innovation Index (GII)[1]	Ranking	18	14	18	16	17	20	17	15	17	16
	Index	3.64	4.46	4.21	50.8	53.1	51.9	53.4	54.1	52.6	53.1
	Gap to position 5	16%	7%	9%	11%	13%	14%	12%	10%	12%	13%
Global Competitiveness Index (GCI)[2]	Ranking	14	15	15	14	12	12	13	14	13	13
	Index	5.24	5.15	5.10	5.26	5.44	5.21	5.38	5.38	5.50	5.56
	Gap to position 5	7%	8%	6%	6%	4%	6%	4%	6%	4%	4%

1) Change in methodology between 2010 and 2011.
2) Sub-indicators "Human capital and training", "Technological readiness", "Business sophistication" and "Innovation".

Sources: Cornell University et al. (2017); WEF (2017). Processing and calculations: ZEW.

the GII, and the USA, Netherlands, Germany and Finland occupy the other spots in the Top 5 of the innovation-related sub-indicators in the GCI. Austria's gap with the five best ranked countries in the innovation-related sub-indicators in the Global Competitiveness Index remains 4% as in the previous year, and is significantly wider in the Global Innovation Index at 13% (after 12% in the previous year).

A comparison of Austria's rankings in both innovation rankings examined here in the period between 2008 and 2017 does not provide any clear indication of an improvement in position (see Table 1-9). The gap between the value for the country ranked in fifth place has not changed much at all over the last few years.

Global Innovation Index (GII)

The GII aims to measure innovation performance by countries comparatively in a comprehensive form. For this it does not just take account of indicators that cover investment in research, technology and innovation as well as the results of these activities, as it also includes lots of indicators on the situation surrounding industrial activity (e.g. tax burden, transport and energy infrastructure, trade barriers), which often only have an indirect and more tenuous link with research, technological and innovation performance capabilities. The total index value of the GII therefore approximates the GCI measure approach more than the European Innovation Scoreboar*d*, which also explains the to some extent clear differences in the rankings. It should also be remembered when interpreting the results of the GII that is includes indicators that depend on the size of the country, and therefore a small country such as Austria performs worse. It also includes a series of indicators for which an increase in the indicator value does not necessarily represent an improvement in innovation performance. This applies e.g. to foreign direct investment or the R&D expenditure of firms that is funded from abroad.

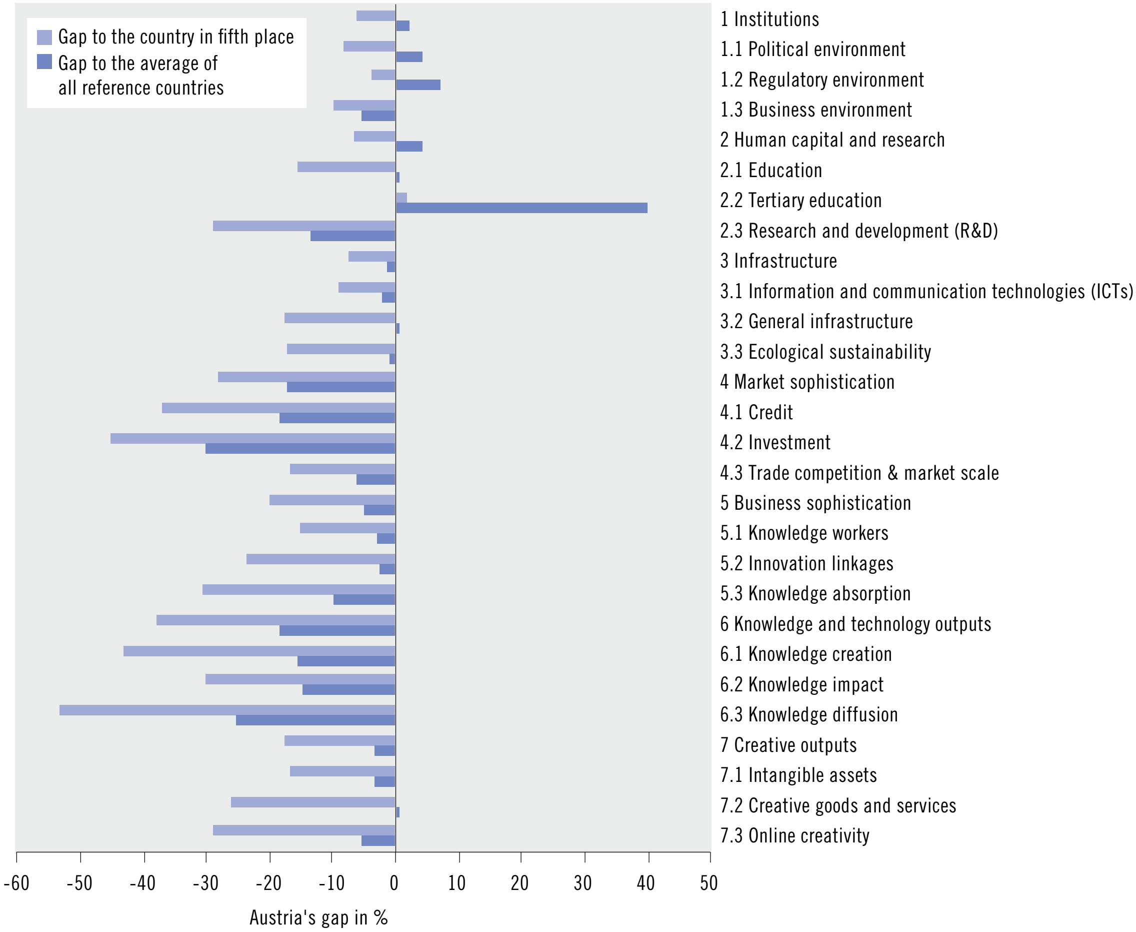
As shown in Fig. 1-35, Austria's relatively poor results in the GII as compared with the innovation-related indicators in the GCI and the European Innovation Scoreboard are attributable in particular to the areas of *Market Sophistication* (17% below the average for the reference countries) and *Knowledge and Technology Outputs* (18% below the average for the reference countries). In *Market Sophistication* this is primarily due to the unfavourable classification of the credit availability and the evaluation of the stock and venture capital markets summarised under "Investment". In *Knowledge and Technology Outputs* it is indicators on scientific publications (which are to some extent measured in accordance with the size of the country),[55] the start-up intensity and the licensing income from abroad as a proportion of total international trade that drag Austria's value down most.

Austria achieves the average value for the reference countries in *Human Capital and Research*. Austria's performance is above average in this area with regard to the indicators on tertiary education. The high proportion of university graduates in the natural sciences and engineering, the high proportion of foreign students and the high proportion of young people with a university degree are responsible for this.[56] The somewhat poor result in the R&D sub-area is primarily down to the indicator which is heavily dependent on the size of the country, i.e. the

55 The H-Index for instance, which states the maximum value of the number H of scientific publications that have been cited at least H-times. It is easier for large countries with lots of scientific publications to achieve a high H-value than it is for small countries with fewer publications.

56 Austria's good performance is also attributable to a statistical reclassification of VET colleges (e.g. higher technical colleges and commercial academies) as tertiary short courses, see also the Austrian Research and Technology Report 2017. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

Fig. 1-35: Austria's position in the Global Innovation Index 2017 as compared with the reference group



Source: Cornell University et al. (2017). Calculations: ZEW.

amount of R&D expenditure of the three firms with the highest R&D expenditure in the country. After New Zealand Austria achieves the second-lowest score here within the reference group. The USA and Germany are in the lead here. Austria also comes in last together with Italy in the university ranking indicator, which provides the average ranking for the three best ranked universities.

Two sub-areas of the GII in which Austria's value also roughly equates to the average for the reference group are *Institutions* and *Infrastructure*. However, both of these have little to do with a country's actual innovation performance. Austria is somewhat below the average of the reference countries with respect to *Business Sophistication* and *Creative Outputs*. In the former area the very good indicator values for business enterprise R&D expenditure and the proportion of business enterprise R&D expenditure funded from abroad is (more than) compensated by very low values for the employment ratio for highly qualified women and payments abroad for rights to intellectual property. In the *Creative Outputs* area a high number of trademark and design registrations, a high number of creative goods and services as a proportion of overall exports, and high revenues per capita in entertainment and the media are some of the factors that have a positive effect.

Austria improved in particular in the Infrastructure area (both with respect to ICT infrastructure and general infrastructure facilities) in the GII 2017 as compared with the previous year. There were also slight improvements in *Business Sophistication* and *Market Sophistication*. There was a fall in the index value in the *Knowledge and Technology Outputs* area, due to lower international licence revenues and lower direct foreign investment.

Global Competitiveness Index (GCI)

The GCI aims to measure competitiveness between countries on a comparative basis. As innovation is an essential factor in international competitiveness, the GCI also contains a series of indicators of innovation. Four of the twelve groups of indicators ("pillars") of the GCI cover innovation-related areas: *Higher Education and Training*, *Technological Sophistication*, *Business Sophistication* and *Innovation*. One particular feature of the GCI is that the majority of the indicators are not based on measured variables that have recorded statistically ("quantitative indicators"), but on expert assessments ("qualitative indicators") that have been obtained from a management survey. A total of 23 of the 30 indicators from this survey originate from the four innovation-related areas.

As shown in Fig. 1-36, Austria performs particularly well in the area of *Business Sophistication*, which is composed exclusively of qualitative indicators, and particularly poorly in-*Technological Sophistication*, which is based overwhelmingly on quantitative indicators. Three indicators on the IT infrastructure and IT use are responsible for the latter result (broadband connections, internet speed, mobile internet usage). Austria is in the top 5 of the reference group for three indicators related to business sophistication (expert assessments about the quality of local suppliers, competitive edges as a result of unique selling points, as well as the breadth of value creation chains) and is above average for the reference countries in a further three indicators. Managers obviously consider the capabilities of Austrian industry to be very high. Austria's performance is also above average in the area of student quotas and in the expert assessments of the availability of further specialised training, the extent of advanced occupational training and the innovation capacities in firms.

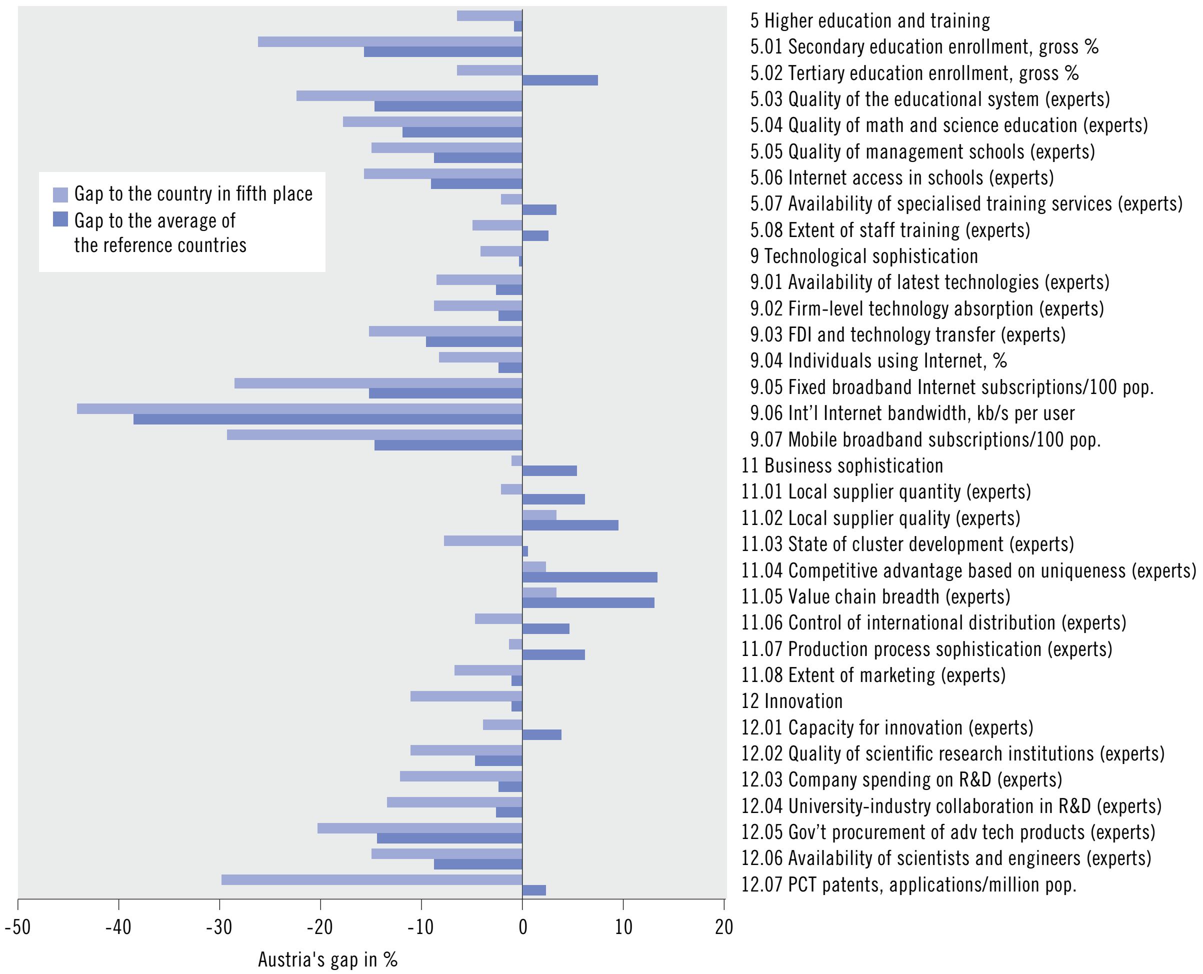
Austria also achieves a value that is above average for the reference group in the quantitative indicator of patent applications. However, the gap between Austria and the country ranked fifth in the reference group remains a very large one here. This is because the applications via the PCT procedure are used in the GCI and not the triadic patent applications, with the former used more frequently by large multinational corporate groups. There are only a few of these large multinationals domiciled in Austria and therefore Austria performs worse in this patent measurement.

Austria was able to improve significantly in two quantitative IT indicators in particular as compared with the previous year's GCI, i.e. broadband facilities and mobile internet usage. There were only a few changes in the area of expert assessments. The assessments on the quality of scientific research, the development of clusters and the competitive edges as a result of unique selling points did better, whereas they performed much worse in some cases in terms of the assessments of the quality of the school system, the quality of education in mathematics and the natural sciences, internet availability at schools, the availability of researchers, the quantity of local suppliers and the extent of advanced occupational training.

1.3.4 Summary

Austria has progressed further towards the group of Innovation Leaders measured in terms of the important RTI indicators. With a total R&D intensity of 3.09% in 2016, Austria achieved the second highest value in the EU 28 and the seventh highest value among all coun-

Fig. 1-36: Austria's position in the innovation-related sections of the Global Competitiveness Index 2017 as compared with the reference group



Note: Indicators with the suffix "(experts)" are based on expert assessments from the WEF survey of corporate managers.

Source: WEF (2017): Calculations: ZEW.

tries in the world. There have also been distinct improvements recently in the other key performance indicators, such as international patent applications. The gap between Austria and the leading most innovative research countries in Europe has reduced significantly. These developments are not, however, reflected in all international innovation rankings. Austria was able to improve by several rankings in the European Innovation Scoreboard in 2017. The gap with the leading countries was also reduced significantly. However, no corresponding improvement in Austria's position was observed in other international rankings, such as the GII and the innovation-related sections of the GCI. In terms of the GII this is primarily attributable to the fact that a larger number of indicators are used in the GII that have little to do with a country's innovation performance. The results of the GCI are based overwhelmingly on subjective management assessments which may differ from the indicators measured statistically.

1.4 EU research, technology and innovation policy: Review and outlook

Funding and promotion of research and technological development is one of the oldest community tasks within the EU. With the Framework Programme (FP) for Research and Technological Development, the EU has had an independent and direct funding tool since 1984 for providing financial support for cooperative R&D activities between firms and scientific establishments as well as research infrastructures (including the Joint Research Centres – JRCs) and subsequently also to individual researchers. Horizon 2020 is the current Framework Programme, following its predecessor the 7th Framework Programme (7th FP) in 2014.

Aside from funding research, the European Commission's activities are also focused on harmonisation and improvement of the research and innovation framework conditions in Europe. The EU has established various instruments and initiatives for this purpose over the last few years, aimed at combining regional and national research capacities and funding programmes within and outside of the FP, which represent the latest additions to the Commission's instrument portfolio in the area of R&I policy. Corresponding forms of public/public and public/private partnerships are illustrated in Section 1.4.4.

In addition to the FPs for research and innovation, European Structural and Investment Funds (ESIFs) are also important for R&D funding. Overall the European Commission will use around €123 billion in the 2014–2020 period to fund R&D in Horizon 2020, ESIFs, the European Atomic Energy Community EURATOM, the nuclear fusion reactor ITER and the Research Fund for Coal and Steel.

Horizon 2020 (not including EURATOM) will receive most of these funds with €74.8 billion or an annual budget of €10.69 billion. Around €44 billion will be distributed to the European Structural and Investment Funds (ESIFs), in particular the European Regional Development Fund (ERDF). Around €5 billion, which can also be seen as research funding in the narrower sense, will be spent on contributions to EURATOM (with a term of 2014–2018), contributions towards constructing the International Thermonuclear Experimental Reactor (ITER) and towards the Research Fund for Coal and Steel. There are also a series of programmes at the European level related to research, such as the two global space programmes Copernicus and Galileo and the Life and Health programmes.

These programmes provide the momentum for R&D among suppliers through procurement contracts. However, there is no exact number as yet in terms of the amount of research caused by this. There are also further important initiatives led by Europe with CERN and ESA.

In the "European Defence Action Plan (EDAP)" published on 30 November 2016, the European Commission put forward proposals for a European Defence Fund (EDF), thereby laying the foundation for establishment of defence research as a new "track" in the next EU budget. The intention with this is that the EDF will support the entire bandwidth from research to development through to eventual procurement. This is due to take place on the one hand with a research window via the European Defence Research Programme (EDRP), and on the other hand with a capability window via a European Defence Industrial Development Programme (EDIDP). The next EU budget as of 2021 (Multiannual Financial Framework, MFF 2021+) is due to include €500 million p.a. for the EDRP and approx. €1 billion p.a. for the EDIDP.

The Commission launched the Preparatory Action on Defence Research (PADR) on 7 June 2017 with a total budget of €90 million in preparation for the establishment of defence research via a separate EDRP in the next MFF as of 2021. The first proposal for the 2017 working programme (€25 million) has already run, and the second proposal (€40 million) is at the preparatory stage.

This EU defence research initiative also opens up entirely new development prospects for Austria as a location for research and technology, with lots of potential in an area that has not experienced much development up until now.

A strategy is being developed on this by summer 2018 led by the Austrian Federal Ministry of Defence (BMLV) as part of the government's overall initiative, with the strategy setting out how Austria will handle the EU initiative and exploit the potential arising from it. An analysis of the potential of the relevant EU programmes for Austria as a location for industry, research and technology was also commissioned in parallel. The strategy plan is aimed at achieving a common national understanding of the EU initiative and will serve as a basis for creating appropriate national framework conditions in Austria.

The strategic development process should ultimately lead to a joint decision by the Austrian Council of Ministers which sets out the national policy as a guideline for all stakeholders involved in the topic area.

The national defence research programme established in 2018 should also among other things play a part in helping to build up corresponding national research and innovation skills (see Chapter 1.5).

The developments related to Horizon 2020 are covered first of all in the next section. Key results of the interim evaluation of Horizon 2020 are then presented along with the status of the involvement of Austrian stakeholders in the current FP. Finally an overview is provided of the national involvement in transnational collaborative research (i.e. multilateral initiatives) and the significance of these to the national R&D landscape.

1.4.1 The Horizon 2020 Research Framework Programme

The launch of Horizon 2020 has meant that the funds available each programme year have been extended significantly once again since 2014 compared with the previous situation. For the current 2014–2020 period they are now €7.87 billion per year (at prices from 2000), which represents a €1.4 billion increase in real terms or rise of 2.9% per year at prices from 2000 as compared with the 7th FP (see Table 1-10). The increase in funds from Horizon 2020 is partly a result of the integration of various programmes, such as the Community Innovation Programme (CIP). Some parts of Horizon 2020 also received significantly better funding compared with the 7th FP.

The share of Horizon 2020 as a proportion of the total EU budget is 7.3% (see Table 1-10). This is a considerable increase on the 6th and 7th FPs. The ratio between the FP funds and

Table 1-10: Scope of the EU Framework Programmes for research and technological development as compared with R&D expenditure in the EU member states

Framework Programme	Duration	Budget for the Framework Programmes in € billion (current prices)	Yearly average in € billion (at prices from 2000)	Average annual real growth rates as a %	Proportion of total EU budget as a %	Proportion of FPs in national government R&D funding of the member states* as a %	Proportion of FPs in total R&D expenditure of the member states* as a %
FP 1	1984–1987	3.8	1.95	-	2.4	4.2	1.8
FP 2	1987–1990	5.4	2.46	8.1	3.2	5.1	2.1
FP 3	1990–1994	6.6	1.96	-7.3	4.0	4.0	1.6
FP 4	1994-1998	12.3	3.27	13.7	4.0	6.4	2.4
FP 5	1998–2002	15.0	3.71	3.2	4.2	6.7	2.3
FP 6	2002–2006	17.5	3.55	-1.1	4.2	4.5	1.8
FP 7	2007–2013	55.8	6.44	8.9	5.5	8.8	3.2
H2020	2014–2020	74.8	7.87	2.9	7.3	11.2[a)]	3.7[a)]

Note: * In the relevant year of the programme lifecycle. a) 2/7 of the total sum of Horizon 2020 as % of R&D expenditure for 2014 and 2015.

Source: Rammer et al. (2011) for 1st – 7th FP, EU office of the Federal Ministry of Education and Women's Affairs for Horizon 2020; OECD Main Science and Technology Indicators. Calculations: AIT.

government R&D funding by the EU member states (i.e. R&D funding by national and regional governments or GOVERD) in Horizon 2020 is around 1:11, i.e. for 11 euros of national R&D funding 1 euro comes from FP funds. From the 4th to the 6th FP this ratio was around 1:15. The FP has therefore gained in significance as a funding instrument for R&D in Europe, even though national government funding still makes up the lion's share, in particular based on basic funding for higher education.

The share of the FP as a proportion of total R&D expenditure (firms, universities, research organisations, other establishments) in the EU member states was 3.2% in the 7th FP. This proportion should rise further in Horizon 2020, although the arithmetical share of the budget for Horizon 2020 as a proportion of total R&D expenditure of EU member states was 3.7% for 2014 and 2015. As with the 7th FP therefore an increase has been recorded, although this is lower than it was in the predecessor programme.

Aside from an increase in funds, new structures were also introduced in Horizon 2020 which are aimed at better reflecting the challenges for European research: The three topic-based pillars of excellent science, industrial leadership and societal challenges are the three central pillars of Horizon 2020 and contain various sub-programmes. They underline the greater focus on partnerships between science and industry and the focus on innovation, along with a greater focus on the development of solutions aimed at overcoming major societal challenges.

Various cross-cutting issues are also promoted in Horizon 2020 in addition to the three topic-based pillars. Measures aimed at *spreading excellence and expanding participation* are aimed at boosting the European Research Area and improving consistency between different regions in the EU. *Science with and for society* continues the activities of the "Science in society" programme of the 7th EU Framework Programme and serves among other things to increase acceptance of science.

Some of the topic-based pillars receive significantly higher funding in Horizon 2020 as compared with the 7th FP (see Table 1-11). The

Table 1-11: Comparison of the contributions between the 7th FP and Horizon 2020, in € millions, current prices

Programme areas	Horizon 2020	FP 7
I. Excellent science	**24,232**	**13,975**
1. European Research Council (ERC)	13,095	7,510
2. Future and Emerging Technologies (FET)	2,585	798
3. Marie Skłodowska-Curie (MSCA)	6,162	4,750
4. Research infrastructures	2,390	1,715
II. Industrial leadership	**16,467**	**15,291**
1. Leadership in enabling and industrial technologies (LEIT)	13,035	13,955
2. Risk financing	2,842	
3. Innovation in SMEs	589	1,336
III. Societal challenges	**28,630**	**18,458**
1. Health, demographic trends and well-being	7,257	6,100
2. Food, bioeconomy	3,708	1,935
3. Energy	5,688	2,350
4. Transport	6,149	4,160
5. Climate change, raw materials	2,957	1,890
6. Integrative, innovative and reflexive society	1,259	623
7. Secure societies	1,613	1,400
Spreading excellence and expanding participation	817	716
Science with and for society	445	330
JRC non-nuclear activities	1,856	1,751

Source: European Commission, EU office of the Federal Ministry of Education and Women's Affairs. Allocation and calculations: AIT.

funds for the *European Research Council (ERC)* have virtually double for instance at €13 billion, while the funds for the *Marie Skłodowska-Curie Initiative* (previously the Marie-Curie Initiative) have risen by around a half. Some topic-based programmes within the three pillars also receive significantly better funding. Energy in the third pillar almost doubled its budget from €2.3 billion in the 7th FP to €5.7 billion in Horizon 2020. At €6.1 billion the topic of transport received €2 billion more in funding than it had in the 7th FP.

Overall the new architecture with the three main pillars of excellent science, industrial leadership and societal challenges and inclusion of the programmes mentioned above represents a crucial structural change in the FP. It means a significant increase in funds for leading-edge research by individual scientists (ERC) and projects for promoting individual mobility in the Marie Skłodowska-Curie Initiative (MSCA) as compared with the 7th FP. At the same time, however, there was also increased focus on the impact sought from research and innovation activities on the creation of jobs and growth, as well as contributions towards solving societal challenges.

The European Commission is following a trend here towards a greater focus on innovations originating from R&D funding which can also be observed at the national level. The International Science, Technology and Innovation Policy (STIP) Survey of the EU and OECD for instance shows that the policy area of "Innovation in Firms and Entrepreneurship" in the funding policies of the OECD countries is the area that is most frequently awarded a high level of increasing significance.[57] Additional changes in Horizon 2020 relate to funding quotas and administrative processes as well as conceptual changes to the funding instruments.

The adjustments to the administrative processes in Horizon 2020 focus on increasing transparency into consistent regulations and processes and thereby guaranteeing improved and faster access to the Framework Programme. The funding quotas were increased from 75% to 100% for research activities and to 70% for innovation activities (100% for non-profit organisations). The different methods for calculating the overheads in the 7th FP were harmonised and set at 25% of the direct costs. The funding decision-making processes were shortened considerably: The Time to Grant (TTG) was reduced from 303 days in the 7th FP to 163 days in Horizon 2020.

The Innovation Actions (IA), the special SME instrument (SME-1) and the pilot initiative "Fast Track to Innovation" means that new funding instruments have also been developed which are predominantly aimed at promoting innovations or which focus on specific target groups for the first time. In addition to this, Horizon 2020 has also for the first time reserved funds for funding instruments/venture capital financing and accompanying measures (€2.84 billion), with at least one-third of this earmarked for SMEs and firms with fewer than 500 employees.

1.4.2 Results of the interim evaluation of Horizon 2020

The interim evaluation of Horizon 2020[58] shows that funds for the project participants are highly additional and create value added for the member states and participating organisations which goes beyond the funding from national and regional programmes. Furthermore the interim evaluation of Horizon 2020 clearly points to the link between the participation of firms in research partnerships and their market success. This is also expressed among other things in the contribution of Horizon 2020 to new patents that can be exploited commercially and other IPR.

57 See OECD (2016, 166).
58 See European Commission (2017a).

In the area of "Industrial Leadership" in particular, where involvement by the private sector is high, 92% of the projects would not have been capable of even being implemented in the first place or this could only have happened following major changes. For 66% of the participants in Horizon 2020, international knowledge transfer would have been weakened without Horizon 2020, and 72% would have had to accept a negative impact on partnerships with industry and new corporate partners within the EU.

Compared with the 7th FP for R&D, Horizon 2020 attaches higher importance to the focus on innovation and impact in the programme design as a result of 1) a focus on major (societal) challenges, 2) funding options from the laboratory to market and 3) an integrated focus on the impact in project applications, reporting and monitoring.

The significance of the FP as a source of funding for R&D in Europe is increasing, even though national funding is still considerably higher. Boosting the transfer of knowledge and findings in the aim of increasing innovation capabilities is particularly evident in the Horizon 2020 instrument portfolio. This is also reflected in the increased integration of SMEs in Pillars II and III of Horizon 2020. The SME-specific instrument is one of the factors that plays an important role in targeted support for market-creating innovation. Last but not least the boost to the transfer of knowledge and findings is also evident from a higher proportion of firms in the total number of applications and project partners. Text mining analyses carried out as part of the interim evaluation of Horizon 2020 show a major contribution towards supporting the innovative capabilities of firms both in Pillars II and III as well as in the areas of future and emerging technologies.

Austria's performance in Horizon 2020 is considered below in light of the changes in circumstances.

1.4.3 Austria's performance in Horizon 2020

Austrian stakeholders have also been eligible to participate in the European Research Framework Programmes (FPs) since Austria joined the EU in 1995. Since the 4th FP at that time (programme period 1994–1998) to the current 8th FP Horizon 2020, Austrian researchers and participating organisations have received a total of just under €2.97 billion according to the data available as at 2018[59]. The following section provides a brief overview of the performance in Horizon 2020 based on the periodic cockpit reports from the European Performance Monitoring (EU PM) at the Austrian Research Promotion Agency (FFG).

A total of €30.59 billion in funds have already been distributed just under two years before Horizon 2020 comes to an end. This equates to 40% of the total budget of €77.2 billion. The proportion of projects with Austrian participation is 2.8% and includes 2.8% of the total funds. Compared with the EU-28, Austria is in ninth place in terms of share of funds, with Germany (16.9%), the UK (14.0%) and France (10.5%) in the top three positions.

44.8% of national participation or 42.1% of the total funds distributed are attributable to Pillar III "Societal Challenges". The largest share by far of the Austrian participation in this challenge relates to the areas of energy and transport. Austria also features a success ratio that is well above average in both areas as compared with the EU-28 of 18.8% (EU-28 16.1%) and 39.2% (EU-28 29.8%) respectively.

25.4% of national participation is attributable to the Pillar I "Excellent Science", and in particular the Marie Skłodowska-Curie Actions (MSCA) and the European Research Council (ERC) with 356 and 87 participations respectively out of a total of 555 successful participations. Austrian stakeholders – i.e. primarily universities given the primary focus of Pillar I

59 Data as at 6 March 2018; published by Austrian Research Promotion Agency EU-PM in the Cockpit Report dated 11 April 2018.

on basic research – feature above-average rates of success here too with 13.3% (EU-28 12.1%) and 17.1% (12.3%) respectively.

In Pillar II "Industrial Leadership" (25.7% of national participations) the ICT programme remains the largest national focus for participation by far with funding of €128.6 million achieved alone as of today. At 18.1% the success ratio is also above the EU-28 average of 13.6%. Firms are responsible for most of the participations here also, as is the case overall in Pillar II. For instance 56% of the 563 institutions participating overall in Pillar II are firms, with 18.7% non-university research institutes and 18.3% universities. The above-average participation by Austrian universities in successful projects in the BIOTECH area must be highlighted here, where it features six of the total of 14 successful national project partners, and is therefore ahead of the corporate partners with a total of five.

1.4.4 Measures aimed at boosting European cooperation

As outlined in detail in the Austrian Research and Technology Report 2017,[60] transnational collaborative research in the form of bilateral and multilateral partnership initiatives between EU member states, funding institutions, business associations and individual stakeholders such as universities and research institutes (multilateral initiatives MULLATs), have become increasingly significant, particularly since the start of the programme period for Horizon 2020 – in addition to the competitive proposals for R&D and innovation projects within the FP.

A distinction can be made between two different types of programmes: 1) *public-public partnerships*, (P2Ps) and 2) *public-private partnerships* (PPPs).[61]

P2Ps and PPPs pursue the objective of boosting coordination efforts for national R&I policies with respect to the development of the European Research Area (ERA). The instruments are intended to assist in the establishment of European networks which are required in order to work on important topic areas at the European level. While P2Ps focus on Europe-wide coordination of national programmes, PPPs are platforms/initiatives driven by European industry that are operated with the involvement of national and European funds.

Other forms of international linkages with Austrian participation include for instance the European/international network for application-related R&D EUREKA and the European technology platforms (ETPs). The European Institute of Innovation and Technology (EIT) also became part of Horizon 2020. The task of the EIT founded in 2008 is to promote industrial growth and competitiveness in Europe by reinforcing the innovation capabilities of the EU and its member states by establishing 'Knowledge and Innovation Communities' (KICs). These include partner organisations that operate in the knowledge triangle of university education, research and innovation.

Around 25% of the budget for Horizon 2020 is allocated to the different transnational RTI partnership instruments. An estimated 9% of this is attributable to Horizon 2020 projects in the annual work programmes initiated by the partnerships (*contractual public-private partnerships*; cPPPs), as well as co-funding by the European Commission for P2Ps.[62] To the extent that government funds are spent on participating in these types of initiatives, these are recorded within the scope of the federal budget estimate for research and research promotion. In 2015 for instance, i.e. the last date for which data is available, the public sector in Austria

60 See Austrian Research and Technology Report 2017, Chapter 5.3 Federal Ministry of Science, Research and Economy (BMWFW), Federal Ministry for Transport, Innovation and Technology (BMVIT) (2017).

61 See Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017) as well as Table 8.2 in Annex I for an outline of the individual instruments.

62 See Boekholt et al. (2017).

Table 1-12: Austrian participation in active public-public initiatives

	Total active	Active AT	Share for AT [as a %]	Coordination AT
Total	**95**	**63**	**66.3**	**6**
ERA Net activities (ERA Net, ERA Net Plus, ERA Net Cofund)	62	38	61.3	4
Art. 169/185	6	4	66.7	0
European Joint Programme Cofund (EJP Cofund)	4	4	100	0
Joint Programming Initiatives (JPI)	10	8	80.0	1
Other	13	9	69.2	1

Source: ERA LEARN 2020; as at 25 January 2018.

spent around €76.5 million on these types of instruments.[63] This equates to just under 2% of public R&D funding for 2015 (€3.48 billion). Funds from private stakeholders (in particular for P2P) as well as contributions from institutional university and research institute budgets are not included in these statistics. Table 1-12 shows the national participation in current active P2P initiatives.

In the area of public partnerships (P2P), activities are significant in particular within the scope of the ERA Net scheme[64] (38 of 62 active), which enables joint proposals by EU member states based on coordination for national R&D programmes. These are also an important tool in implementing the objectives for Joint Programming Initiatives (JPIs).[65] Similar to the ERA Net, the instrument of the European Joint Programme Cofund (EJP Cofund)[66] is aimed at coordinating national programmes, but is intended for durations in the medium term (five years). Austria is involved in all active EJPs. Austria is currently involved in four out of six Article 185 initiatives.[67]

Austrian stakeholders have also been and still are involved in a series of contractual public-private partnerships[68] that are developing Calls within Horizon 2020.[69] With EIT Raw Materials, Austria is also involved in a Knowledge and Innovation Community (KIC) at the European Institute of Technology.[70]

In the area of public-private partnerships for instance, Austrian stakeholders are currently taking part in six out of seven joint technology initiatives (JTIs in accordance with Article 187 TFEU).[71] The particular relevance of these partnership instruments to Austria is illustrated with the example of ICT through participation in the ESCEL Joint Technology Initiative[72]. Via the JTI the EU is attempting to support transnational research and innovation cooperation through joint long-term public-private partnerships and to contribute towards increased competitiveness in European industry. Implementation of a common strategic research agenda is being advanced in a partnership with industry in a bottom-up process driven by industry.

It is being funded through contributions from industry, the European Commission and the member states. The EU's maximum contribution towards funding in Horizon 2020 is estimated to be around €1.19 billion. The contribution originates from FP funds. The ECSEL member states are making a financial contribution of at least €1.17 billion to the operating costs of the joint venture, funded in Austria via

63 See Eurostat (2017): National funding towards transnationally coordinated R&D [gba_tncoor].
64 See https://www.ffg.at/programme/era-net
65 See https://www.ffg.at/programme/joint-programming-initiativen
66 See https://www.era-learn.eu/public-to-public-partnerships/european-joint-programme-cofund-ejp-cofund
67 In accordance with the Treaty on the Functioning of the European Union (TFEU).
68 See https://www.ffg.at/programme/private-public-partnerships
69 See Austrian Research Promotion Agency (FFG) (2017).
70 See https://www.ffg.at/programme/eit-kic
71 See https://www.ffg.at/en/joint-technology-initiatives
72 Electronic Components and Systems for European Leadership.

the "ICT of the future" programme by the Federal Ministry for Transport, Innovation and Technology (BMVIT). Members from the private sector are contributing at least €1.66 billion.

Austria occupies a central position in ECSEL in the network of EU member states and in particular is enabling European research and innovation cooperation with firms and research institutes from Germany, France, the Netherlands and Spain.

1.4.5 The route towards the new Framework Programme

The term of the current FP for Research and Programme, Horizon 2020, ends in 2020. The preparatory processes for the 9th FP started in 2015 with a focus primarily on the following components:

- The interim evaluation of Horizon 2020[73] which was completed in summer 2017
- Implementation of a foresight process which was started in spring 2016 and completed at the end of 2017[74]
- Appointment of a high-level group of experts (the "Lamy Group") which put forward key guidelines in summer 2017 for the next FP[75]
- Model calculations on different structural and budgetary variants for the 9th FP, although the results of these are not yet available[76]

Numerous member states and stakeholder organisations have also set out their expectations for the FP in position papers in parallel with this.[77] With due regard to the formal Proposal of the European Commission on the mid-term financial framework expected for May 2018, submission of a first official draft for the 9th FP is expected from the Commission for June 2018, based on an impact assessment similar to the case for Horizon 2020. An online consultation on the concept of mission-oriented research and innovation was carried out in March 2018 as a further input towards development of the Proposal for the 9th FP, making reference to a background paper by Mariana Mazzucato (2018) and aimed at providing further ideas for the drafting of the Commission's Proposal.[78] The results of the online consultation and the impact assessment will then form the background for the subsequent policy negotiation and decision-making processes between the Commission, Council and Parliament.

Foresight for preparation of the 9th FP

While the interim evaluation and appointment of a high-level group of experts are common components in the process of preparing for FPs, a dedicated foresight process was also launched by the European Commission for the first time in 2016 as part of the preparations for the 9th FP, which is supposed to supplement the other components by providing a systematic outlook into potential future topics.

The BOHEMIA (Beyond the Horizon: Foresight in Support of EU's Future Research and Innovation Policy) project commissioned by the European Commission aims on the one hand to summarise potential global and socio-economic environmental developments until 2040 in the form of scenarios. Future requirements related to research and innovation which

73 See European Commission (2017a).
74 See Weber et al. (2018).
75 See European Commission (2017b).
76 These model calculations are used to review the impact of various budgetary variants at the macro level for the 9th FP using the NEMESIS simulation model. See Di Comite and Kancs (2015) for a comparison of the essential macroeconomic models used by the European Commission.
77 There is no official position paper on the 9th FP from the Austrian side, but there are two expert papers discussed at the European level through the Framework Programme (FP) 9 Think Tank appointed by the Federal Ministry of Science, Research and Economy (BMWFW) at that time, see Austrian FP 9 Think Tank (2016); Austrian FP 9 Think Tank (2017).
78 Further current contributions to the ongoing discussion on the 9th FP can be accessed on the Commission's corresponding website, including on the mid-term financial framework.

could shape future agendas in terms of societal challenges should be recorded as a result of this. On the other hand, future developments in the areas of science and technology with a high transformative potential should be identified and evaluated as part of a Delphi process[79]. Finally any potential topic areas for a future FP should be developed from the interplay between these two components, with current considerations related to a stronger focus for the FP on "missions" also taken into account.

The BOHEMIA project has provided stimulus for the ongoing debates with respect to two important aspects in particular. Analysis of the global and socioeconomic environmental scenarios that have been developed has revealed that the two essential ambitions pursued by the European Commission with the FPs, i.e. boosting Europe's global industrial and political position through research and innovation as well as making an important contribution towards implementation of the UN's 17 sustainable development goals, will only be achieved with four fundamental transitions. These transitions relate to the four areas of social needs, biosphere, innovation and governance.[80]

Enshrined within these four transitions and picking up on the results of the Delphi process, there are also 19 future areas ("targeted scenarios") put forward that are validated with experts and stakeholders as part of an online consultation and refined further through priority research topics ("Top priority R&I directions").

The targeted scenarios are formulated in such a way that in addition to addressing their content, they also address their relevance to Europe's global positioning and the UN's 17 sustainable development goals, the requirements related to adjacent policy areas with respect to the framework conditions to be created and the priority research topics identified within the targeted scenarios. The synopsis of the priority research topics shows that aside from basic research aimed at improving understanding of the problem and solution-oriented research and innovation, research aimed at supporting regulatory policy and social and/or organisational innovations for upscaling new solutions are also seen as further priorities.

The targeted scenarios and priority research topics developed in BOHEMIA are used as input for the further debates regarding the content-related and instrumental orientation of the next FP. Lots of suggestions from BOHEMIA have, however, already made their way into the Commission's own internal debates on potential topics for the 9th FP as a result of the intensive engagement with the European Commission's Foresight Correspondents Network (FCN) which supported the overall project. To this extent the BOHEMIA Foresight process has had an impact on the ongoing preparations for the 9th FP both through the inclusion of experts as well as through internal collaboration with the Foresight Correspondents Network.

1.4.6 Summary

This Chapter outlines the key trends in European research and innovation policy over the last ten years. With respect to this matter the expenditure for R&D at the European level has risen faster than at the level of the member states; the share of the FP as a proportion of national R&D funding has been on the increase since 2007. This trend has been observed since the first FP in the mid-1980s.

The programme areas "Excellent science" (ERC) and "Societal challenges" have expanded heavily in Horizon 2020 as compared with its

79 A Delphi process is a special survey technique in which statements on future developments are subject to evaluation by experts. Delphi processes were traditionally implemented in several rounds in order to achieve convergence between the evaluations; nowadays online real-time techniques are standard. The arguments underlying the evaluations were also surveyed in BOHEMIA.

80 These transitions were described as follows in the original text: "Social needs: Providing for the needs of people"; "The biosphere: Safeguarding a hospitable planet"; "Innovation: Harnessing the forces of change"; "Governance: Joining forces for a better world"; see Weber et. al. (2018).

predecessor the 7th FP, whereas the amounts awarded to "Industrial leadership" have hardly changed.

A series of new instruments were introduced at the instrument level with the aim of coordinating national R&D initiatives such as JTIs, ETP, cPPPs, and that now account for a considerable proportion of around 25% of total available funds, and which also have an increasing influence on the programming for the FP's overall activities. Austrian stakeholders are very active in the area of these instruments. These create important value add by combining national resources in the areas of R&D and innovation funding, and through linking related activities in the public and private sectors and forming critical and internationally competitive masses in selected priority areas. These linkages also provide the possibility of actively playing a part in anchoring and designing R&D and innovation policy priority areas at the European level.

The preparatory processes for FP 9 began in 2015. Submission of a first official draft for the 9th FP is expected from the Commission in early summer 2018, based on an impact assessment similar to the case for Horizon 2020. A foresight process commissioned by the European Commission as part of the programme planning for the 9th FP has revealed that the two essential ambitions pursued by the European Commission with the FPs, i.e. boosting Europe's global industrial and political position through research and innovation as well as implementation of the UN's 17 sustainable development goals, will only be achieved with four fundamental transitions. These transitions relate to the four areas of social needs, biosphere, innovation and governance. Aside from basic research aimed at improving understanding of the problem and solution-oriented R&I, research aimed at supporting regulatory policy and social and/or organisational innovations for upscaling new solutions are also seen as further priorities in the new FP.

1.5 Strategic measures, initiatives and further developments

The RTI strategy adopted in 2011[81] forms the framework for the targets and longer-term perspectives for Austria as a research location. The RTI task force set up to define and coordinate implementation of the strategy and made up of representatives of the relevant ministerial departments (Federal Ministry of Finance (BMF), Federal Ministry of Education, Science and Research (BMBWF), Federal Ministry for Transport, Innovation and Technology (BMVIT), Federal Ministry for Digital and Economic Affairs (BMDW), and chaired by the Federal Chancellery, BKA) also continued its activities over the past year. This boosted the cooperation and reciprocal exchanges and discussions on RTI-related activities. Further details are provided below of those work priority areas that have shaped the past year.

The key topics of the working group (WG) on the RTI priority area of **Climate change/Scarce resources** over recent years were the bioeconomy and RTI activities in Austria as well as the bioeconomy RTI strategy. There has also been increased discussion and exchange on activities, projects, strategies and research-policy aspects related to climate and energy since September 2016.

The WG on the RTI priority area of **Quality of life and demographic change** highlights different research aspects in these topic areas and initiates cross-departmental activities on topic-based priority areas. Up until now this involved joint participation in the "More Years Better Life" (MYBL) Call "Ageing in Place" (2017), the dementia and mobility networking workshop, including Active and Assisted Living AAL (2017), the proposal priority area of health and dementia in "Mobilität der Zukunft" (Mobility for the Future) (2016), a roundtable on migration (2016) as well as the creation of a mobility roadmap in the context of quality of life and demographic change (2015).

81 See BKA et al. (2011).

The **Research infrastructure** WG involved a presentation and discussion of the results of the research infrastructure proposals from higher education structural funds and the National Foundation for Research, Technology and Development from 2016. The status of Austrian participation in Horizon 2020 was also presented, with input provided for modification of the conditions for future proposals.

The **Knowledge transfer and new enterprises** WG is concerned with coordination and implementation of start-ups and knowledge transfer promotion programmes, such as "Seed financing", "JumpStart", "Knowledge transfer centres and IPR exploitation", "AplusB Scale-up" and the "Phoenix" start-up prize and new "Spin-off Fellowship Programme". It is also involved in implementation of measures from the Open Innovation and/or IP strategies, such as the implementation of the new IP coaching programme for firms and the IP Hub. Data on the start-up and entrepreneur landscape was also surveyed via the Global Entrepreneurship Monitor (GEM). The first comprehensive Austrian Start-up Monitor was developed in 2017. Results are expected for summer 2018.

Topics in the working group on **Internationalisation and RTI foreign policy** most recently included efforts to continue expansion of the OSTA (Office of Science and Technology Austria) services in Austria as well negotiation and formation of bilateral agreements and Joint Calls with important RTI nations (using science diplomacy, including in Argentina, Brazil, China, Israel and Korea). Initiatives to promote internationalisation for Austrian firms and start-ups also include the "Beyond Europe Programme" and "Global Incubator Network", the coordinated use of international EU and/or European instruments as well as international awareness methods (e.g. USA Austrian Research and Innovation Talk 2017 in Austin, Austrian-Canadian Science and Innovation Days 2017 in Vienna).

A further WG has been working intensively on the topic area of **Alignment** since the autumn of 2017. The policy paper on the development of an Austrian position on alignment[82] has formed the basis for this. Strategies and actions for further development of alignment are now being identified, in particular institutional alignment. Stakeholders from the science, research, technology and innovation industries should also be included in this process.

A WG was set up to accompany the current ongoing **OECD Innovation Policy Review**. The Review is supposed to develop principles for a future federal government RTI strategy (from 2020 onwards). The terms of reference for the review were decided by the RTI task force in 2017 following a proposal by the WG. A comprehensive Background Report was also provided to the OECD over the last year with detailed descriptions of the functioning methods for key areas of the RTI system in Austria. The OECD delegation's fact-finding mission in Austria took place in autumn 2017. The preliminary results of the OECD Review are due to be discussed at a stakeholder workshop in June 2018. The final report will be presented at a Europe conference on 14 December 2018.

The representatives from the ministerial departments responsible report directly to the task force on the topic of human potential in the area of the RTI guideline 2 "Developing talent, awakening passion". The focus is on initiatives and measures such as "Jugend Innovativ" (youth innovation competition), Sparkling Science and vocational education and training (VET) 4.0, which promote the benefit of research and interest for STEM and Industry 4.0 content in a targeted manner in education.

Numerous initiatives have been designed and developed both at the federal government and ministerial department levels with the aim of achieving the targets of the RTI strategy. The following section provides an overview of the latest trends in strategic processes, RTI-related

82 See Polt et al. (2016).

activities and the implementation of new projects and programmes.

Austrian University Development Plan

The Austrian University Development Plan[83] is a strategic planning instrument for the development of higher education and an instrument for transparent illustration of the objectives of the relevant federal minister responsible for science and research for a total of two performance agreement periods. As such the Austrian University Development Plan is integrated into the Austrian University Plan and the control system[84].

The statutory basis for an overall Austrian University Development Plan was provided with the first implementation step aimed at the introduction of a new university funding system (Federal Law Gazette I No. 52/2013). However, the relevant Section 14d (in the version of the federal act in Federal Law Gazette 52/2013) ceased to be effective after 31 March 2014. Nevertheless, an overall Austrian development plan was developed in close coordination with the Austrian Science Board and following detailed discussions with representatives from Universities Austria. An initial version of the Austrian University Development Plan related to the 2016–2021 planning period was created in 2015 following a consultation process with 42 university institutions. The Austrian University Development Plan was revised in 2017 on a rolling basis for the 2019–2024 planning period in preparation for the negotiations for the performance agreement in 2018 and formation of the 2019–2021 performance agreements.

The objectives and developments sought in the Austrian University Development Plan are presented in eight system targets: further development and reinforcement of the higher education system, reinforcement of basic research, improvement in the quality of university teaching, improvement in relevant key teaching performance indicators, promotion of young scientific talent, expansion in knowledge and innovation transfer and in locational benefits, increased internationalisation and mobility, social responsibility of universities (gender equality, diversity and social inclusion, responsible science, sustainability and digital transformation)[85]. These system targets also form the strategic framework for the action areas and tasks to be prioritised by the universities. The Austrian University Development Plan also includes planning variables (or variables sought) for teaching that cover the whole of Austria, such as student numbers, graduating students, support and supervision relationships, as well as a parameter for the new university funding model through the indicator of "courses where students are actively taking exams". In the context of the new university funding mechanism and in particular the focus on capacities associated with this for the teaching area, the amendment to the Universities Act 2002 (Federal Law Gazette I No. 8/2018) now includes a statutory basis for an Austrian University Development Plan covering the whole of Austria by virtue of Section 12b of the Universities Act.

Revisions to university funding

Through the federal act of 1 August 2017 (Federal Law Gazette I No. 129/2017) the National Council set the total amount of university funding at €11.07 billion for the 2019–2021 performance agreement period, and tasked the federal government with developing an implementation model for capacity-oriented student-related university funding by 31 January 2018. The draft bill put forward was based on a funding model developed in coordination with the Federal Ministry of Finance (BMF) and Universities Austria (uniko), which was itself based

83 See https://bmbwf.gv.at/fileadmin/user_upload/wissenschaft/publikationen/2015_goe_UEP-Lang.pdf
84 See BMBWF (2018, 78).
85 See BMBWF (2018, 79).

around the federal act that had expired from Federal Law Gazette I No. 52/2013. The corresponding revision to the Universities Act 2002 was put forward by the National Council on 28 February 2018 and became law on 4 April 2018 (Federal Law Gazette I No. 8/2018). In parallel with the capacity-oriented university funding, the federal access regulations for very popular degree programmes are being expanded to include the fields of education of "law", "foreign languages" and "educational sciences", with university-related access regulations also enabled if the support and supervision reference values for the relevant degree course exceed a certain percentage. This is aimed at ensuring better controls over teaching capacities.

The new university funding model will be implemented in the 2019–2021 performance agreement period from 2019. It is based on capacity-oriented student-related funding linked to the following objectives:

- increasing the quality of teaching and research/advancement and appreciation of the arts by improving support and supervision ratios and reinforcing research priorities;
- more transparency through separate consideration of the areas of "teaching", "research/advancement and appreciation of the arts" and "infrastructure/strategic development"; and
- increasing the proportion of students actively taking exams[86].

The Austria-wide targets and framework parameters for further development of universities are enshrined within the Austrian University Development Plan. The corresponding contributions for the individual universities are negotiated and agreed with the universities in performance agreements for a three-year period. The universities continue to receive a global budget for implementation purposes which is comprised of three partial amounts – for the performance areas "teaching" and "research/advancement and appreciation of the arts" and "infrastructure/strategic development" (three-pillar model). The partial amounts for the first two areas mentioned are calculated using specific indicators and weighted subject groups: the number of courses where students are actively taking exams (student places) and the number of scientific and/or artistic staff (research/advancement and appreciation of the arts basic performance). These are supplemented by competitive indicators as an additional incentive (e.g. number of graduates, "fast" students, revenues from third-party funding, structured doctoral educational courses).

A financial link for measures with the social dimension in teaching and on the social mix of students is another new element. Up to 0.5% of the university's global budget can be withheld and only paid out following evidence of actual implementation in order to ensure that such measures are actually implemented.

Implementation of "Strategic further development of the framework conditions for humanities, social sciences and cultural studies"

Following the result of the process for further strategic development of the framework conditions for humanities, social sciences and cultural sciences (GSK), a strategy document[87] was published at the end of 2017 that combined 41 measures according to five topic areas. The five topic areas identified through a consultation with the research community are as follows:

- Space for research
- Quality and performance measurement
- Internationalisation
- Alternative networking spaces
- Aid for young talents

The Federal Ministry of Education, Science and Research (BMBWF) has since developed specific actions in dialogue with the humanities, social sciences and cultural sciences community and

86 This means students who provide a minimum of 16 ECTS or 8 hours per semester week of successful exam performance per academic year.

87 See Federal Ministry of Science, Research and Economy (BMWFW) (2017).

in collaboration with the high-level group along with relevant promotion and funding institutions. This development process involved around 300 experts. The actions are being implemented by the Federal Ministry of Education, Science and Research (BMBWF) in collaboration with the funding institutions, research institutes, stakeholders and the research community. Work is taking place currently for instance on comprehensive presentation of the research infrastructures for the humanities, social sciences and cultural sciences in the research infrastructure database of the Federal Ministry of Education, Science and Research (BMBWF). Further examples of implementation include implementation of the Austrian Social Science Data Archive (AUSSDA) as part of the performance agreements with the Universities of Vienna, Graz and Linz, as well as achievement of higher levels of participation for humanities, social sciences and cultural sciences in existing funding programmes through corresponding actions by the research promotion agencies in coordination with the ministerial departments. Aside from new actions, existing funding, consultation and support offerings are also due to be developed in some areas. The actions will be implemented by 2021 and are being supported by a monitoring group.

Monitoring implementation of the "Open Innovation Strategy for Austria".

Austria became the first EU member state to put forward a comprehensive national Open Innovation Strategy (OI strategy) in July 2016.[88] Numerous activities and actions have been implemented since then by the ministries entrusted with implementation as well as by stakeholders at the federal, state and local authority level.[89] Current examples of implementation of the strategic vision of positioning Austria as an international role model for the design and control of Open Innovation systems by 2025 are illustrated below.[90]

A range of activities were implemented at the ministry level. An OI method workshop for the stakeholder community was held for the first time in June 2017 by the two ministerial departments in charge, i.e. the Federal Ministry of Education, Science and Research (BMBWF) and the Federal Ministry for Transport, Innovation and Technology, in order to develop an OI toolkit. The Federal Ministry for Transport, Innovation and Technology is also increasingly implementing initiatives aimed at greater inclusion of users and citizens in RTI funding programmes and innovation development (Action 8 of the OI strategy). These include open consultations e.g. as part of the efforts to develop the energy research strategy for Austria, innovation laboratories focusing on different topics, as well as test environments, such as for automated driving. With "Massive Open Online Courses" on the topic of smart cities, the Federal Ministry for Transport, Innovation and Technology is also attempting to make the topic of smart cities accessible to a wider professional audience. The Austrian Exchange Service (OeAD) was commissioned by the Federal Ministry of Education, Science and Research (BMBWF) to support its activities in the area of citizen science and with the annual Citizen Science Awards, which will take place once again in 2018, in the aim of ensuring greater inclusion of users and citizens in RTI funding programmes.

Other ministerial departments are also playing a crucial part in successful implementation

88 See Open Innovation Strategy for Austria, http://openinnovation.gv.at/wp-content/uploads/2015/08/OI_Barrierefrei_Englisch.pdf Although countries such as Sweden and the UK are working intensively on the topic of Open Innovation, Austria remains the only EU country so far that has its own OI strategy.

89 For a detailed presentation of the process, objectives and stakeholders and further empirical findings on the situation in Austria, see the Austrian Research and Technology Report 2017. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

90 Based on the annual status quo survey by the monitoring group and the information on the official website (www.openinnovation.at). An overview of the measures and associated initiatives aimed at implementation can be found in Table 8.4 in Appendix I.

of the OI strategy actions. The Federal Ministry for Digital and Economic Affairs (BMDW) is playing an essential part in OI methods in public administration (Action 3 of the OI strategy) via the "Public procurement promoting innovation" initiative (PPPI) implemented in conjunction with the Federal Ministry for Transport, Innovation and Technology, using a matchmaking platform, crowdsourcing challenges and community management. This is also the objective of the "GovLab" of the Federal Ministry of Civil Service and Sports (BMÖDS) in collaboration with University for Continuing Education Krems, as an open and interdisciplinary experimental space for the development of cross-organisational solutions for key challenges in the public sector.

As part of the "Open Austria" initiative[91] initiated jointly by the Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA) and Austrian Federal Economic Chambers (WKO), an office was opened in San Francisco in 2016 as a contact point for Austrian startups, firms and researchers planning to settle or become involved in the Bay Area around the central points of San Francisco, San Jose, Palo Alto and Berkeley, i.e. Silicon Valley. "Open Austria" provides a platform for successful Austrians in the tech industry and/or prestigious research and scientific centres and its mission is to turn ideas for the future into useful options for Austria. Open Austria also acts as a contact point for Austrian policy-makers and officials for analysis of the potential impact of technological revolutions originating from Silicon Valley. A further objective involves attracting corresponding investment to Austria. The Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA) also supports efforts to monitor the OI strategy for Austria with international status reports on the development of OI in other countries.

The national promotion and funding agencies are important intermediaries in supporting OI implementation through their programmes and funding activities. The Austrian Research Promotion Agency (FFG) has numerous initiatives in place aimed at incorporating OI into existing programme lines in particular, and uses targeted measures such as social crowdfunding for social innovation projects to promote OI approaches as part of the Impact Innovation package of measures. The Austrian Science Fund (FWF) primarily implements anchoring of Open Data and Open Access principles in research specifically in the area of Open Science and Open Access measures, and endeavours to achieve virtually 100% Open Access for quality-reviewed publications from FWF projects by 2020. In addition to organising events on the topic of OI as part of the NCP-IP, Austria Wirtschaftsservice (aws) also specifically contributes towards Action 9 in the OI strategy dedicated to the development of fair sharing and remuneration models for crowdwork, with its coordination of a working group on "Fair(er) remuneration in Open Innovation".

The Ludwig Boltzmann Society (LBG) is also implementing activities as part of its "Open Innovation in Science" (OIS) initiative. An "Ideas Lab" designed as a five-day interactive workshop was held in May 2017 with the aim of initiating interdisciplinary research projects in the area of children of mentally ill parents.

A range of further stakeholders in the public sector are also implementing OI initiatives. The Austrian Patent Office for instance focuses heavily on the topic of Open Data and the treatment and public provision of data associated with this. The mediation of knowledge on strategies for protection and exploitation associated with OI – particularly for SMEs – is also being promoted by the Austrian Patent Office (Actions 12 and 13 of the OI strategy). Government body ASFINAG uses OI methods partly so that it can respond to the needs of users of the Austrian motorways and expressways in a more targeted manner. This was implemented for in-

91 See http://www.open-austria.com

stance by involving a larger number of user groups as part of a project aimed at increasing the appeal of motorway service stations. Representatives from Austrian industry such as the Federal Economic Chambers and the Federation of Austrian Industry have also reported increasing use of OI methods in Austrian firms. Universities and universities of applied sciences are also implementing corresponding projects within their spheres of action. Increased interest in OI projects is also being reported at the regional government level. This applies in particular to Salzburg, Upper Austria and Vienna.

The examples listed here merely provide an overview of ongoing OI initiatives, but they also illustrate an increased readiness to implement actions across all stakeholder areas covering the entire content-related breadth of the actions defined in the OI strategy for Austria.

Public procurement promoting innovation (PPPI)

Public procurement promoting innovation (PPPI) represents an important cornerstone of demand-side innovation policy. The topic of PPPI is also explicitly enshrined in the Austrian federal government's programme for 2017–2022[92]. The aim is to increase the share of public procurement that is used for innovations. Valued at around €40 billion and with an estimated PPPI share of around 2–3%, the role of public procurement as a driver of innovation is becoming evident.

A key milestone in the PPPI initiative under the joint responsibility of the Federal Ministry for Digital and Economic Affairs (BMDW) and Federal Ministry for Transport, Innovation and Technology (BMVIT)[93] is the creation of the Europe-wide one-stop PPPI online platform[94] for public administration and innovative firms. Since the autumn of 2015 the PPPI online platform has made an important contribution towards capitalising on the innovative potential in industry and administration. Firms can provide their products and services on the marketplace of the online platform free of charge. A jury of experts decides which of these are suitable for PPPI and can be used by the public sector. The virtual marketplace now offers more than 100 products and services that are suitable for PPPI, including from the areas of digitalisation, mobility, energy, construction as well as medicine. If a public client is unable to find the right solution on the marketplace, then it can publish a "Challenge" as an invitation to innovative firms to submit new and individual solutions. More than a dozen purchasers open to innovation have already made use of this option. The role of the PPPI online platform as a link between public administration and innovative firms was recognised through the awarding of a certificate of recognition at the Austrian Administration Awards 2017.

Aside from the national award, the PPPI initiative has also received recognition at the European level: the PPPI initiative from the Federal Ministry for Digital and Economic Affairs (BMDW) and Federal Ministry for Transport, Innovation and Technology (BMVIT) was awarded a Best Practice Certificate in the "European and National Level" category at the European Public Sector Award 2017. A comprehensive evaluation of the implementation status of the PPPI guiding concept[95] and the impact achieved so far was also carried out in 2017 (see Chapter 5.3).

Implementation of the IP strategy

In addition to the discussion surrounding openness and the publication of research results and data, exploitation rights also represent an important cornerstone in the efforts to achieve a European research area and an innovative value

92 See https://www.bundeskanzleramt.gv.at/documents
93 See www.ioeb.at
94 See www.innovationspartnerschaft.at
95 See https://www.bmdw.gv.at/Wirtschaftspolitik/Wirtschaftspolitik/Documents/IÖB-Leitkonzept_2012.pdf

creation chain. Scientific findings will only develop their overall potential for all areas of life following a strategic combination of both elements. This is why specific strategies (on IP, Open Innovation and Open Access etc.) have been developed in Austria which take into account aspects related both to "Open Access to Publications and Data" as well as "Intellectual Property".

The Intellectual Property strategy for Austria was put forward by the federal government on 14 February 2017. A monitoring group also made up of representatives from the Federal Ministry for Digital and Economic Affairs (BMDW), the Federal Ministry for Transport, Innovation and Technology (BMVIT)/Patent Office, the Federal Ministry of Education, Science and Research (BMBWF), the Austria Wirtschaftsservice (aws) and the Austrian Research Promotion Agency (FFG) was appointed in order to monitor implementation of this strategy. Some of its responsibilities include documenting the progress for implementing the strategy and ensuring coordination with the target groups of the IP strategy, such as the ministries and applicable stakeholders.

A series of measures aimed in particular at improving the service portfolio in light of customer needs have been undertaken since the IP strategy was adopted. These include the creation of the IP Hub[96] online platform in June 2017 at the Austrian Patent Office as a central contact for prospective holders of property rights. With more than 70 services on offer currently, the platform is the central starting point for advice and funding related to intellectual property in Austria.

With the launch of the Patent Office's Focus Research facility, all innovative firms have a new funding tool at their disposal that supports the decision-making process on dealing with intellectual property through one-on-one initial and follow-up discussions. This way, customers receive important tailor-made advice on the latest technology available for their specific technical areas, particularly at the start of the development process. The new option of submitting a provisional patent application to the Patent Office allows prospective patent owners to protect their innovation at the crucial development phase, even though not all of the formal requirements may have been met at the point of registration.

"Fast Track" is another new customer-oriented service for all registrants in the area of trademarks. It allows a trademark to be registered in around ten days provided that it is eligible for protection. The new PreCheck service provides a legally acceptable estimate to the registrant. If the relevant symbol is registered as a trademark within three months, the Patent Office considers itself generally bound by the assessment of the distinctive character in the PreCheck results report.

The existing support measures in the IP area have been streamlined in Austria Wirtschaftsservice (aws). The new IPR services IP Coaching and modular IP exploitation support have been established as new services. Overall the measures are aimed at "leveraging" IP through realisation of innovations.

The new IP.Coaching programme supports SMEs with development and implementation of a tailor-made strategy for use of intellectual property (IP strategy). This sustainable IP strategy is coordinated with the firm's relevant business model. The business model and enterprise environment (market, competitors, partners, technologies, etc.) must therefore be incorporated into the advice in order for any such packages of IP measures to be developed. The programme includes advisory services (analysis of the potential along with strategic coaching for IP strategy development) and grants (implementation of the IP strategy).

The new IP.Market support services helps SMEs and research institutes that develop technology in exploiting their intellectual property

96 See http://www.ip-hub.at

(important future technologies that are strategic in the long term) outside of the firm (licensing) or outside of the research institute (third-party exploitation). The programme includes advisory and marketing services as well as grants.

Preparatory actions aimed at establishing and organising the "Motivation and fair exchange in Open Innovation processes" working group were initiated as part of the ncp.ip (national contact point for knowledge transfer and intellectual property), in order to provide guidance documents and/or sample contracts within the IPAG sample contract database[97]. In coordination with the federal government's OI strategy, the working group mentioned above should also contribute towards representing international developments and good practice and developing guidelines for the Open Innovation community if required. The aim is also to offer IP-related events for representatives from science and industry.

Efforts have also started aimed at expanding the mediation of IP knowledge, with seminars such as 'Knowledge of property rights for teachers', focusing on copyrights, patents, trademarks, designs, exploitation of IP, etc. offered at the teaching universities. The number of participants has increased significantly.

Schools at the secondary education level II are covering the processes for dealing with intellectual property in greater detail in order to prepare secondary school graduates for their mandatory preliminary scientific thesis (as an individual thesis at secondary academic school) and diploma thesis (as a team thesis as occupational colleges).

Another important action in the IP strategy is consistent sharpening of patent and exploitation strategies in the ongoing and future performance agreements with universities, IST Austria and the Austrian Academy of Sciences (ÖAW). The strategy plans should in particular ensure optimum structuring and presentation of the process for dealing with intellectual property related to research results, make technology transfer management a more professional process and thereby accelerate cooperation activities. Efforts are also being driven to ensure that professional and strategic processes are in place for IP when an academic spin-off is founded. The relevant university and/or research institute requires a sound patent strategy as part of the "Spin-off Fellowships" support programme.

IP skills are specifically being advanced within the scope of teaching and further educational events through the projects run by the regional knowledge transfer centres[98], which are aimed at covering direct university needs as far as possible related to the exploitation of intellectual property.

The Patent Voucher (Patent.Scheck), which is being administered jointly by the Austrian Research Promotion Agency (FFG) and Patent Office, encourages firms (in particular SMEs and start-ups) to examine the options for protecting their IP at an early stage in line with the specific development project. The costs incurred in clarifying the patentability and in preparing for/implementing specific IP protection strategies (national and/or PCT patent application) are funded.

Selected digitalisation initiatives

Within the context of increasing digitalisation and the impact of this on industry and society, the Austrian federal government and the individual ministerial departments are implementing a series of actions and priorities aimed at actively helping to shape Austria as an information and knowledge society and boosting its competitiveness and innovative potential as a location. A selection of these is presented below.

97 See https://www.ipag.at/en/
98 See http://www.wtz.ac.at/wissenstransferzentrum-english/

The Austrian “*Council for Robotics*” (Rat für Robotik) was established by the Federal Ministry for Transport, Innovation and Technology in 2017 in the aim of improving efforts to overcome the technological and regulatory challenges arising from the developments in the area of robotics and artificial intelligence. It acts as an advisory panel and consists of nine robotics experts with backgrounds in technology, philosophy, law, employment organisation, technology education and industry. The Council for Robotics identifies and discusses the long-term challenges that arise from the use of robotics and artificial intelligence (AI) at the technological, industrial, societal and legal level on the one hand. Recommendations and expert opinions from the Council are set out as specific strategic guiding principles for the Federal Minister for Transport, Innovation and Technology. There are also plans in place for the rest of 2018 whereby the Council for Robotics will support the Federal Ministry for Transport, Innovation and Technology in developing a strategy for the use of robotics and artificial intelligence.

With its “*broadband strategy 2020*” and masterplan for promoting broadband based upon this strategy, the Federal Ministry for Transport, Innovation and Technology has set itself the target of making super fast broadband (= more than 100 mbps) available across the board by 2020. Expansion of the digital infrastructure is being supported by funds from the federal government’s “Broadband billion” fund. The Master Plan is based on a flexible funding system in three separate phases and builds on several funding programmes that are coordinated in terms of their impact. The first phase was evaluated in the spring of 2017.[99]

Since 2015 around €332 million has been provided from the broadband billion fund. One third of the funds planned until 2020 is already subject to contractual agreements. The funds are being used in the individual funding programmes for the “Broadband Austria 2020” funding strategy from the Federal Ministry for Transport, Innovation and Technology with various focal points (e.g. complete expansion, upgrades to existing networks, ducts laid in conjunction with other digging work, establishment of fibreglass connections). The funds here cover up to 50% of the investment costs for the projects, or up to 90% in the case of schools, and are awarded based on a technology neutral policy. The funding programmes support broadband expansion particularly in those areas where there is no existing quality broadband supply and where there are no plans for expansion over the next three years. This ensures that the public funds are used efficiently and in a targeted manner and represent an investment incentive both for municipalities and telecommunications firms to expand broadband services in less densely populated regions of Austria. Supplementary promotional measures such as AT:net promote the use of innovative services and applications based on broadband.

With respect to the broadband expansion, the federal government has set ambitious new targets that include rapid expansion of a modern and efficient telecommunications infrastructure, establishing Austria as a pilot country for 5G by 2021 and supplying gigabit ports across the entire country, in addition to country-wide mobile supply based on the latest fifth generation of mobile technology "5G" by 2025. In this respect the national 5G strategy currently being finalised by the Federal Ministry for Transport, Innovation and Technology and Federal Ministry for Digital and Economic Affairs (BMDW) addresses facilitation of the infrastructure expansion for mobile networks in particular.

In addition to provision of the digital infrastructure, attention is also being paid to funding and support for technologies of the future, such as automated or autonomous driving (see Section 4.2.1) as well as digitalisation and linkages in the context of the Internet of Things

99 See Neumann et al. (2017).

(IoT) and Industry 4.0 (see Section 4.2.2), in order to close the ranks further with the Leaders in European innovation. This includes the development and use of decentralised concepts such as the *blockchain* and other *distributed ledger technologies (DLT)*, the potential of which is currently being discussed in research, industry and public administration (see Section 4.2.3). The significance of this technology has also been recognised in RTI policy, with the blockchain becoming enshrined as part of the Digital Roadmap Austria[100]. Aside from a broad discussion of the (potential) functioning methods, opportunities as well as risks, the priorities for the associated initiatives and actions involve the establishment of sustainable basic and applied research in this area and the development of application-oriented best practice examples in the form of "lighthouse projects" in close collaboration with stakeholders in industry and society.

Traditional industries such as building, one of Austria's largest economic sub-sectors, are currently undergoing a sustained phase of digital transformation. While visualisation is increasingly being used at the start of the project using augmented, mixed or virtual reality, the greatest potential for digitalisation is currently seen in Building Information Modelling (BIM) as a planning method spanning all trades. SMEs in particular are faced with growing challenges in providing evidence of their capabilities in planning, constructing or running BIM projects. The industry initiative *"BRA.IN Bauforschung 2020"* (BRA.IN construction research 2020) was launched by the Federal Ministry for Digital and Economic Affairs (BMDW) and Federal Ministry for Transport, Innovation and Technology (BMVIT) in 2017 in collaboration with representatives from industry and science with the aim of enabling application examples that have undergone scientific examination and of further promoting digitalisation processes in the construction industry. The funding programmes run by the Austrian Research Promotion Agency (FFG) that can be used by representatives from the construction industry in order to intensify their research and innovation activities are combined in a package within this initiative. The initiative supports projects from the entire structural and civil engineering sector as well as the production and recycling of construction materials and building products. The support measures also focus on relevant services (planning, structural analyses, etc.) and construction machinery.

Education at all levels – from elementary to tertiary education – also plays a key role in terms of *vocational training with regard to digitalisation and Industry 4.0*. Both female as well as male pupils should equally be inspired by science, technology, engineering, and mathematics (STEM; see Chapter 3.1) at the earliest possible stage and in collaboration with research institutes and industry in order to counteract the lack of interest and the gender gap between the different disciplines. Another important point involves preparing young people for skills-oriented performance assessments and incorporating the latest digital testing formats and innovations in the teaching organisation and teaching technologies into the curriculum.

The VET (vocational education and training) 4.0 working group was launched by the Federal Ministry of Education, Science and Research (BMBWF) in 2016 in light of this in order to coordinate corresponding strategies for vocational training with the leading educational management departments. The measures include in particular the acquisition of STEM skills, development and adaptation of courses and vocational training in the context of Industry 4.0 and the development and implementation of innovative learning and digital testing methods. Examples of corresponding activities include the STEM seal of quality awarded for innovative and inspiring learning methods in this

100 See https://www.digitalroadmap.gv.at/en/

area to teaching establishments from elementary to degree level. The seal was awarded to 113 schools and colleges during the first academic year in 2016/17.

Teachers from various types of schools are due to be certified as coordinators for VET 4.0, a collaborative project between the Federal Ministry of Education, Science and Research (BMBWF) and the University College of Teacher Education Lower Austria, as part of the Industry 4.0 courses starting during the rest of 2018. A total of 15 clusters involving 40 schools and colleges throughout Austria have linked up with practice and research partners from industry, and are currently involved in joint projects aimed at coming to a common understanding of the requirements for Industry 4.0 and as a consequence for VET 4.0.

Work is currently taking place to establish a corresponding research centre named "SILICON AUSTRIA LABS (SAL)" with the objective of raising the innovation ecosystem of the Austrian electronic-based systems (EBS) industry to world class levels. SAL is planned as a physical centre with long-term prospects and a corresponding infrastructure that represents sustainable establishment and restructuring in EBS research in Austria, combines the fragmented, dispersed and up until now barely coordinated capacities in non-university research into one central unit, and will have a differentiated international research portfolio in order to become a leading non-university research centre in Europe. The essential process steps for this consisted of the formation of a set-up company (Si. A. Errichtungs-GmbH), setting up an interim management team, entering into an agreement in principle on financing, governance and determination of the sites in Graz, Villach and Linz, developing a comprehensive research programme alongside sub-programmes and in setting up corresponding control groups. Negotiations are currently being held with the Federal Ministry of Finance (BMF) on the final implementation of the concept in the form of founding a new enterprise, SILICON AUSTRIA GmbH.

Implementation of the "Strategy for the future for life sciences and pharmaceuticals in Austria"

The objective of the "Strategy for the future for life sciences and pharmaceuticals in Austria"[101] presented in November 2016 is to maintain and extend the industrial and scientific competitiveness of the sectors that are significant for Austria as a location. A series of measures have been implemented since then based on the action areas defined in the strategy.[102] As part of the "Future University" project completed in 2017 for instance, the life sciences courses offered nationally were analysed in terms of their adequacy and permeability and found to be suitable. Numerous teaching and research partnerships in life sciences were identified that should be expanded further over the next few years. Crucial steps were also implemented in 2017 in expanding the stem cell research centre at the Institute of Molecular Biotechnology. There are now five groups with a total of 43 researchers working at this centre. There is also a stem cell biobase which archives and prepares the stem cell clones for research.

Requirements related to the processing of big data in life sciences have been under discussion in light of the implementation of the General Data Protection Regulations (Regulation 2016/679) and the discussions following this.

A series of measures have already been successfully implemented in the action area of Personalised Medicine: the Austrian platform for personalised medicine (ÖPPM)[103] started oper-

101 See https://www.bmdw.gv.at/Innovation/Publikationen/Documents/Life_Science_Strategie_barrierefrei.pdf

102 These include the following areas: boosting basic research, research infrastructure, big data, personalised medicine, clinical research, science/industry collaboration and translation, corporate location conditions, production and market, dialogue between science and society.

103 See http://www.personalized-medicine.at

ating in October 2017 following a kick-off conference and with major interest among the public. The Federal Ministry of Education, Science and Research (BMBWF) and Austrian experts played an active part in the activities and workshops for the International Consortium for Personalised Medicine – IC PerMed. The Austrian Science Fund (FWF) is involved in a Europe-wide proposal on personalised medicine together with 30 additional funding and promotion agencies.

The launch of a working group coordinated by the Austrian Federal Office for Safety in Health Care (BASG/AGES) in 2017 must be highlighted in the area of clinical studies in preparation for implementation of Regulation (EU) 2014/536 on clinical trials on medicinal products for human use. This specifically involves establishing the infrastructure required by the BASG and the ethics committees and revision of the Medicinal Products Act.

The research programme based on a crowdsourcing initiative at the Ludwig Boltzmann Society (LBG) in the mental health area organised an Ideas Lab in 2017. This allowed two interdisciplinary research groups to be established which will start their research work on the topic of children of mentally ill parents during 2018.

Within the scope of the thematic knowledge transfer centre Life Sciences, a business plan for a Translational Research Center (TRC) was put forward for the period following the expiry of the funding period (see Chapter 3.5). The TRC should make a crucial contribution towards expanding the knowledge transfer driven by firms and thereby play a part in boosting innovative force and sustainable strategic further development of Austria as a location for R&D. A discussion process was also started with representatives from the Federal Ministry for Digital and Economic Affairs (BMDW), Austria Wirtschaftsservice (aws) and stakeholders from the drugs industry in order to establish a knowledge transfer centre in the area of medicinal products, with the aim of establishing a corresponding platform here within the scope of promoting knowledge transfer centres in the near future.

The importance of forms of indirect R&D research in terms of the competitiveness of the business enterprise location is growing, particularly in the life sciences sector. A recent study[104] highlights in this regard the role of the research tax premium, which contributes both to securing Austria as a location and to off-shoring R&D activities to Austria, above all for internationally active, research-intensive firms. A range of measures aimed at boosting location marketing and awareness of the start-up potential in Austria were also implemented. Location marketing in the area of life sciences is prepared and implemented through the LISA (Life Science Austria) initiative, and LISA also coordinates the appearances made by Austrian biotech firms at trade fairs abroad. The 2019 spring event for Europe's largest life sciences trade fair (BIO-Europe) was held in Vienna. BIO-Europe Spring provides every opportunity to present the life sciences location with prominence.

In order to increase the visibility of research, start-ups, entrepreneurship and partnerships between science and industry through competitions, the life sciences prizes "Best of Biotech" (BoB, prize for the best business plan), the "Science2Business Award" (for the best research partnerships between science and industry) and the "Life Science Research Awards Austria" from the Austrian Association of Molecular Life Sciences and Biotechnology (ÖGMBT) (for basic research and applied research in molecular biosciences and biotechnology) were announced and awarded in 2017 with the involvement of the Federal Ministry for Digital and Economic Affairs (BMDW). The open-topic

104 See Ecker et al. (2017).

start-up prize Phoenix was also awarded in five categories in collaboration with both ministerial departments.

The surveys for the periodic standard statistical report "Life Science Report Austria 2018" began in 2017. The industrial data following the OECD definitions for the entire sector and the key data for all basic research organisations active in life sciences are presented cumulatively in this. Together with the directory of firms published in parallel with this, the brochure is a reference work for the Austrian life sciences research and industrial location.

Implementation of the "creative industries strategy for Austria"

With their strong innovative and transformative force, the creative industries are the instigators and a key industrial factor for Austria as a place for business. The Seventh Austrian Creative Industries Report[105] published in 2017 confirms the strong links within the creative industries and with other economic sub-sectors, and documents the role of these firms as a key factor in the dynamic force of industry.

Promotion and funding for innovations based on the creative industries are important in terms of implementation of the "Creative Industries strategy for Austria"[106]. The programmes aws impulse XS and XL were implemented for instance in 2017 with two rounds of proposals each in order to address different innovation projects or phases in a targeted manner. A proposal was implemented for the "aws Creative Industries Voucher" in 2017 in order to boost collaboration with the creative industries across all sectors. A pilot programme was also developed for lighthouse projects which address and increase the visibility of increased use and integration of creative industry know-how along the entire value creation chain and across sectoral boundaries. An initial rounds of proposals for the pilot programme is planned for 2018/2019.

Intensifying education and further training for creative individuals is another important action area. The creative industries coaching initiative "C hoch 3" (C to the power of 3) was for instance implemented across Austria in 2017. The Austria Wirtschaftsservice initiative (aws) "Creative (X) Entrepreneur" was also continued as a pilot in 2016. This initiative incorporates the latest developments and trends in the creative industries and sets topic-based priorities (X) based around needs and addresses these with a newly designed professionalised format. Entrepreneurial professionalisation was promoted in the focal areas of fashion (Vienna) and design (Styria) in 2017.

The national "FORTE" defence research programme

Guaranteeing "security" is a key responsibility for nation states that spans all ministerial departments within the scope of ensuring comprehensive national security. As with security research, there is a need for a targeted contribution from research and development for the specific area of defence policy in order to meet impending military challenges. This should take place via defence research within the context of implementing the RTI strategy and in accordance with the government's current programme for 2017–2022[107], as well as for the purposes of implementing government strategy documents, such as the defence policy sub-strategy. Defence research should also be reflected in the national research promotion landscape in accordance with the European developments in the area of defence research. The national research promotion portfolio is expanded with the "FORTE" defence research programme (covering research and technology), with a new format created for collaboration with relevant

105 See Kreativwirtschaft Austria (2017).
106 See Federal Ministry of Science, Research and Economy (BMWFW) (2016).
107 See https://www.bundeskanzleramt.gv.at/documents

research institutes and industrial firms. The contents of defence research complement the numerous competencies already existing in the civil/national area so as to avoid duplications.

The defence research programme under the programme responsibility of the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the content-related/topic-based responsibility of the Federal Ministry of Defence supports those national research projects that are required in order to fulfil the purely military tasks, in addition to the funding programme for security research KIRAS (see Section 5.3.3). For the purposes of targeted further development of the Austrian Armed Forces, FORTE will therefore be focused in particular on making a time and needs-based contribution based on research to the most urgent military research areas at present, such as cyber defence, management information systems and robotics (including with international participation). With FORTE the Federal Ministry of Defence and the Austrian Armed Forces are positioned as partners to industry for research, innovation and technological development, with national defence research skills also boosted, so that national research institutes and partners in industry can also participate successfully in the international competition for defence research (EU research programmes) and additional national value add is generated.

The relevant fields of expertise in the areas of applied research and the formulation of defence research needs are merged together through the collaboration between the Federal Ministry for Transport, Innovation and Technology and Federal Ministry of Defence in order to create optimum synergies and effectively avoid duplication. Once all required framework conditions have been guaranteed, FORTE will be administered as a national support programme via the Austrian Research Promotion Agency in accordance with the Research and Technology Promotion Act. With an operational programme volume of €5 million the first proposal for FORTE is planned for the fourth quarter of 2018.

2 Major Federal Funding Agencies in Austria

Research, technology and innovation (RTI) make a significant contribution to actively addressing economic, social and ecological challenges and strengthening Austria's competitiveness and innovative potential. Austria's funding system for RTI can be described as well developed, by international standards. Funding levels in the business enterprise sector in particular are amongst the highest in the EU and in OECD countries.

Various aspects of the innovation chain, from basic research and applied research to developing marketable products and services, are supported by a series of public funding agencies through the programmes and initiatives they administer. This chapter describes the major agencies, their statutory basis, current figures and priorities, as well as new strategic initiatives and funding programmes.

- The **Austrian Science Fund (FWF)** is the central funding agency not only for basic research, but also for the advancement and appreciation of the arts. Its responsibilities include the enhancement and development of the country's scientific research systems and increasing the attractiveness of Austria as a location for research: the most important element of this is support for researchers through stand-alone projects. Through targeted projects the Austrian Science Fund (FWF) provides financial support for Austrian research centres, to help them compete in the international marketplace for leading researchers and the best ideas. In 2017, 642 projects (+2.9% on 2016) received support from the Austrian Science Fund (FWF), amounting to a total of €217.3 million (+18.2%). The approval rate of 22.4% (by total funding amounts) or 25.5% (by project proposals) confirms the competitive nature of the Austrian Science Fund (FWF) funding programmes.
- The **Austrian Research Promotion Agency (FFG)** is the national agency for funding applied research and experimental development. Using a targeted combination of funding instruments, which includes both direct support for stand-alone projects in industrial research (through Austrian Research Promotion Agency (FFG) general funding programmes) and industrially oriented structural programmes, cooperation between science and industry is to be strengthened and developed further. In order to achieve a "critical mass" of research in strategically-important fields for the future, also internationally, special emphasis has been placed on specific, thematically-oriented programmes. In 2017 the Austrian Research Promotion Agency (FFG) approved 3,602 projects (+13% on 2016) with a total funding volume of €434.3 million (cash value: +9%). The approval rate for project proposals was 56%.
- The **Austria Wirtschaftsservice GmbH (aws)** is the federal development bank. Its support is focused particularly on the transition of technological and social innovations into economic growth and enterprise creation. Activities and instruments are purposely designed to prioritise small and medium-sized enterprises (SMEs) and start-ups. In 2017 the Austria Wirtschaftsservice (aws) approved 5,482 funding applications (+42.5% on 2016), with an overall financing volume of €1.15 billion (+41.2%). The approval rate was 53.02%.

2.1 The Austrian Science Fund (FWF)

Legal framework and funding aims

The Austrian Science Fund (FWF) is the central Austrian funding body for basic research and the advancement and appreciation of the arts. It was founded in 1968 and in its present form is a legal entity established by federal law (Research and Technology Promotion Act, FTFG). The Federal Ministry of Education, Science and Research (BMBWF) is responsible for administration of the Austrian Science Fund (FWF), as defined by Section 2 of the Research and Technology Promotion Act (FTFG). This includes ensuring that its commercial activities are conducted in accordance with the law, and that its management and administration are maintained and supervised in accordance with the regulatory provisions. In certain matters, decisions by executive bodies of the Austrian Science Fund (FWF) must be approved by the supervising authority (e.g. on the annual accounts and budget planning, as well as medium-term and work programmes).

In accordance with Section 2 of the Research and Technology Promotion Act (FTFG), the Austrian Science Fund (FWF) was established to promote research that serves to increase knowledge and to both broaden and deepen scientific understanding, rather than focusing on profit. The Fund is intended to support developments in science and culture, in the interests of a knowledge-based society, and so to contribute to increased value creation and prosperity in Austria.

Instruments, key performance indicators and priorities

The core instrument of the Austrian Science Fund (FWF) consists of project-specific funding for researchers in all subject areas. This includes “Exploring New Frontiers – Funding of top-quality Research” (single project funding, international programmes, priority research programmes, awards and prizes), “Cultivating Talents – Development of Human Resources” (structured doctoral programmes, international mobility, career development for researchers) and “Realizing Ideas – Interactive Effects Science and Society” (supporting practical basic research, funding artistic research, publication and communication and expanding Austrian Science Fund (FWF) grant funding).

A 18.2% increase in funding approvals can be seen, up from €183.8 million (2016) to €217.3 million (2017)[1] (see Table 2-3). Although the number of applications considered (2,493) fell by 3.0% on 2016, the total volume increased by 11.3% to €879.4 million (see Table 2-1 and Table 2-3). Austrian Science Fund (FWF) decisions on approval or rejection of funding applications within the available budget are made by their experts on the basis of international evaluations. The most essential criterion used for awarding these competitively allocated funds is scientific quality. For this purpose 4,701 expert opinions were gathered from 66 different countries.

The largest proportion by far of Austrian Science Fund (FWF) funding is accounted for by staff costs at 83.5%. As of the end of 2017 a total of 4,078 people (or 2,819 full-time equivalents) employed in scientific research were financed by the Austrian Science Fund (FWF). In terms of full-time equivalent (FTE) positions, most of these were employed as pre-doctoral (1,374 FTEs) and post-doctoral researchers (1,115 FTEs) (see Table 2-2). The proportion of female research employees financed by the Austrian Science Fund (FWF) fell on the previous year. Among post-doctoral researchers there was a 2.7% (-6.7%) fall in the proportion of female research employees, among pre-doctoral researchers a 0.6% (-1.4%) fall, and among technical staff a 0.5% (-0.9%) fall. While this may involve normal fluctuations among the pre-doctoral researchers and the technical staff, the fall in the proportion of female post-doctoral researchers is a development that can be observed once again after 2016. In order to counteract this development, a minimum participa-

1 The total volume of approvals including supplementary grants increased by 18.3%, from €188.1 million (2016) to €222.6 million (2017).

Table 2-1: Austrian Science Fund (FWF): Number of grants in 2016–2017

Programme	Project proposals		Projects led by women (in %)	Project employees [1]	Stakeholders (research institutions)	New approvals		Approval rate (in %)
	2016	2017	2017	2017	2017	2016	2017	2017
Austrian Science Fund (FWF) (Total)	**2,569**	**2,493**	**33**	**1,483**	**552**	**624**	**642**	**25.5**
Stand-alone projects	1,090	1,025	27	727	38	285	295	28.8
International programmes	552	466	23	212	32	98	106	22.7
Special Research Areas (SFBs) – new applications (Sub-project level)	52	33	18	13	6	26	7	5.3[3]
Special Research Areas (SFBs) – extensions (sub-project level)	29	24	25	39	6	17	20	83.3
START Programme	70	88	30	23	4	6	6	6.8
Wittgenstein Prize	22	20	20	n. a.	1	1	1	5.0
Doctoral Programmes – new applications	-	5	20	43[4]	4	-	4	25.0[3]
Doctoral Programme extensions	6	8	0	97[4]	11	6	7	87.5
doc.funds	-	45	16	61	6		7	15.6
Schrödinger Programme	182	146	40	53	17	64	53	36.3
Meitner Programme	202	209	39	50	13	50	50	23.9
Firnberg Programme	71	83	100	21	15	16	21	25.3
Richter Programme (including Richter Programme for the Development and Inclusion of the Arts / PEEK)	71	74	100	23	11	16	17	23.0
Clinical research programme (KLIF)	81	81	33	31	7	14	13	16.0
Programme for the Advancement and Appreciation of the Arts (PEEK)	49	67	46	34	6	8	9	13.4
Open Research Data	-	40	28	26	8	-	12	30.0
Science Communication Programme	22	23	48	14	3	6	5	21.7
"Tyrol-South-Tyrol-Trentino" interregional project network	-	38	11	3	1	-	2	5.3
Top Citizen Science	27	18	33	13	5	5	7	38.9
Partnership in Research	43	-	-	-	-	6	-	-

1 Figures are based on proposed project staffing on approved projects. These figures may not correspond exactly with the number of employees ultimately financed for the projects.

2 The "Total" figure is not the sum of the figures under "Stakeholders", as any stakeholders involved in more than one programme are only counted in the overall view. Austrian Academy of Sciences (ÖAW) is classified as an institution (incl. all institutes and GmbHs).

3 The approval rate is calculated from the number of applications approved, from complete applications to conceptual plans. Concept applications are not included in this table.

4 This figure includes proposed project staffing and proposed PhD places "fully funded by the Austrian Science Fund (FWF)". Additional PhD places with partial funding are not included.

Source: Austrian Science Fund (FWF).

Table 2-2: Austrian Science Fund (FWF): R&D staff financed by the agency, 2016–2017

R&D staff	FTE (full time equivalents) 2016 Reference date 31 Dec.	Of which Women in %	FTE (full time equivalents) 2017 Reference date 31 Dec.	Of which Women in %	Change in number of women as %
Total staff	**2,771.7**	**43.6**	**2,819.3**	**42.1**	**-3.4**
Researchers					
Post-docs	1,101.1	40.2	1,114.9	37.5	-6.7
Pre-docs	1,341.9	43.1	1,373.6	42.5	-1.4
Technical staff[1]	328.8	57.0	330.9	56.5	-0.9

1 Technical and other staff.

Source: Austrian Science Fund (FWF).

tion threshold for the relevant underrepresented gender (30%) was stipulated for instance in the new post-doctoral "Zukunftskolleg" project, developed together with the Austrian Academy of Sciences and funded by the National RTD Foundation. In addition to this, the project management teams are under a general obligation to publish approved positions within the

Table 2-3: Austrian Science Fund (FWF): Total funding in € millions, 2016–2017

Programme	Value of funding applications Applications/project proposals		New approvals		Approval rate (approvals/applications) (in %)	Total costs[1]
	2016	2017	2016	2017	2017	2017
Austrian Science Fund (FWF) (Total)	**790.0**	**879.4**	**183.8**	**217.3**	**22.4**	**222.6[2]**
Stand-alone projects	347.5	337.4	88.1	97.8	29.0	98.7
International programmes	142.6	131.6	22.1	27.5	20.9	27.6
Special Research Areas (SFBs) – new applications	19.8	13.3	11.7	3.3	4.3[3]	3.3
Special Research Areas (SFBs) – extensions	11.7	11.0	6.9	8.4	76.8	9.1
START Programme	81.0	101.1	7.0	6.8	6.7	6.8
Wittgenstein Prize	33.0	30.0	1.5	1.5	5.0	1.5
Doctoral Programmes – new applications	-	11.6	-	7.7	19.0[3]	7.7
Doctoral Programme extensions	17.0	23.5	13.7	17.9	76.0	19.5
doc.funds	-	65.3		11.3	17.3	11.3
Schrödinger Programme	22.0	18.7	8.5	7.2	38.4	8.0
Meitner Programme	31.1	32.6	7.7	7.9	24.2	8.2
Firnberg Programme	16.2	19.1	3.7	4.8	25.3	5.0
Richter Programme (including Richter Programme for the Development and Inclusion of the Arts / PEEK)	20.2	21.4	4.5	4.8	22.2	5.1
Clinical research programme (KLIF)	20.4	22.7	4.0	4.0	17.5	4.0
Programme for the Advancement and Appreciation of the Arts (PEEK)	15.9	25.1	2.8	3.4	13.5	3.4
Open Research Data	-	8.2		2.2	27.0	2.2
Science Communication Programme	1.0	1.1	0.2	0.2	23.2	0.2
"Tyrol-South-Tyrol-Trentino" interregional project network	-	4.9	-	0.3	5.8	0.3
Top Citizen Science	1.3	0.8	0.2	0.3	41.5	0.3
Partnership in Research	9.4	-	1.3	-	-	-

1 Total costs include supplementary amounts approved for ongoing projects in addition to new approvals. These supplementary amounts cover items such as inflation allowances, accounting allowances and pension insurance payments.

2 Includes additional approvals in programmes in which there were no new approvals in 2016/2017.

3 The approval rate is calculated from the number of applications approved, from complete applications to conceptual plans. Concept applications are not included in this table.

Source: Austrian Science Fund (FWF).

projects as of 2018 in order to make recruitment opportunities more visible for post-doctoral and pre-doctoral candidates.

Of the newly approved subsidies in 2017 the area of "Biology and Medical Sciences" received 36.2%, "Natural and Technical Sciences" received 41.0%, and "Humanities and Social Sciences" received 22.8%. A comparatively stable rough percentage distribution of 40-40-20 can be observed over these three groups of disciplines over the years. Similar to 2016, the largest share of new approvals in 2017 can be attributed to the discipline of Biology (19.9%) (see Table 23 in the statistics appendix), followed by Mathematics (11.5%) and Physics/Astronomy (10.8%).

Consistent with the goal of increased support for basic research, universities were the largest group of funding recipients (see Table 24 in the statistics appendix). Compared to 2016 their proportion of new approvals rose by 2.1% to 85.1%[2], followed by the Academy of Sciences (7.8%) and non-university research institutes (6.0%).

With respect to the regional distribution, Vienna was responsible for a share of €124.2 mil-

2 Incl. the University for Continuing Education Krems.

lion or 57.2% of the funds of the Austrian Science Fund (FWF) in 2017. The remaining federal states collectively accounted for €93.0 million (42.8%), representing a 2.0% higher share of funding as compared with 2016. Aside from Vienna, the federal states with the largest shares are Styria with €32.5 million (15.0%) and Tyrol with €28.9 million (13.3%). Research facilities abroad received €0.1 million which is less than 0.1% of all funds.

The National Foundation for Research, Technology and Development (RTD) provided matching funds, based on cooperation agreements between the Austrian Science Fund (FWF) and most federal states. This allows projects which – despite extremely positive evaluations – cannot be financed by the Austrian Science Fund (FWF) itself, due to budget constraints, to be recommended to the federal states for funding. If a project is accepted for financing by a state government, this covers 50% of the costs, and the other half is covered by funds from the National Foundation for Research, Technology and Development (RTD) via the Austrian Science Fund (FWF). There was a significant increase on 2016 both in the number of projects as well as the total funding for the matching funds. In 2017 there were 30 such projects (2016: 17) across five federal states which received a total funding of €9.7 million (2016: €4.2 million). Carinthia was a further federal state that became part of the initiative towards the end of the year.

Strategic developments

The Executive Board of the Austrian Science Fund (FWF), in office since autumn 2016, visited Austria's research sites between March and December 2017 accompanied by a team from the Austrian Science Fund (FWF) office as part of an informational and dialogue tour. Intensive discussions took place with representatives from the research institutes, scientists and politicians on the Austrian Science Fund's new strategic orientation, the portfolio and the matters affecting the institutes in a total of 15 one-day events and 27 high-level meetings.

The Austrian Alliance of Science Organisations was founded by the President of the Austrian Science Fund (FWF) in order to make the benefits of science more transparent to the public. This alliance of representatives from Austrian science and research organisations is aimed at coordinating positions on science, teaching and research strategies and publishing opinions on research policy topics.

Further future collaborative developments in the area of research agendas in Europe are a joint concern of the European Commission, the Member States and the European stakeholder organisations. The Austrian Science Fund (FWF) was also active in several ways at the European and global levels in 2017, for instance through its membership of Science Europe and the umbrella organisation for European research funding organisations, as well as through participation in multilateral ERA networks in the area of basic research.

An international symposium took place in Beijing in early July at the invitation of the National Natural Science Foundation of China (NSFC), in which the Austrian Science Fund (FWF) also took part. Representatives from funding organisations from 22 countries and from seven international scientific organisations discussed the options for setting up a joint research area between China, other Asian countries and European countries ("Belt and Road").

Trends in the portfolio of instruments

Funding programmes represent a major pillar in the Austrian Science Fund's portfolio, enabling young researchers to achieve scientific independence and providing prospects for them in terms of international mobility. The grants for stays abroad from the Erwin Schrödinger Programme and the new Lise Meitner Programme established as of February 2017 contributed towards these goals. The latter programme expanded the post-doctoral career funding to in-

Table 2-4: Austrian Science Fund (FWF): New initiatives and funding instruments

Funding programme/initiative	Target group	Objective
Financial funding instruments		
"Lise Meitner" programme – Incoming/Reintegration	Post-doctoral projects from abroad	Improving scientific quality and cooperation with countries of origin, Brain Gain
netidee SCIENCE	Researchers	Expanding the beneficial aspects of the internet to society
Young Independent Researcher Groups (in cooperation with Austrian Academy of Sciences ÖAW)	Post-docs from Austria and abroad up to a maximum of 4 years following conferral of a doctorate	Funding for young post-docs, professional as well as cross-border and interdisciplinary research cooperation
Research groups	Researchers	Networking between researchers independent of location, interdisciplinary and multidisciplinary
doc.funds	Austrian research institutes legal right to grant doctoral degrees	Support for (artistic) scientific education of doctoral candidates, strengthening of research focus

Source: Austrian Science Fund (FWF).

clude "Brain Gain, Reintegration" and the development of human potential, in order to raise Austria's appeal in the scientific environment even further. The doubling in the number of submissions in the Incoming Programme "Lise Meitner" (2011: 104; 2017: 209) points to a growing interest from foreign scientists in carrying out their research activities in Austria.

For some years the Austrian Science Fund (FWF) has also managed to boost the willingness to fund basic research using private funds. These efforts were intensified further in 2017. Overall four private foundations currently provide funding for Austrian Science Fund (FWF) research projects amounting to approx. €1.6 million. The "netidee SCIENCE" prize was awarded in 2017 on behalf of the latest foundation brought in, the Internet Foundation Austria (IPA), tightening the cooperation further.

Since last year the Austrian Science Fund (FWF) has been working intensively and in close coordination with the universities on formats that account for those matters affecting the scientific community. Some initial initiatives have been implemented, for instance with the call for "Young Independent Researcher Groups", "Research Groups" and "doc.funds", the successor programme for the Doctoral Programmes. The new "Research Group" funding instrument in particular enables networking independent of locations, and thereby closes a gap between stand-alone projects and special research areas.

The Austrian Science Fund (FWF) will receive an additional €110 million from the Austrian federal government for the period between 2018 and 2021. Further funds are provided by the National Foundation for Research, Technology and Development (RTD) and from the Austrian Fund, amounting to around €40 million for the full year 2018. The Austrian Science Fund's basic budget is currently €184 million per year. Despite the budget increase, the Austrian Science Fund (FWF) remains well away from the relative budget level of the German Research Foundation (DFG) that would be required to keep pace with the international competition for the best talent and most creative ideas.

2.2 The Austrian Research Promotion Agency (FFG)

Legal framework and funding aims

The Austrian Research Promotion Agency (FFG) is the national agency for funding applied research and experimental development. It was founded on 1 September 2004 by the "Act on the Establishment of the Austrian Research Promotion Agency" (FFG-Gesetz: Federal Law Gazette I no. 73/2004). The Austrian Research Promotion Agency (FFG) is fully owned by the Republic of Austria. The agency is sponsored by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Federal Ministry for Digital and Economic Affairs (BMDW). As a provider of funding services the Austrian Research Promotion Agency (FFG) is also often commissioned by other national and international institutions (e.g. the Federal Ministry of Finance (BMF), Federal Ministry of Education, Science and Research (BMBWF), Austrian Economic Chambers (WKÖ) and Austrian Federal Railways (ÖBB)). The Austrian Research Promotion Agency (FFG) also supports the implementation of the programme of the Climate and Energy Fund (KLIEN), taking responsibility for funding offered through federal-state partnerships and evaluating applications for research tax premiums. In addition the Austrian Research Promotion Agency (FFG) provides strategic inputs for the development of Austrian RTI policy, based on continued monitoring of national, transnational and European programmes.

The Austrian Research Promotion Agency (FFG) supports RTI policy in 1) broadening the basis for innovation, 2) structural change (e.g. start-ups and funding for particularly risky but strategically important R&D proposals) and 3) strengthening the basis for Austrian research and innovation in strategic areas (e.g. energy, manufacturing, mobility, ICT). Improving the interaction between science and industry, promoting young talent, supporting career development in applied research for science and industry, and promoting equal opportunities are further goals for the Austrian Research Promotion Agency (FFG), which are being implemented through a wide-ranging portfolio of funding instruments.

Instruments, key performance indicators and priorities

The range of funding instruments provided by the Austrian Research Promotion Agency (FFG) is varied and includes:[3]

- Projects which involve exploring possible research and development themes and options for innovation, and devising initial preparatory steps for projects (entry);
- Specific R&D projects, from basic research through to market-oriented development projects (RDI projects), in the form of both stand-alone projects and R&D projects in co-operation with other firms and institutions;
- Structural projects to facilitate the development and improvement of structures and infrastructure for research and innovation;
- Person-specific projects to promote young talent, develop the qualifications of R&D personnel and improve equality of opportunities; and
- R&D services required to implement commissioned R&D for research investigations on specific issues.

In the 2017 reporting period the Austrian Research Promotion Agency (FFG) received 5,561 applications for funding, of which 3,602 were approved. This represents an increase of approximately 6% in applications, while the number of approvals grew by around 13% compared to the previous year. The success rate for approvals considered in the 2017 reporting year was 56%. The general funding area ("General Programme"), which covers in particular stand-alone projects, and also offers small formats with the Innovation Voucher and Patent Voucher, saw an increase in project approvals of 25%. The structural programmes area, which covers in particular the COMET programme for competence centres, saw an increase of almost 8%, while in the area of topic-based programmes there was a fall of 10%.

3 for an overview of the current portfolio of the Austrian Research Promotion Agency's funding instruments see https://www.ffg.at/instrumente-ueberblick

Table 2-5: Austrian Research Promotion Agency (FFG): Number of grants, 2017

Programme structure	Applications		New projects		Participations	Stakeholders	Approval rate (in %)
	2016	2017	2016	2017	2017	2017	2017[1]
FFG (Total)	**5,270**	**5,561**	**3,186**	**3,602**	**5,870**	**3,407**	**56.2**
General programmes area	2,191	2,686	1,328	1,664	2,192	1,608	67.5
Structural programmes area	1,734	1,557	1,360	1,475	2,318	1,485	43.9
Thematic programmes area	1,264	1,228	470	421	1,271	991	34.0
Aeronautics and Space Agency (ALR)	81	69	28	33	77	57	47.8
European and international programmes		21		9	12	7	47.6

1 Small-scale programmes ("cheque" formats and internships) are not included in the approval rate.

Source: Austrian Research Promotion Agency (FFG).

Table 2-6: Austrian Research Promotion Agency (FFG): Total funding in € millions, in FFG categories, 2016–2017

Programme structure	2016	2017	Cash value 2017	Total costs 2017
FFG (Total)	**521.5**	**562.5**	**434.3**	**1,102.5**
General programmes area	291.7	307.7	179.5	606.8
Structural programmes area	57.9	90.6	90.6	217.4
Thematic programmes area	164.3	155.5	155.5	267.7
Aeronautics and Space Agency (ALR)	7.6	7.3	7.3	9.1
European and international programmes	0	1.4	1.4	1.5

Source: Austrian Research Promotion Agency (FFG).

With regard to the volume of approved funding, in the 2017 reporting year new funding (including loans and liabilities) amounted to €562.5 million. This corresponds to a cash value of €434.3 million. Around 41% of the total cash value of new funding approvals was allocated to the general funding area, 36% to the topic-based programmes area, 21% to structural programmes and 2% to support for the Aeronautics and Space Agency (ALR). The European and International Programmes area implemented measures which resulted in contractual commitments amounting to €1.4 million or 0.3% of the Austrian Research Promotion Agency's total volume. Within the general funding area the monetary emphasis is on the "general programme", which covers R&D projects in individual firms. Amongst the structural programmes, the majority of newly approved funding is accounted for by the COMET programme for competence centres, and by the R&D infrastructure programmes and Research Studios Austria. In the topic-based area the research emphasis is on energy, mobility, ICT and manufacturing.

As far as the range of topics is concerned, approximately 23% of newly approved funding awards are for the manufacturing sector, 21% for the ICT sector and 15% for energy/environment (see Table 2-5 in the statistics appendix). Mobility and Life sciences topics accounted for a further 13% and 11% respectively of the total approved funding in 2017.

An analysis of how Austrian Research Promotion Agency (FFG) funds are distributed among the federal states shows that in 2017, Styria was the frontrunner with a 30% share (see Table 2-6 in the statistics appendix). The state of Vienna is responsible for 23% of funds and Upper Austria for 20%. Compared with the previous year it can be seen that the federal states of Styria and Vienna have swapped plac-es. The shares correspond with the distribution from 2015. Upper Austria remains consistent at third place with a relatively stable share of the funds. For the remaining federal states the funding statistics show no significant changes.

Strategic developments

The Austrian Research Promotion Agency (FFG) has been working consistently on expanding its services and eliminating bureaucratic hurdles for some years. Comprehensive measures have already been implemented, e.g. with the further development of eCall, introduction of the evaluator database and the funding pilots. Further development of funding consultation services remains an additional focus in the customer service area. Work took place in 2017 to improve and simplify the initial information and initial consultation service, which is due to be implemented as of 2018. A project was also launched aimed at simplifying the proposal process; initial pilots are expected to be implemented by the end of 2018.

Trends in the portfolio of instruments

The Austrian Research Promotion Agency (FFG) explored some entirely new avenues in programme development in 2017 in line with its multi-year programme. The focus was on developing and implementing new approaches aimed at broadening the basis for innovation ("Impact Innovation", "Ideas Lab 4.0", "Innovation Workshops"), as well as on supporting efforts to broaden the product pipeline ("Early Stage"). These measures are described in brief below.

- Impact Innovation was developed and implemented as a pilot initiative aimed at broadening the basis for innovation. It promotes the development of innovative ideas and solutions with respect to the innovation process. Knowledge about the methods required can only be built up in the project with external support. The funding can be used for intensive problem analysis and finding ideas for solutions through to developing the solution itself. A total of 104 proposals were submitted in the initial pilot phase, with around 60% of these coming from new customers. The budget available of €1 million allowed 16 proposals to be funded. There are plans to incorporate this initiative into regular operations in 2018 and to expand it to include new elements and empirical values from the pilot phase.
- The Austrian Research Promotion Agency (FFG) launched a new format with the Ideas Lab 4.0 initiative that supports the development of new and innovative ideas for research projects across industries, disciplines and organisations using sandpit workshops. Various stakeholders are brought together in the idea generation procedure with simulation of common out-of-the-box thinking. The first proposals are planned for 2018.
- The first "Innovation Workshops" call was also implemented in 2017. This format makes a structural contribution within the scope of the targets of the Open Innovation Strategy (see Chapter 1.5). Innovation Workshops allow new groups to be incorporated and mobilised in innovation activities and act as interactive on-site communication spaces.
- Firms with high growth potential in new areas of business and technology or in a changing market environment are approached with the new "Early Stage" programme. Standalone projects are funded at the early research stage, i.e. those that have an extremely high level of risk inherent to them.

A measure aimed at targeting prospective academic start-ups was also implemented with the "Spin-off fellowship". This provides support to academics and students with innovative ideas, courage and entrepreneurial spirt in order to prepare research results to be exploited more easily and rapidly within the scope of spin-offs.

The 2018 amendment to the Federal Tendering Act laid the foundation for a further new instrument: the "R&D innovation partnership". This involves a special tendering proce-

Table 2-7: Austrian Research Promotion Agency (FFG): New initiatives and funding instruments

Funding programme/initiative	Target group	Objective
Financial funding instruments		
Impact Innovation	SME	• Promotes the development of innovative ideas and solutions. • An innovation process that develops the ideas and solutions with intensive interaction between all relevant stakeholders is key to this. • Knowledge about the methods required can also only be built up in the project with external support. • The funding can be used for intensive problem analysis and generating ideas for solutions through to developing the solution itself.
Ideas Lab	Firms, research institutes, other non-commercial institutions, individual researchers, associations	• Generation and implementation of new ideas, e.g. for institutes' sub-sector RDI projects across all industries, disciplines and organisations. • Various stakeholders are brought together for a proposed RDI problem situation with simulation of common out-of-the-box thinking.
Innovation laboratories in thematic proposals: https://www.ffg.at/programme/mobilitaet-der-zukunft https://www.ffg.at/programme/produktion **Open-topic innovation laboratories:** https://www.ffg.at/innovationswerkstatt	Firms, research institutes, other non-commercial institutions	• Creation of Open Innovation and experimentation spaces (see chapter 1.5 "Monitoring implementation of Open Innovation Strategy for Austria"). • Easier access to innovation infrastructure and innovation partners. • Improved practical performance through provision and development of test environments under real-life conditions. • Improved innovation skills.
Early Stage	Business enterprises	• Funding high-risk stand-alone projects at the early research phase with high prospects of success in overall economic terms.
Spin-off fellowship	Universities, universities of applied sciences, centres of excellence, research institutes, individual researchers	• The exploitation of existing and newly developed intellectual property for creation of a company should be boosted at the research institutes at a very early stage.

Source: Austrian Research Promotion Agency (FFG).

dure for the development and subsequent acquisition of innovative products and services, unless these are already available on the market. It allows public clients to establish a long-term partnership with one or more partners for the development and subsequent acquisition of innovative products and services, without requiring a separate tendering procedure for acquisition of the innovation developed. The first pilot projects are planned for 2018 using funds from the National RTD Foundation.

At the topic-based level the Austrian Research Promotion Agency (FFG) provides pioneering work with the development of the first national "Quantum research programme". The programme is focused on establishing research capacity and expertise in the area of quantum technology. An Austrian area of strength which is highly competitive on an international level is being driven forward and expanded here in a targeted manner together with the Austrian Science Fund (FWF) as of 2018 based on funds from the National RTD Foundation.

In the area of digitalisation there is already a solid national funding basis with ICT of the future and the broadband initiative (see Chapter 1.5) that is being expanded through the Digital Innovation Hubs. These are a pillar in the "SME.digital strategy"[4] and are seen as networks of expertise, consisting of individual nodes in the form of existing research institutes, intermediaries, multipliers and non-profit organisations that support SMEs in their digitalisation efforts. The "SILICON AUSTRIA" initiative (see Chapter 1.5) is creating new structures throughout Austria. An optimum environment is being created for work in networks, with a leading-edge research institute, supplemented by endowed professorships, innovation labs, etc. The Austrian Research Pro-

4 See https://www.wko.at/Content.Node/kampagnen/KMU-digital/index.html

motion Agency (FFG) is making a crucial contribution to this with its funding instruments. A supplementary focus covering the area of microelectronics is being placed in the Carinthia/ Styria region with "Silicon Alps".

While the KLIPHA programme line (Clinical Studies Phase I and II) was discontinued based on an assessment procedure, the evaluation of the Innovation Voucher[5] was used as an opportunity for replacing the two existing voucher formats with a single revised format. The "New Innovation Voucher" has been available since early 2018. New formats are also being prepared for the Innovation Foundation for Education.

2.3 Austria Wirtschaftsservice (aws)

Legal framework and funding aims

The Austria Wirtschaftsservice GmbH (aws) is the Republic of Austria's wholly owned funding bank for Austrian industry. It was founded by the Act to establish the Austria Wirtschaftsservice (Federal Law Gazette 130/2002), effective from 31 December 2001, and opened on 1 October 2002 under special legislative provision. Owners' interests are represented by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Federal Ministry for Digital and Economic Affairs (BMDW), which appoint the management team and supervisory board of the Austria Wirtschaftsservice (aws). The principals are the owners (the Federal Ministry for Transport, Innovation and Technology and Federal Ministry for Digital and Economic Affairs) and other federal ministries, states and public bodies.

In accordance with its legal remit, the Austria Wirtschaftsservice (aws) is the central point of contact for promoting growth and innovation (Section 2 of the aws Act). The essential tasks of Austria Wirtschaftsservice (aws) set out there include: protecting and creating jobs, strengthening competitiveness taking the special significance of funding for technology and innovation into consideration, supporting research locations by awarding and implementing firm-related federal funding for industry, taking into consideration the special significance of funding for technology and industry for business development and value creation, and the provision of finance and advisory services in support of industry.

Instruments, key performance indicators and priorities

The funding instrument of the Austria Wirtschaftsservice (aws) is geared towards achieving an improvement in the resource basis for innovation and growth projects in the business enterprise sector with the two priority areas of "New enterprise" and "Growth and Industry". Both the basis for funding and the knowledge base of firms are addressed, whereby funding is applied in the five phases of entrepreneurial spirit, technology evaluation, new venture, introduction of new products and services, and leaps in growth. The funding instruments of guarantee, loan, subsidy and equity capital along with non-monetary funding services (e.g. information and consultancy services, coaching) are geared towards specific project requirements and used either alone or in combination.

- Austria Wirtschaftsservice (aws) guarantees are used primarily to provide access to private funds, including in particular bank loans, as well as equity capital; any lack of or insufficient bank collateral (key term "squeeze on collateral") can be balanced, thereby achieving a leverage for additional non-public funding. To this extent they counteract any capital market failure with projects that are comparatively large or risky compared with the firm's funding power. This applies in particular to innovative new ventures, innovation projects as well as leaps in growth, which require capacity to be es-

5 See Austrian Research and Technology Report 2017, Chapter 6.2.4. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

tablished in Austria, as well as for the purposes of steps towards internationalisation.

- The Austria Wirtschaftsservice (aws) erp loan instrument provides particular benefits to firms when project financing requires third-party funding. This often allows both an improvement in the financing structure as well as a reduction in financing costs to be achieved for the firms receiving funding, taking advantage of particularly favourable terms, such as with respect to a suitable term and low fixed interest rates. Use of the classic erp loan is also characterised by particularly good options for combination with grant instruments; this applies in particular to EU structural funding motivated by regional policy or regional governments' strategic objectives. There are also good options available that are increasingly being chosen for combining erp loans with any required Austria Wirtschaftsservice (aws) guarantees.T
- From a funding point of view, the Austria Wirtschaftsservice (aws) grants correspond with strengthening the equity capital base of the firms receiving the funding without requiring a subsequent repayment of the funds. In particular when successful implementation of a firm's plans requires an injection of equity capital, e.g. in light of the size, long-term nature or level of the technological or economic risk with planned investments, but an adequate injection of private funds (e.g. at the early stage of an innovative start-up project) is only possible to a limited extent, the Austria Wirtschaftsservice (aws) grants are especially effective as the costs and structure for the funding as well as the access to additional private funds can be improved in equal measure.
- The equity capital instruments offered by Austria Wirtschaftsservice (aws) can also be used to boost the financial resources for innovation and growth projects. In particular they assume the role of reducing existing financing gaps for start-ups and innovative firms focused on growth, and thereby counteract any failure of the domestic finance markets in the area of equity capital and venture capital financing. The Austria Wirtschaftsservice (aws) strategy plan here is not limited to the direct provision of public funds for equipping firms with equity capital through the Austria Wirtschaftsservice (aws) SME fund and the Austria Wirtschaftsservice (aws) start-up fund. On the contrary, Austria Wirtschaftsservice (aws) also uses its funding instruments as a lever for the injection of private capital (Venture Capital Initiative, Business Angel Fund) and to reduce the search costs incurred between firms and investors through using corresponding mediation services.
- Aside from the four instruments designed primarily to improve funding bases, Austria Wirtschaftsservice (aws) also offers a range of non-monetary consultancy, information and coaching services. This can improve the information and knowledge base for firms, ranging from measures aimed at raising awareness (e.g. awareness for innovation, new trends such as digitalisation) to eliminating information deficits in the designs and plans for innovative projects, to exploiting project results (e.g. IPRs). This uses both the extensive knowledge and expertise of the Austria Wirtschaftsservice (aws) developed in funding processes and also enables access to networks and external expertise for the service offering.

Against the backdrop of the decision by the Austrian Council of Ministers to launch a start-up package and investment campaign, the Austria Wirtschaftsservice (aws) service development for 2017 features some substantial enhancements as compared with the previous year. Aside from the equity capital instruments, which had already reached a high level in 2016, an extraordinary increase can also be identified in terms of monetary funding, as measured against the output indicators such as the number of new approvals and the financing services provided. Improvements to existing service offerings both with respect to guarantees and loans are primarily responsible for this, whereby the business enterprise sector's readiness to invest that rose over the course of the year facilitated the corresponding demand for the Austria Wirtschaftsservice (aws) products; in the area of guarantees in particular, however, it is clear that Austrian firms frequently rely on support with access to credit and capital markets for the funding for new venture, innovation and growth projects. By contrast, in terms of the grant instruments, enhancements to the Austria Wirtschaftsservice (aws) portfolio to include predominantly temporary programmes, including in particular the employment bonus, investment growth premium, ancillary salary cost funding and venture capital premium have resulted in increased applications, commitments, financing services and funding values.

At €1.15 billion the total financing services was approx. 41% above the same value in the previous year, with the increases amounting to 19.6% in loans, 31% in equity investments and 37% in guarantees, while the introduction of broad-based grant programmes even enabling a tripling of the volume of grants (from €74 million in 2016 to €223.7 million for 2017). Accordingly the cash value of the funding granted also featured a +142% rise to €257.9 million.

Smaller firms represent the strongest group of those receiving funding, measured not only applications and commitments. In terms of use of funds also, sole proprietor companies, microenterprises and small enterprises are responsible for more than half of the funds deployed, with shares of 9%, 18% and 28% respectively, while medium-sized and large enterprises achieve shares of 29% and 14% respectively. With regard to the distribution of grant recipients across different sectors, it can be seen that in 2017 manufacturing accounted for the largest proportion of newly approved funding, with 36% of the total, although this has fallen sig-

Table 2-8: Austria Wirtschaftsservice (aws): Number of grants, 2017

Programme/ Instrument	Applications		Participations	Stakeholders	New approvals		Approval rate (in %)
	2017	2016	2016	2016	2017	2016	2017
Austria Wirtschaftsservice (aws) (Total)	**10,340**	**8,025**	**n. a.**	**n. a.**	**5,482**	**3,874**	**53.0**
Guarantee	1,666	1,458	n. a.	n. a.	1,114	1,028	66.9
Loan	1,782	1,416	n. a.	n. a.	1,367	1,127	76.7
Subsidy[1]	6,269	4,467	n. a.	n. a.	2,932	1,676	46.7
Participation	623	684	n. a.	n. a.	69	43	11.1

1 Grants: Not including the 12,648 applications already received in 2018 on the employment bonus.

Source: Austria Wirtschaftsservice (aws).

Table 2-9: aws: Total funding in € millions, 2017

Programme	Applications		New approvals (including liabilities and loans)		Cash value of new approvals (including liabilities and loans)	Approval rate (cash value of approvals/applications)	Total project costs
	2017	2016	2017	2016	2017	2017	2017
Austria Wirtschaftsservice (aws) (Total)	**22,988**	**8,025**	**5,482**	**3,874**	**257.9**	**n. a.**	**3,990.9**
Guarantee	1,666	1,458	1,114	1,028	17.9	n. a.	498.3
Loan	1,782	1,416	1,367	1,127	16.4	n. a.	594.9
Subsidy	18,917	4,467	2,932	1,676	223.7	n. a.	2,822.1
Participation	623	684	69	43	0	n. a.	75.6

Source: Austria Wirtschaftsservice (aws).

nificantly since 2014. In contrast, the proportion of newly approved funding rose for the services sector, trade and the food and beverages industry.

The federal states of Upper Austria and Lower Austria confirmed their traditionally strong positions as compared with all federal states, collectively receiving more than half of the total Austria Wirtschaftsservice (aws) financing in 2017 with 38% and 18% respectively. A further 10% is attributable to Vienna and 7% to Tyrol, two federal states that feature a particularly strong dynamic in 2017. Significantly weaker development in the federal states of Styria, Carinthia and Salzburg is reflected in the fall in funding on the previous year of 8%, 6% and 5% respectively. Although Burgenland and Vorarlberg record the highest increases on the previous year, the shares of these two federal states in the total funding are still just 3% and 2% respectively.

Strategic developments

The directions set for 2017 have temporarily enabled an expansion is the Austria Wirtschaftsservice (aws) funding by 41.25%, i.e. from €810 million in 2016 to €1.15 billion in 2017. For 2018 also, as the financing Bank for the Republic, the Austria Wirtschaftsservice (aws) plans to provide funding of more than €1 billion to the domestic economy in the form of guarantees, loans, grants, investments, as well as services and consultancy.

While a fall overall in funding activity is expected due to time and budgetary restrictions among the broad-based grant programmes, meaning that submissions for the employment bonus were only possible until the end of January 2018, the venture capital premium was suspended as of the end of 2017, and the funds planned for the SME investment growth premium were already completely exhausted in 2017, a continuation in the high funding potential can still be realised for guarantees and loans. Adjustments to the conditions for funding already planned or implemented since early 2017 are playing a role in this. In the erp loan area for instance, continuation of the new venture small loan is planned with an attractive fixed interest rate of 0.5% over the entire term, with simplifications planned for the utilisation and accounting arrangements, and an extension to the utilisation period from six months to one year. The seed expansion stipulated in the Austrian Council of Ministers in 2016 of €20 million by 2020 has also been enshrined in the budget, in order to take account of the significance of the support for highly innovative new enterprises at the early stages to the national economy. While maintaining its high level of funding, the Austria Wirtschaftsservice (aws) can also make a corresponding contribution towards one of its outcome objectives in 2018 – creating growth and employment.

Trends in the portfolio of instruments

The strategic orientation of the portfolio of instruments at Austria Wirtschaftsservice (aws) in recent years has been characterised by on-going further developments aimed at increasing the effectiveness among firms receiving funding, as well as simplifying access to funding and reducing administrative costs and efforts. In view of initial cautious economic performance therefore, further development of the portfolio in 2017 is not based solely on the introduction of new programmes, but is based on numerous adjustments to the terms and conditions for funding, which make the Austria Wirtschaftsservice (aws) funding more attractive overall in financing innovation and growth projects. These include for instance adjustments to the guarantee guidelines, which are expressed through an increase in the upper amount limits, reduced processing and guarantee fees, safeguarding of non-investment-related innovation and growth measures and an expansion in the group of states for project guarantees. The efforts surrounding the erp guideline 2018 which prioritise harmonisation with the Austria

Wirtschaftsservice (aws) guarantees can be seen in a similar manner.

Unlike 2017, which involved a range of new funding measures at Austria Wirtschaftsservice (aws) which were also in part for limited periods[6], only a few new products are planned for 2018. The focus now is on established instruments with due regard to the experience gathered in pilot phases or as part of initial trials for recently introduced instruments. The latter applies for instance to service and consultancy for the IPR programme, including in particular "IP.Coaching" (a programme aimed at developing and implementing IP strategies for SMEs focused on technology), "IP.Market" (with assistance on external commercial exploitation and market transition of innovation and technology) and "License.IP" (which provides support to SMEs and new enterprises in the search and licensing of technological solutions). Industry-specific consultancy services are also experiencing a significant rise in interest, particularly in Life Sciences and ICT. A current strategic objective also involves further development of programmes on knowledge transfer and IP generation at Austrian research institutes, with the topic-based focus placed on Life Sciences.

6 See Austrian Research and Technology Report 2017, Chapter 2.3. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

3 Scientific Research and Tertiary Education

Universities play a key role in the further development of Austria as a location for innovation by imparting knowledge and skills in the fields of science, technology, engineering and mathematics (STEM). In light of the frequently mentioned impression that there is a lack of graduates in the STEM field for the Austrian labour market, Chapter 3.1 discusses certain aspects of a comprehensive mapping of the supply and demand for academically trained STEM specialists in Austria.

Chapter 3.2 will then deal with the topic of equality in R&D and decision-making bodies: on the one hand, the development of women scientists' participation in the R&D sector and in individual sectors of performance in Austria is examined and discussed. On the other hand, the status quo of women in management positions and collegial bodies at universities is outlined. The subsequent sections focus on applied non-university science and technology research and basic non-university research facilities. Finally, the situation of equality in the Austrian Science Fund (FWF) is presented – both in the application process and in the allocation of funding as well as in the committees at the Austrian Science Fund.

Chapter 3.3 examines the question of complementary approaches in the context of Open Science that attempt to reduce the gap (known as "Dark Knowledge") between possible and actual public knowledge. The role of universities in innovation will be examined in more detail in Chapter 3.4; domestic life sciences and health research as well as measures to support the translation of scientific findings into practice in Chapter 3.5.

3.1 STEM university graduates: factor for technological development and innovation

Technological development and innovation are highly dependent on the qualifications of a country's workforce. In addition to the innovative achievements of higher education institutions themselves through their research, their graduates also drive technological and social developments after leaving the educational and training institutions. Education is one of the most important determinants of economic growth. The effect is strongest where the average level of education best fits the economic structure. For catching-up countries, secondary education and imitation or adaptation are of particular importance. For OECD countries characterised by complex technologies and organisational forms, tertiary education has the greatest influence on economic growth.[1] The creation of excellent framework conditions for universities and universities of applied sciences as the basis of the innovation system is therefore one of the central goals of the RTI strategy 2011.[2] The importance of higher education for innovation is made clear, among other things, by the fact that the educational level of the (young) population is a central indicator in the European Innovation Scoreboard. Human resources are measured there by the percentage of 25-34 year olds who have completed tertiary education and the number of new doctorate de-

1 See Ang et al. (2011); Teixeira and Queirós (2016).
2 See BKA et al. (2011).

grees in this age group (per 1,000 persons in the population aged 25-34).[3]

A central factor for technological development and innovation are especially graduates of so-called STEM subjects, whereby it is important to inspire young people for these contents as early as possible in the educational process. STEM stands for science, technology, engineering and mathematics. In Austria the term MINT is generally used (mathematics, informatics, natural science and technology).

3.1.1 The STEM concept in the context of higher education and on the labour market

In a constantly changing economic environment, STEM skills are central to the entire population in order to participate in productivity progress. In particular, the importance of IT skills has been increasing for years in almost all professional fields due to digital transformations. Almost every third employee in Austria, for example, has "something to do with technology".[4] In order not only to keep up with progress, but also to promote technological development and innovation, the advanced knowledge of STEM experts acquired at secondary schools and above all at universities is needed.

STEM subjects are, according to most national and international definitions, the ISCED-F-2013 fields of education "Science, Mathematics and Statistics", "Information and Communication Technology" and "Engineering, Manufacturing and Construction". EU definitions do not include the sub-category construction, which covers architecture, civil engineering and landscape planning.[5] While at school level the majority of vocational medium-level schools and VET colleges can be allocated to STEM education, at the higher education level this includes a broad spectrum of subjects ranging from biology and nutritional sciences to physics, geography, mathematics, various specialisations in computer science and mechanical engineering through to process engineering and architecture.

Graduates of these subjects are particularly active in STEM occupations: according to the EU definition, the ISCO (International Standard Classification of Occupations) occupational groups 21 "natural scientists, mathematicians and engineers" and 25 "academic and comparable specialists in information and communication technology" are designated "STEM professionals", the occupational groups 31 "engineering and comparable specialists" and 35 "information and communication technicians" are classified as "STEM associate professionals".[6]

3.1.2 Demand for STEM graduates

Generally better qualified

The economy and the world of work are undergoing a structural change towards a knowledge-based society characterised by research, technology and innovation. This leads to an increasing importance of knowledge-based employment, as can be seen from the development of the number of people with higher education in gainful employment: from 2008-2015 this has increased by approx. 200,000 (+48%) – and thus much stronger than those of all people in gainful employment (+7%).[7] While the number of vacancies requiring low qualification has decreased according to Statistics Austria, the number of vacancies requiring high formal education has increased since 2012. Despite this significant expansion in the number of academically qualified employees, individual educational returns, i.e. the income advantage gener-

3 See European Commission (2017).
4 See Schmid et al. (2016).
5 See European Commission (2015b).
6 See ibid.
7 See AMS (2016).

ated by a university degree, have remained constant over the past two decades.[8]

The absolute number of unemployed with a university degree has increased due to the strong increase in the number of academics. However, since the beginning of the economic crisis in 2008, the unemployment rate among academics has risen much less than among the population as a whole: in December 2017, the national definition of the unemployment rate for graduates was 3.7%, well below the Austrian average of 9.4% and the unemployment rates of persons with higher secondary education (AHS 6.4% and BHS 4.2% respectively).[9]

Thus the expansion of education has not yet led to "education inflation", and university degrees generally continue to be rewarded. The labour market demand for university graduates has increased with the supply. Academics can benefit from the Europe-wide observable change in the employment structure in favour of the highly qualified and to the disadvantage of the low-skilled workers.

Demand for STEM university graduates

The labour market situation of academics can generally be regarded as good, in some fields of education the demand on the labour market is even likely to exceed the supply of university graduates. Surveys of firms often talk about a shortage of skilled workers – this usually refers to well-trained engineers and computer scientists.[10] Highly qualified STEM graduates are in great demand in many economic sectors, especially in those with high innovation intensity such as information and communication technologies, research services and manufacturing of goods.[11] Recruitment difficulties in these innovative industries are particularly severe compared to other economic sectors.[12]

In the last five years, the number of employees has increased particularly in the academic STEM occupations "natural sciences, mathematics, engineering" (+48%) and "information and communication technology" (+40%).[13] This has been accompanied by a reduction in the individual educational returns of technical and natural scientific degrees since 2005.[14] The starting salaries of STEM university graduates have fallen slightly from 2005-2013 after adjustment for inflation. However, salaries are above average, especially after graduating in engineering, so the increased demand is unlikely to be fully covered.

This is also evident in the predominantly problem-free entry into the labour market of STEM university graduates: their labour market integration and income are higher and the time until their first employment is shorter than that of graduates from most other fields of education. However, for both men and women, the income and labour market integration of STEM graduates and graduates of other subjects converge about five years after graduation. The separate calculation by gender is necessary because a clear disadvantage of female STEM graduates compared to male STEM graduates can be observed on the labour market.[15]

At least in the first years after graduation, the labour market data of STEM university of applied sciences and university graduates are very similar. Most firms are looking for higher education graduates independent of the training institution, and graduates from technical colleges are also often sought.[16] Jobs in research

8 See Vogtenhuber et al. (2017).
9 See AMS (2016); AMS (2017).
10 See IV (2016); Jaksch and Fritz (2015).
11 See Binder et al. (2017, 219ff).
12 See Gaubitsch (2015, 87).
13 See Microcensus Labour Force Survey of Statistics Austria. Annual data 2011-2016 StatCube (Statistics Austria). ISCO-08.
14 See Vogtenhuber et al. (2017, 30ff).
15 See Binder et al. (2017, 228ff).
16 See Schneeberger and Petanovitsch (2011, 75f).

and development are an exception; these are often explicitly advertised for university graduates. As a result, STEM university of sciences graduates are significantly less common than STEM university graduates in the particularly research-intensive economic sectors of education and teaching (especially employment at universities) and in freelance, scientific and technical services.[17]

The importance of sufficient availability of STEM specialists is often discussed in studies by international institutions. Although not everywhere in Europe, there is a shortage of STEM specialists in regions with a high concentration of high-tech and knowledge-intensive firms.[18] Among other reasons for these gaps, analysts say there are too few university graduates to fill the increasing demand and that tasks in STEM occupations are becoming increasingly difficult.

Differences in demand for different fields of education

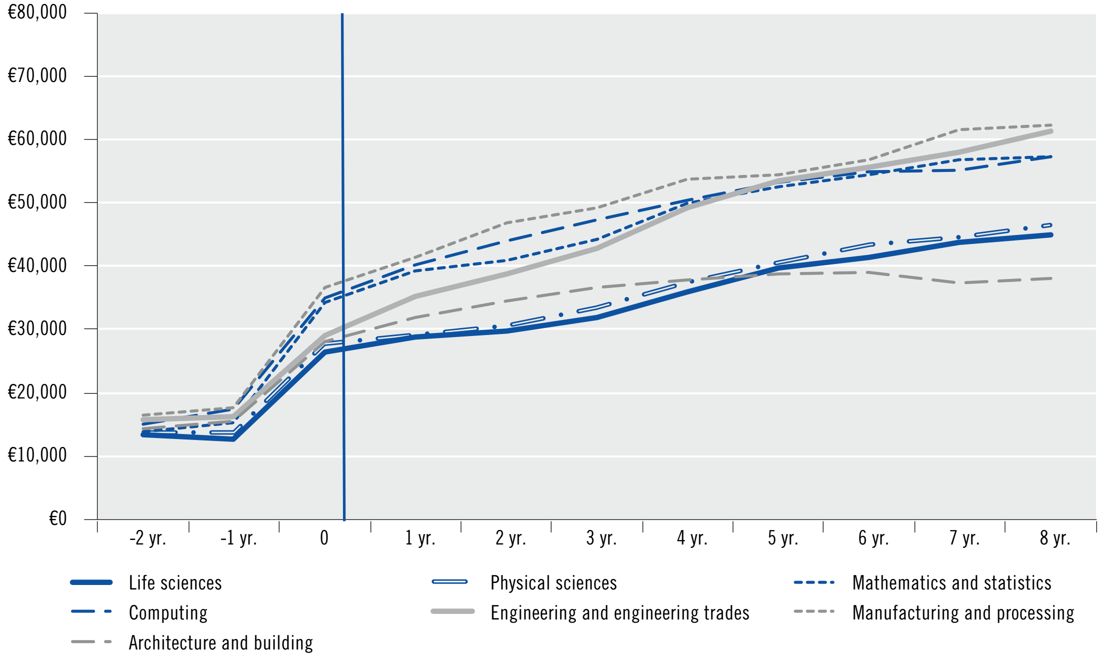
Analyses of the labour market situation, separated by subject, show large differences in demand between the STEM study subjects. On average, graduates of a master's or degree programme in computing or engineering find work much more quickly in employment or as self-employed persons than graduates in the life sciences, physical sciences or architecture. A particularly high number of computer science students are also already employed during their studies. This indicates that many IT students are recruited without a degree to meet labour market needs.[19]

Surveys show firms also mostly look for graduates in the fields of engineering and computer science rather than natural scientists and architects. In order to diagnose a shortage of skilled workers, the number of job seekers for a particular job is compared with the number of vacancies.[20] If a maximum of 1.5 job seekers (in exceptional cases 1.8) are registered with the AMS for a vacant position, then the occupation is listed by the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK) as an understaffed profession.[21] In 2018 this list includes some non-academic occupations, engineers and graduate engineers for mechanical engineering, power engineering and data processing as well as graduate engineers for low-current and telecommunications engineering. Bottlenecks among highly qualified people in the fields of IT, mechanical engineering and electrical engineering are not specific to Austria, but represent a problem in several European regions.[22]

By comparison, there is less demand for graduates in the fields of life sciences and physical sciences. In the STEM comparison, they work more frequently in the less research-intensive industries of the public sector and commerce. A comparatively high proportion of approx. 7-8% of master's degree and diploma graduates leave the country within four years of graduation.[23] In 2016 the former Federal Ministry of Science, Research and Economy (BMWFW, now the Federal Ministry of Education, Science and Research, BMBWF) presented a strategy to strengthen Austria as a life sciences and pharmaceutical location (see Chapter 1.5), the possible consequences of which are not yet visible in the available data.

17 See Binder et al. (2017, 223ff).
18 See European Commission (2015a); Cedefop (2016); German Federal Employment Agency (2016).
19 See Binder et al. (2017, 185ff).
20 The disadvantage of this method is that only a fraction of the vacancies are reported to the Public Employment Service. The proportion of jobs reported to the AMS in all of the jobs surveyed by Statistics Austria in the "Job Vacancy Survey" amounted in 2012 to approx. 41%, with a particularly low reporting rate for highly qualified jobs.
21 See Fink et al. (2015, 38).
22 See European Commission (2015a).
23 See Binder et al. (2017, 200ff).

Fig. 3-1: Median income of female university graduates (Master's/diploma) by field of education



Note: graduation years 2004/05–2008/09. All graduates with a social security number valid at the beginning of their studies and worked for more than one month in the respective year.
Y-axis: extrapolated gross annual income adjusted for inflation in €. X-axis: years before and after graduation.

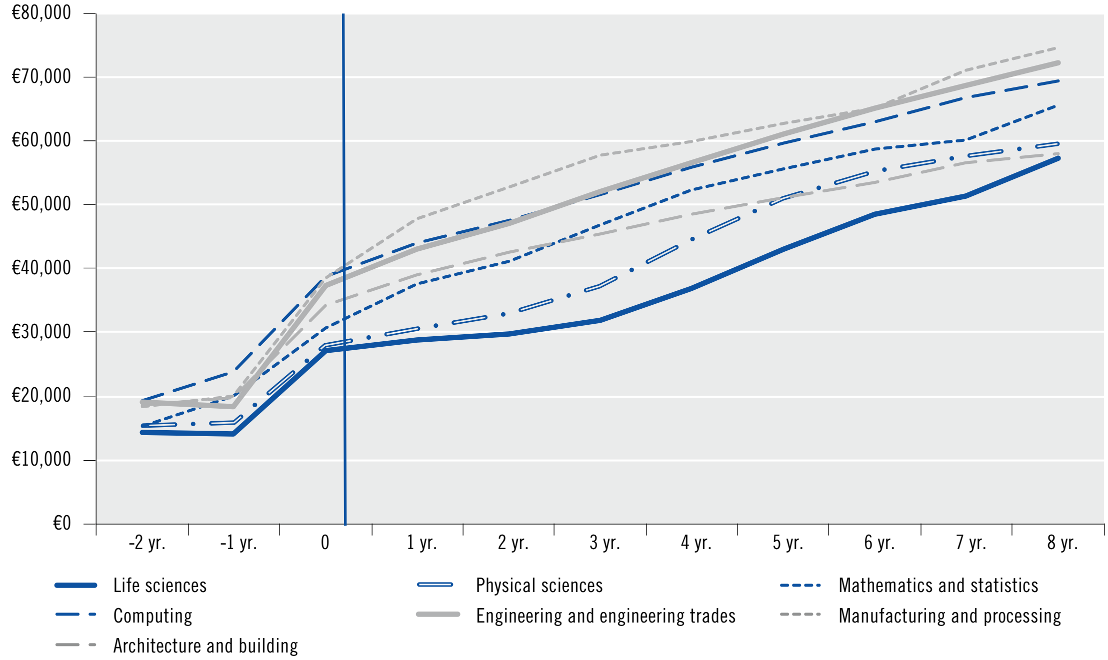
Source: Binder et al. (2017, 216).

These differences between subjects are also reflected in the incomes of STEM professionals. Figs. 3-1 and 3-2 show the median income of master's degree and diploma graduates at universities two years before and eight years after graduation. The reference point is the calendar year marked with a vertical blue line in which the degree was completed. All gainfully employed are taken into account, regardless of the number of hours they work. Both men and women earn significantly more after graduating in computing, engineering, manufacturing and processing[24] than after graduating in life sciences, physics, architecture or building. In all fields of education, income increases significantly in the years after graduation. The differences between the fields of education among male university graduates narrow over time. Some of the gender differences visible in the figures are due to the different average hourly figures. However, even comparing full-time employees only, women earn significantly less than men, especially in the technical subjects and computing.[25]

24 These include in particular courses of study offered at the University of Leoben, such as mining or petroleum engineering, as well as parts of the forestry and wood industry.

25 See Binder et al. (2017, 333f).

Fig. 3-2: Median income of male university graduates (Master's/diploma) by field of education



Note: graduation years 2004/05–2008/09. All graduates with a social security number valid at the beginning of their studies and worked for more than one month in the respective year.
Y-axis: extrapolated gross annual income adjusted for inflation in €. X-axis: years before and after graduation.

Source: Binder et al. (2017, 216).

Future demand trends

The demand for STEM university graduates is expected to continue to grow in the future. This is shown by most labour market forecasts, according to which the trend towards generally higher qualifications will continue. Accordingly, employment in Austria will increase in all academic professions. For STEM occupations, one of the highest growth rates is predicted.[26] According to data from Cedefop[27], the number of academic STEM jobs in the European Union will increase by +12.1% between 2013 and 2025. At +24.7%, Austria has one of the highest growth rates forecast. The Cedefop forecast also makes it clear that STEM jobs will be created primarily in the highly qualified segment, while medium and low-skilled jobs will only be partially filled again if they become vacant.[28]

The demand for experts in information and communication technology is likely to increase in particular. Although this is difficult to validate due to a lack of statistical data, most forecasts assume particularly high growth rates in the ICT sector.[29] This also applies to Austria, despite the danger of outsourcing in this industry to countries with lower wage levels.[30] In addition to the demand for IT experts, the demand for IT skills should also increase in most (research) areas.[31] This can be seen, for example, in the establishment of research priorities and centres for "Digital Humanities", in which in-

26 See Fink et al. (2014); Alteneder and Frick (2015).
27 European Centre for the Development of Vocational Training.
28 See European Commission (2015a, 27).
29 See OECD (2016a).
30 See Eichmann and Nocker (2015, 158).
31 See OECD (2016a).

formation technologies are used in the cultural sciences and the humanities. Persons in ICT-intensive occupations earn on average 2.4% more in Austria than persons in comparable, non-ICT-intensive occupations.[32] According to surveys of firms and labour market forecasts, the demand for academically trained engineers will also continue to rise due to the generally higher qualification.[33] According to estimates by labour market experts, the mixed labour market situation of life scientists and natural scientists in Austria will continue to change little in the future.[34] The Europe-wide expansion of so-called "green jobs" is also likely to benefit engineers and people who combine science and technology knowledge.[35]

In Germany, the warnings of an emerging shortage of STEM academics are even louder than in Austria due to the demographic development with a strongly shrinking working population there.[36] If this should prove true, there could be increased efforts to entice away Austrian specialists.

However, due to the unpredictable effects of digitalisation, automation and industry 4.0 on the labour market, forecasts for the future are subject to great uncertainty. Between 1995 and 2015, 390,000 jobs were added and 75,000 jobs lost in Austria's highly to extremely digitalised industries, while 189,000 jobs were added in moderate to less digitalised sectors, but 280,000 were lost.[37] According to this, digitalisation has not (yet) led to the employment losses feared by many researchers. Frey and Osbourne (2013), for example, expect automation potential of up to half of the jobs in the USA in the future.[38] Whereas the analysis by Frey and Osbourne (2013) refers to the automation potential of individual occupations as a whole, a series of more recent studies – which are at a more realistic level of estimating the rationalisation potential of individual tasks within specific occupations – come to significantly less dramatic results.[39] Based on this activity-based approach, Arntz et al. (2016) calculate for example that the percentage of jobs with high automation probability ranges from 2% in Russia to 12% in Austria, Germany and Spain.[40] Nagel et al. (2017) come to a similar conclusion for Austria with an activity-based rationalisation potential of 9% of employees. Academics throughout have the lowest "automation risk", while the demand of firms for medium and low qualifications could collapse further as a result of technological progress. Since new job profiles are likely to call for highly qualified employees in most cases, the existing trend towards higher qualification due to automation and industry 4.0 is likely to accelerate even further. At the same time, however, innovations in the IT sector, particularly with regard to "artificial intelligence", also have the potential to replace more complex tasks in the future, according to some forecasts, which on the one hand would alleviate feared labour shortages and on the other hand could increase unemployment among academics in certain industries.

3.1.3 STEM at universities, universities of applied sciences and in school-related areas

Altogether in 2014/15 there were approx. 92,000 students (excluding doctoral students) enrolled in STEM fields of education, 82% of them at

32 See (2017b, 108f).
33 See Fink et al. (2014).
34 See (2015).
35 See Haberfellner and Sturm (2013).
36 See Federal Employment Agency (2016).
37 See Streissler-Führer (2016).
38 See Frey and Osbourne (2013).
39 See Austrian Research and Technology Report 2017, Chapter 4.3. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017); as well as Zilian et al. (2016).
40 See Arntz et al. (2016).

public universities and 18% at universities of applied sciences.[41] Around 16,000 STEM bachelor studies were newly enrolled in for the 2014/15 academic year (69% at universities and 31% at universities of applied sciences) and almost 8,000 were completed (64% at universities and 36% at universities of applied sciences). Within an observation period of 14 semesters, 31% complete the STEM bachelor's programme they have begun at universities, 13% are still enrolled in the programme they have begun, 30% have changed to another programme and 26% have discontinued all studies at public universities. Taking into account the degrees in other studies, after 14 semesters half of the STEM beginners have completed (some) course of study – the one they started, or another.[42] At universities of applied sciences, the success rates after 14 observation semesters are 70% (full-time courses of study) and 60% (extra-occupational courses of study) – by then no more students are enrolled at universities of applied sciences. The main reasons for these discrepancies according to university type are the differing access regulations to studies and differences in the organisation of studies.[43] The success rates for started STEM studies are lower at universities and universities of applied sciences than in other fields of education. However, STEM beginners at universities more often complete any degree than beginners in other subjects.

Around 5,750 people completed a STEM master's degree or degree programme in 2014/15 (67% at universities and 33% at universities of applied sciences; see Table 3-1), 3,200 of them in the STEM core areas of engineering and engineering trades (2,100) and computing (1,100). After several years of stagnation, the number of STEM courses taken, begun and completed from 2009/10 to the academic year 2014/15 has risen by around 10%, slightly higher at universities of applied sciences than at universities. In the last five years, the number of graduates in computer science degree courses (+35%) and engineering studies at universities (+26%) has increased quite strongly, although they had decreased on a similar scale in previous years.[44]

The proportion of female students in the STEM core areas of computing and engineering remains below 20%, though slightly higher in life science, physical science and mathematics.[45] The proportion of first-year female STEM students in Austria is slightly lower than the OECD average.[46]

Austria has a special international position, particularly with regard to technical vocational training: firstly, many technical skilled workers in high demand from the economy receive dual training. Secondly, vocational secondary schools and VET colleges also have a high status. They also offer highly specialised technical training in innovative fields such as industrial engineering and mechatronics. The high level of this training has recently been recognised by UNESCO: according to the International Standard Classification of Education-2011, qualifications at VET colleges are classified as tertiary (ISCED Level 5).

Table 3-2 roughly estimates the number of persons completing a STEM training per year for all levels of education. Each person is considered only once (with the highest level of training). A simple addition would clearly overestimate the number of graduates, since, for example, a person who has completed a technical college, a bachelor's and a master's degree would be counted three times.[47] Around 6,000

41 Private universities hardly offer STEM studies. They will not be considered in the following.
42 See BMBWF (2018, 211).
43 See ibid, 183. At universities of applied sciences, studies are organised according to age groups similar to school classes.
44 See Binder et al. (2017, 101).
45 See ibid., 140ff.
46 See OECD (2017a, 282). ISCED-F 2013 natural sciences, mathematics and statistics fields of education: AT: 49% vs. OECD: 50%; information and communication technology: AT: 17% vs. OECD: 17%; engineering, manufacturing, architecture and building: AT: 23% vs. OECD: 24%.
47 See Binder et al. (2017, 171).

Table 3-1: STEM degrees at public universities and universities of applied sciences, academic year 2014/15

		Degrees Bachelor	Degrees Master's/diploma	Last 5 yrs.: Degrees Master's/diploma
Biosciences	University of applied sciences	95	42	-
	University	1,003	571	-3%
	Total	1,098	613	+4%
Physical sciences	University of applied sciences	-	-	-
	University	785	594	+14%
	Total	785	594	+14%
Mathematics and statistics	University of applied sciences	-	-	-
	University	254	158	-21%
	Total	254	158	-21%
Computer science	University of applied sciences	763	536	+35%
	University	603	563	+1%
	Total	1,366	1,099	+16%
Engineering and engineering trades	University of applied sciences	1,700	1,136	+2%
	University	1,018	977	+26%
	Total	2,718	2,113	+12%
Manufacturing and processing	University of applied sciences	85	40	+0%
	University	124	123	+31%
	Total	209	163	+22%
Architecture and construction	University of applied sciences	153	144	-18%
	University	1,279	863	+7%
	Total	1,432	1,007	+2%
STEM Total	University of applied sciences	2,796	1,898	+10%
	University	5,066	3,849	+8%
	Total	7,862	5,747	+9%

Note: studies begun and degrees completed in the academic year 2014/15. Last 5 years (5 yrs.): growth from the academic year 2009/10 to the academic year 2014/15: doctoral studies, non-degree programmes and incoming mobility students were excluded from all analyses.

Source: Binder et al. (2017, 99). Data source: university statistics. Calculations: IHS.

Table 3-2: Persons who complete a STEM training per year but then do not complete any further training (estimate)

Apprenticeship	approx. 24,000-25,000
Intermediate technical and commercial schools	approx. 3,000-5,000
Technical and commercial upper secondary schools	approx. 7,500-9,500
University of applied sciences	approx. 3,000
University	approx. 6,000
Total	**approx. 43,500-48,500**

Note: calculations/estimates based on university statistics, the school statistics of Statistics Austria, and the apprentice statistics of the Austrian Federal Economic Chambers (WKO).

Source: Binder et al. (2017, 172).

people per year finish at a STEM university for the first time, and approx. 3,000 people graduate from a STEM university of applied sciences for the first time. Between 7,500 and 9,500 graduate from a technical college each year and then do not complete a STEM university degree. Roughly estimated, between 3,000 and 5,000 people complete a medium-level technical-commercial school each year, and approx. 25,000 an apprenticeship in a technical or manual profession. After adjustment for multiple degrees, a total of around 45,000 people successfully complete a STEM training each year. However, it can be assumed that not all graduates actually work in STEM occupations afterwards.

Level of education and number of graduates in international comparison

As a result of the upgrading of the qualifications of VET colleges, the tertiary rate, i.e. the proportion of the 25-64 year old resident population with a tertiary education, has risen to the EU average of 31%.[48] Half of them have obtained a degree from a VET college, other college or comparable educational institution, the other half from a university.

The proportion of STEM graduates in an international comparison is also very high due to the high proportion of technical colleges (HTLs) among VET colleges: in 2015, 20% of tertiary qualifications were in the fields of engineering and engineering trades (EU-22: 14%), 6% natural sciences, mathematics and statistics (EU-22: 6%) and 4% in information and communication technologies (EU-22: 4%), i.e. about 30% in total of all STEM subjects.[49] This is the second highest value of all OECD countries after Germany, Austria is just ahead of Sweden and Finland and far ahead of innovation leaders such as the Netherlands (15% excluding doctorate degrees) and Denmark (20%). Looking exclusively at university degrees without the degrees from higher vocational schools, in Austria in 2014/15 about 27% each of bachelor's, diploma and master's degrees were in STEM fields of education.[50]

The proportion of STEM graduates among the 25-64 year old population with a tertiary education is 34% (OECD: 26%)[51], just as much above the OECD average as the proportion of STEM beginners (31%) among all tertiary beginners (OECD: 27%).[52]

In terms of the number of new doctorate degrees (per 1,000 persons of the 25-34 year old population), an indicator of the European Innovation Scoreboard, Austria is slightly above the EU average at 1.9 (EU-28: 1.8).[53] Looking at the STEM subjects in Fig. 3-3, Austria, with 0.9 doctorates per 1,000 persons of the 25-34 year old population, was also in the upper midfield of the European Union in 2015, behind innovation leaders such as Sweden (1.5), Denmark (1.4) and the United Kingdom (1.4), but ahead of most Central and Southern European countries.

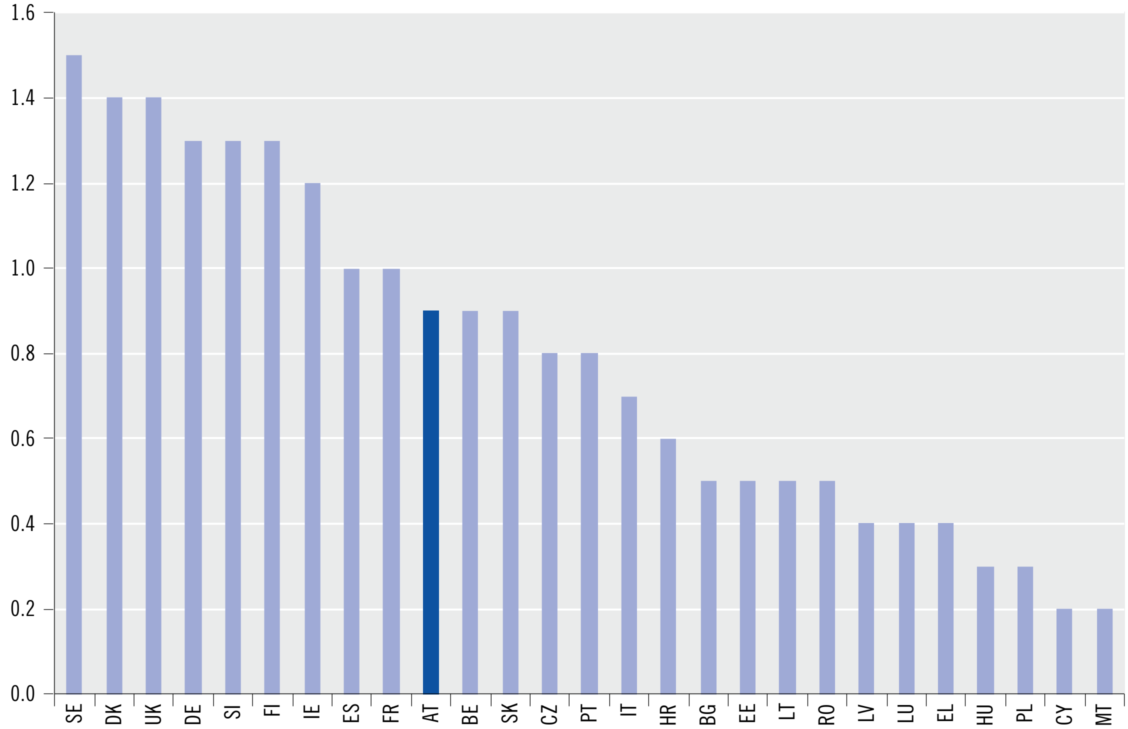
Measures for enhancing the numbers of highly qualified STEM graduates

The Austrian University Development Plan aims to reduce drop-out rates and increase the number of prospective students in order to counteract over the long term the risk of a shortage of graduates in the STEM industries that are in high demand on the labour market.[54]

In the performance agreements of the Federal Ministry of Education, Science and Research (BMBWF) with the universities, a special focus will be placed in future on the fields of engineering and computer science[55]. In the next performance agreement period, an improvement in support and supervision is planned in order to increase the success rates. Qualification offers and support measures (e.g. for graduates of secondary academic schools, who have significantly higher drop-out rates in most STEM subjects than, for example, graduates of technical colleges) are intended to reduce the heterogeneity in relation to previous knowledge acquired at school and to reduce drop-outs. In order to reduce jobouts (dropout due to employment) in the IT sector, cooperation between universities and universities of applied sciences is envisaged, which should facilitate getting a degree alongside the job. In addition, the interest of

48 See OECD (2017a, 72). The share of 25-34-year-olds with a completed tertiary education (= indicator of the European Innovation Scoreboard) is 39.7%, slightly above the EU average (38.2%; see European Commission 2017, 82).
49 See OECD (2017a, 72).
50 See Binder et al. (2017, 97ff); Unger et al. (2017, 101f).
51 See OECD (2017a, 52).
52 See Ibid, 282.
53 See European Commission (2017, 82).
54 See Federal Ministry of Science, Research and Economy (BMWFW) 2017, Austrian University Development Plan 2019-2014, system target 4c.
55 Among other things on the basis of the results of the "Computer Science" action field of the "Future University" project (see BMBWF 2018, 53).

Fig. 3-3: New doctoral degrees in STEM subjects per 1,000 persons aged 25-34 in the EU-28, 2015



Note: EL data from 2014. No data available for NL. For country codes see Table 8.1 in Annex I.

Source: Eurostat Database.

those entitled to study in being admitted to STEM studies is to be improved by joint information activities of the universities, with a targeted focus on women. A well-founded study selection decision should be supported by a better communication of the training, qualification and professional profiles. New study places for engineering and computer science are to be created at universities of applied sciences; in a first step, 450 new study places will be available in these courses of study from the academic year 2018/19.

Measures to increase STEM interest in school-related areas

However, the basis for the interest in STEM must already be laid before the school leaving examination. The basic skills for a vocational education and training 4.0 are already laid down at school. Many school measures, mostly accompanied by scientific evaluations, are aimed at raising STEM awareness. The Federal Ministry of Education (now the Federal Ministry of Education, Science and Research, BMBWF), the Federation of Austrian Industry, the University College of Teacher Education Vienna and the Knowledge Factory have initiated a STEM seal of approval. This award is given for three years at a time and is intended above all to contribute to the development of priorities at the respective school (including pre-schools).[56] In order to support schools in their further development towards STEM schools, coaching and gender-sensitive courses such as "MINT mag man(n) eben" are also offered. With the pilot

56 See www.mintschule.at

project "MINT 3D Printing" in cooperation with the "Industrie 4.0 Pilotfabrik" at the Vienna University of Technology, this forward-looking technology is to be used to creatively and artistically strengthen interest in STEM (MINT) subjects among both schoolgirls and schoolboys. Initiatives such as IMST ("Innovations make schools top!") and competitions such as "Jugend Innovativ" are intended to encourage pupils to take part in projects in STEM subjects. Innovative teaching concepts such as "Mathematik macht Freu(n)de" propagate a fearless and fun handling of mathematics and a stronger individualisation of the teaching provide for increased STEM enthusiasm. The continuing VET 4.0 course under the aegis of the Federal Ministry of Education, Science and Research (BMBWF) prepares vocational school teachers for the new pedagogical and technical challenges of digitalisation and Industry 4.0 and stimulates corresponding projects with industrial firms and tertiary institutions (see Chapter 1.5).

3.1.4 Summary

Innovative research is only possible when a sufficient number of well-trained people are available. University graduates in the STEM subjects are of particular importance for the advancement of technological developments. The results presented in this chapter suggest that the demand for some STEM qualifications exceeds supply. This applies in particular to the fields of computer science and engineering. In these areas, university graduates have easy access to the labour market and comparatively high incomes. The demand is somewhat lower for graduates from other STEM fields of education such as life sciences, natural sciences or architecture. These have a more difficult entry into the labour market with lower incomes, lower labour market integration and a higher proportion of graduates who move abroad after graduation.

The change in the employment structure towards increased demand on the labour market for highly qualified workers also makes increased investment in higher qualifications and higher education in the STEM sector unavoidable. The current high demand for university graduates is likely to continue to rise in the future – most labour market data speak against the often expressed fear of a devaluation of university degrees despite the increase in the number of graduates. Even if future developments are difficult to predict due to disruptive technological changes (Industry 4.0, digitalisation), there is much to suggest that existing recruitment problems in the areas of information technology, mechanical engineering, electrical engineering and electronics could become even more acute in the coming years. The number of highly qualified STEM jobs, which has already risen sharply in recent years, is expected to increase further.

Since a shortage of highly qualified STEM specialists would jeopardise the innovative ability of the Austrian economy, special attention is paid to ensuring there is a sufficient number of graduates in the fields of engineering and computer science. Increased measures are to be taken to increase the success rates. A variety of projects and information campaigns are carried out both at universities and schools in order to increase interest in STEM and thus the number of those who choose further education in this field.

3.2 Equality in R&D and decision-making bodies

The promotion of gender equality in research, technology and innovation (RTI) is an essential component and cross-cutting theme in Horizon 2020, and the Austrian ERA Roadmap specifies three objectives in this regard,[57] in order to improve the balance between the sexes and compensate for associated inefficiencies.

- Firstly, the proportion of women in all sec-

57 See Federal Ministry of Science, Research and Economy (BMWFW) (2016a).

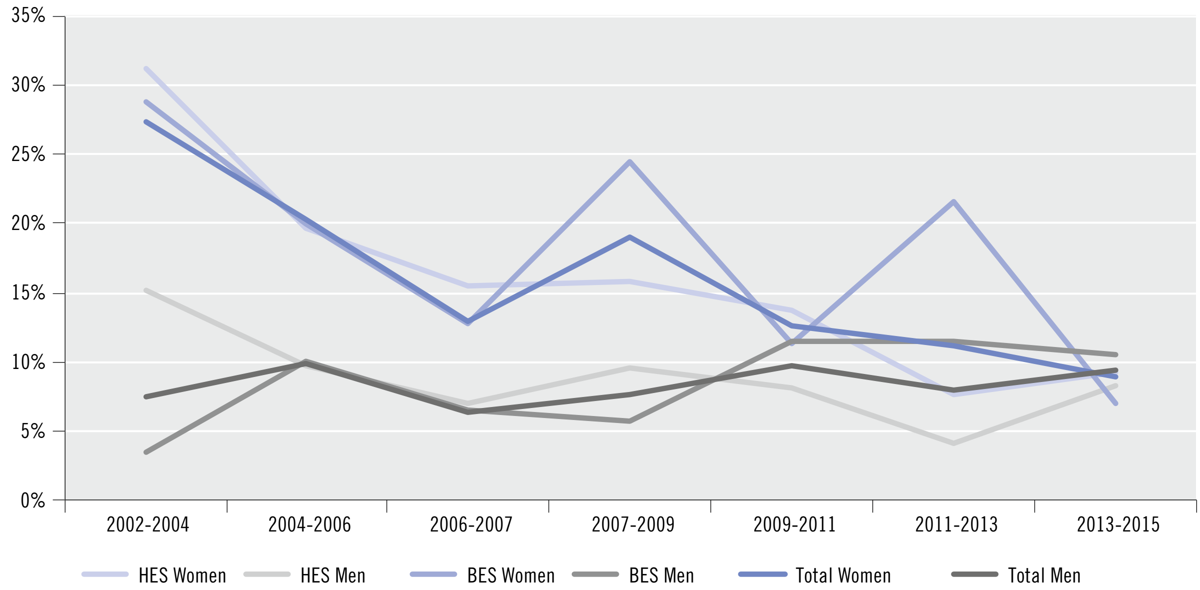
tors and hierarchy levels is to be increased, thereby reducing vertical and horizontal segregation.
- Secondly, cultural change is to be initiated in scientific and research organisations by integrating equality into structures and policies.
- Thirdly, the gender dimension should be more firmly anchored in research content and teaching.

These objectives are also reflected in the various objectives of the ministries. The Federal Ministry for Transport, Innovation and Technology (BMVIT) aims to improve gender equality in the R&D business enterprise sector. This is measured by the number and proportion of women scientists employed in the business enterprise sector. Here, the proportion of women scientists in the business enterprise sector is to be increased to 20% by 2020. However, the Impact Monitoring for 2016 showed that, at 14.8%[58], the target was not achieved. Until 2020, the Federal Ministry of Education, Science and Research (BMBWF) will be pursuing the goal (according to Impact Monitoring, subdivision 31) of achieving balanced gender relations at Austrian universities by increasing the proportion of female professors, filling university management bodies in line with quotas, increasing the proportion of women in career positions at universities and increasing the proportion of women in the executive bodies of the Agency for Quality Assurance and Accreditation Austria (AQ Austria). The 2016 Impact Monitoring showed a better-than-expected degree of target achievement for the key figures "proportion of female professors and women in university careers", and for the key figures "proportionately staffed university management bodies" and "proportion of women in the executive bodies of AQ Austria" the degree of target achievement was achieved in full. The Federal Ministry for Digital and Economic Affairs (BMDW) aims to make better use of the existing potential of skilled workers by 2020 (according to Impact Monitoring, subdivision 40). The corresponding gender-relevant indicator is the increase in the proportion of women in leading positions in research projects funded by the Austrian Research Promotion Agency (FFG) on behalf of the Federal Ministry for Digital and Economic Affairs (BMDW). This key figure is shown in the 2016 Impact Monitoring as *"fully achieved"*.[59] In addition, the coordination of activities to promote equality between the federal ministries takes place within the framework of two thematic clusters, one dealing with the area of labour market and education and the other with decision-making positions and processes.[60]

Overall, the report on Impact orientation states that progress has been made in the field of gender equality in RTI, *"but there is still a long way to go to reach the goal"*[61]. The following sections will therefore present the development of the representation of women in the RTI sector. The data from Statistics Austria's R&D surveys are used to describe the differences between the two major R&D sectors – the higher education sector and the business enterprise sector (see Section 3.2.1). Subsequently, the participation of women in university management positions and collegial bodies is presented (see Section 3.2.2). The next two sections focus on applied non-university science and technology research (see Section 3.2.3) and then on basic non-university research facilities (see Section 3.2.4). The last section (3.2.5) is devoted to the representation of women in the executive bodies and review procedures of the Austrian Science Fund.

58 Proportion of women scientists in the business enterprise sector measured as FTE (full time equivalents).
59 See BKA (2017); see www.wirkungsmonitoring.gv.at
60 See BKA (2017, 418ff).
61 See BKA (2017); see www.wirkungsmonitoring.gv.at

Fig. 3-4: Growth rates in the number of male and women researchers (headcount) for the Higher Education Sector (HES), the Business Enterprise Sector (BES) and the whole R&D sector, 2002-2015



Source: R&D surveys, Statistics Austria. Calculations: JOANNEUM RESEARCH.

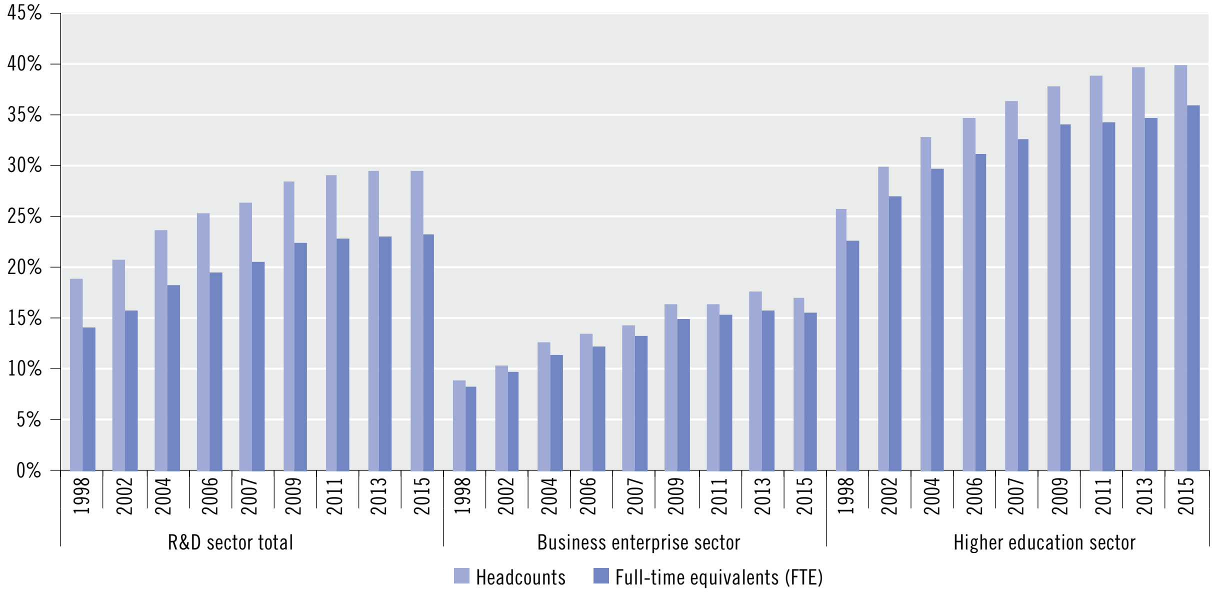
3.2.1 Trends in the participation of women researchers in the R&D sector

The data from the 2015 R&D survey show that a total of approx. 23,000 women scientists (represented in headcounts)[62] are employed in the R&D sector in Austria. Since 1998, the number of women scientists (headcounts) has risen by approx. 290% from 5,901 to 23,020 – in comparison, the number of scientists (headcount) rose by 116% from 25,503 to 55,031 (see Fig. 3-4). This has led to a significant increase in the proportion of women from approx. 18.8% to 29.5% between 1998 and 2015. However, the proportion of women scientists has stagnated since 2011: while the share in 2011 was already 29.0%, it has only increased since then to 29.5% in 2015. The growth rates of the number of women scientists (headcounts) in 2013 are lower than in 2015 and are identical to those for male scientists. Although this increased the number of women scientists, the proportion of women in the entire R&D sector is stagnating.

However, there are significant differences in the representation of women in the two largest R&D sectors in Austria. Both sectors employ around 94% of all researchers (headcount) in Austria – both in the business enterprise sector and in the higher education sector around 47% of R&D personnel are allocated to scientific staff. Although the total number of women scientists is almost equal in both sectors, more than twice as many women are employed as scientists in the higher education sector than in the business enterprise sector (14,655 vs. 6,320). This is also reflected in very different proportions of women scientists in the two sectors: the corresponding share is 39.9% in the higher education sector and only 17.1% in the business enterprise sector. In both sectors, the growth rates in the number of women scientists have flattened considerably over the last ten

62 Scientists are those persons who are classified as researchers in Statistics Austria's R&D survey and are thus distinguished from other, non-scientific employment categories.

Fig. 3-5: Women researchers by headcount and FTE for R&D in the higher education sector, business enterprise sector and R&D as a whole, 1998–2015



Source: R&D surveys, Statistics Austria. Calculations: JOANNEUM RESEARCH.

years and are now closer to those of men. As a result, only a slow increase in the share of women scientists can be observed. In the business enterprise sector, there was even a slight decline in the proportion of women between 2013 and 2015. However, it should be noted that part of the demand from firms concerns industries with a generally low proportion of female graduates, for example in STEM subjects. At the same time, attention must be paid on the supply side to creating attractive working conditions for women scientists in order to increase the proportion of women in the long term. In contrast, the proportion of women in the higher education sector has risen slowly but steadily since 2009 from 37.8% to 39.9% – although the trend flattened considerably between 2013 and 2015.

Looking at the participation of women scientists on the basis of full-time equivalents[63] (FTE) for R&D shows that the proportion of women in R&D personnel capacity is significantly lower than the headcount (see Fig. 3-5). In the whole R&D sector, the proportion of women scientists measured in full time equivalents (FTE) for R&D in 2015 was 23.2%. The proportion of women researchers was 35.9% in the higher education sector and 15.5% in the business enterprise sector. As already shown in the headcount figures, the development in the entire R&D sector between 2009 and 2015 is flattening significantly, so that only minor increases in the proportion of women can be observed. This can also be seen in the development of the proportion of women scientists in the business enterprise and higher education sectors. However, the trend between 2013 and 2015 differs significantly between the two sectors. While the proportion of women researchers in the business enterprise sector declined slightly, it continued to rise in the higher education sector from 34.8% to 35.9%.

63 A full-time equivalent (FTE) for R&D corresponds to the work performed by a full-time employee working exclusively in R&D throughout the year. Part-time employees and persons who were not permanently involved in R&D are calculated on a pro rata basis (Schiefer 2017). In this respect, the FTE reflects data on personnel capacities used for R&D.

The varying proportions of women researchers measured in FTEs for R&D compared to the headcounts indicate that women are reflected in the statistics with lower – in the higher education sector significantly lower – personnel capacities in R&D than their male colleagues. This is mainly due to the higher level of part-time employment among women scientists compared to their male colleagues. On the other hand, this is only to a very small extent due to the fact that women scientists have more working time for teaching and administrative tasks than male scientists and can therefore use less personnel capacity for R&D. Rather, the 2015 R&D survey data for the higher education sector show no significant gender-specific differences in the distribution of working time between teaching, research and administrative tasks.

In an international comparison, Austria is just ahead of Luxembourg (28.9%), Malta (28.5%), Germany (28.0%), Czechia (26.9%) and the Netherlands (25.4%) in terms of the proportion of women researchers in the entire R&D sector, and thus in the group of EU countries with the lowest proportions of women researchers. In most EU-28 countries, the proportion of women scientists grew only slowly or even declined slightly between 2013 and 2015. An increase of more than 1 percentage point can only be observed in Ireland. Looking at the period 2009 to 2015, only three EU-28 countries show continuous increases in the proportion of women researchers: Italy, Germany and Spain.

If one differentiates between the results for the two central R&D sectors in Austria, it can be seen that the proportion of women in the R&D business enterprise sector in terms of headcount (17.1%) is clearly below average compared to the other EU-28 countries and is only lower in Luxembourg (12.3%), Czechia (12.8%), Germany (14.7%) and the Netherlands (17.0%). Seven countries have a lower proportion of women in the higher education sector than Austria (39.9%): Malta (33.1%), Czechia (35.2%), Cyprus (37.6%), Greece (37.7%), Luxembourg (38.1%), Germany (38.7%) and Hungary (39.4%).

A study commissioned by the European Commission[64] clearly shows that the proportion of women scientists in the entire R&D sector is also influenced by its structure. The larger the R&D business enterprise sector in relation to the other R&D sectors in one country, the lower the proportion of women scientists in the whole R&D sector. In those countries where research is more focused on the public sector (government and higher education sectors), the proportion of women is also higher throughout the R&D sector. This is due, among other things, to the fact that the measures taken so far to promote gender equality have focused primarily on the public R&D sectors and in particular on the higher education sector.

3.2.2 Women in management positions and collegial bodies at universities

As there is no data available for the business enterprise sector on the representation of women in management positions and committees in R&D enterprises, only developments at Austrian universities are presented in the following section.

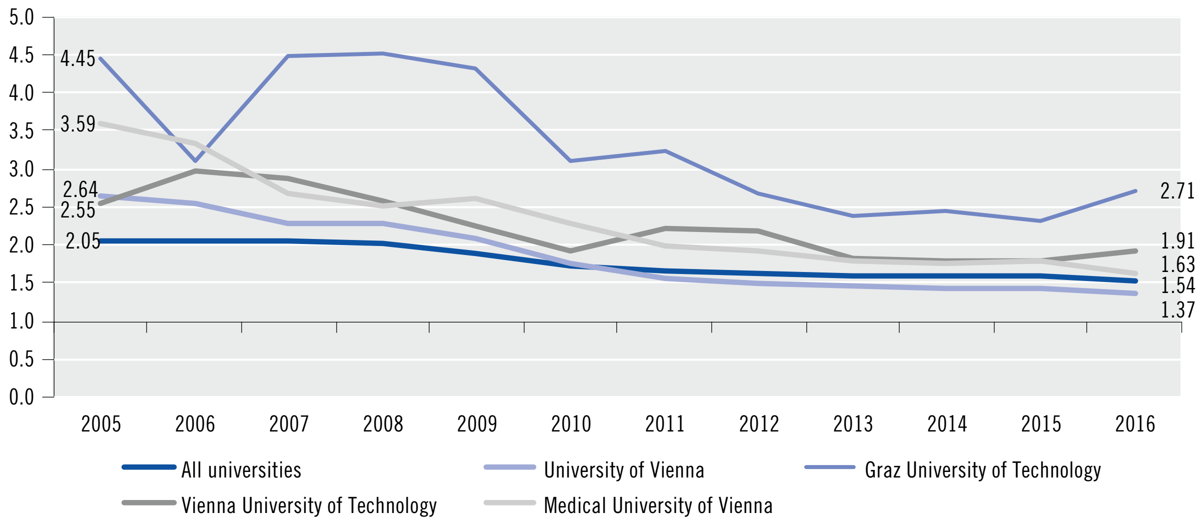
Vertical segregation along the university career ladder is very visible in Austria. The proportion of women is continuously decreasing along the career ladder. Among the professors, the proportion of women is only about 23.6% (winter semester 2016). Although the proportion of women in career positions (35.3%) as professors has continued to grow between the winter semester 2013 and 2016,[65] is still far from a balanced gender ratio. The comparatively high

64 See European Commission (2008a).
65 See BMBWF (2018).

proportion of women in the higher education sector (see Section 3.2.1) is therefore due to a higher representation of women at the first university career stages[66].

The so-called glass ceiling index shows that women's opportunities for advancement on the academic career ladder are significantly lower than those of men.[67] In 2016 this index for all Austrian universities amounted to 1.54[68] – in 2005 it was clearly higher at 2.05. Meanwhile, although career opportunities for women at universities have improved, they are still lower than those of their male colleagues. There are also different career opportunities by university: the University of Vienna (1.36), which is characterised by a broad spectrum of disciplines, has a significantly lower glass ceiling index than technical universities such as the Vienna University of Technology (1.91) and the Graz University of Technology (2.71). The Medical University of Vienna also has a slightly higher glass ceiling index (1.63). These differences between universities indicate, among other things, that women's career opportunities vary according to scientific disciplines. This can also be seen in the varying shares of female professorships by field.[69] Overall, it can be noted that the career opportunities of women at Austrian universities have improved in the long-term trend (see Fig. 3-6). However, these catching-up processes are of long-term duration due to the structure of scientific qualification processes and the limited availability of professorships that become vacant.

Fig. 3-6: Development of the Glass Ceiling Index for selected universities in Austria, 2005–2016



Source: unidata BMBWF. Calculations: JOANNEUM RESEARCH.

Since the University Amendment Act 2009, which came into force on 1 October 2009 (Federal Law Gazette I No. 81/2009), the proportion of women must be at least 40% for all university collegial bodies in accordance with the Basic Law. With the amendment to the UG of 13 Janu-

66 These are externally funded staff and scientific and artistic assistants.
67 The Glass Ceiling Index (GCI) measures the relative chance of women to be promoted to the top echelons compared to men. A GCI value of 1 indicates equal opportunities for advancement for women and men. The higher the GCI, the lower the opportunities for advancement for women.
68 See Datawarehouse for the higher education sector of the Federal Ministry of Education, Science and Research.
69 See European Commission (2016a, 133).

ary 2015 (Federal Law Gazette I No. 21/2015) now applies a quota of at least 50% for women.[70] The university collegial bodies must therefore be staffed with at least 50% women in accordance with the statutory quota.[71] In 2016 this applied to 21 of 22 rectorates at Austrian universities. Overall, the proportion of women in the rectorates averaged 47.9% in 2016. In 2005, this was still around 21,6%. Looking exclusively at the position of rectors, it becomes apparent that at the end of 2016 eight out of 22 rector posts were filled by women (36.4%). The number of female rectors has risen continuously since around 2010. In the case of the Vice-Rectors, the proportion of women had already reached approx. 28.6% in 2005, by 2016 it was 50.7%.[72]

The university councils also reached the quotas at all universities in 2016: on average, 48.9% of all university council members were women. Women were also represented among the chairmen with 45.5%. Ten out of 22 university council chairs were women. Since at the end of 2016 the university councils of the term of office had been in office since 1 March 2013, the 40% quota still applied to them. However, for the Senates, all of whom took office on 1 October 2016, the 50% quota already applied. This was only achieved in twelve of 22 cases. The University of Klagenfurt (26.9%), the University of Leoben (27%), the University of Innsbruck (30.8%) and the Vienna University of Technology (30.8%) clearly failed to meet the legal requirements for the composition of the Senate.[73]

In the other collegial bodies such as habilitation commissions, appointment commissions and curricular commissions, too, the legally prescribed quotas can only be achieved in full at selected universities: in the winter semester 2016, 69.5% of all habilitation commissions, 64.8% of all appointment commissions and 57.3% of all curricular commissions at Austrian universities were staffed in accordance with legal requirements. Due to the low proportion of female professors, technical universities in particular have problems meeting the statutory quotas.[74]

3.2.3 Working conditions and equality in applied non-university science and technology research

The following section is based on monitoring data on the employment situation of scientists in non-university science and technology research in Austria. The monitoring includes those research institutes that are essential links between university research and the business enterprise sector. These are the Austrian Institute of Technology (AIT), JOANNEUM RESEARCH (JR), Salzburg Research (SR), the COMET centres[75] (COMET), the Laura Bassi Centres of Expertise (LBC), the Christian Doppler Laboratories and Josef Ressel Centers (CDG), the NanoTechCenter Weiz (NTCW) and the members of Austrian Cooperative Research (ACR). Other non-university research institutes, such as the Ludwig Boltzmann Society, the Austrian Academy of Sciences, Research Studios Austria or IST Austria, have not yet been included in the gender equality survey.

As the results over time show (see Fig. 3-7), the proportion of women in non-university science and technology research is slowly but steadily increasing. Between 2004 and 2015, the proportion of women scientists rose from around 20% to 27%. The results of the previous sections show that this R&D area thus lies between the results of Austria's two major R&D

70 See Report on the implementation of the 2015 quota for women, https://bmbwf.gv.at/wissenschaft-hochschulen/gender-und-diversitaet/umsetzung-der-frauenquote-2015

71 In the case of an odd number of members, the number of members is mathematically reduced by one to calculate the quota. This calculation arithmetic can lead to a proportion of women well below 50% being sufficient to meet the quota (BMBWF 2018).

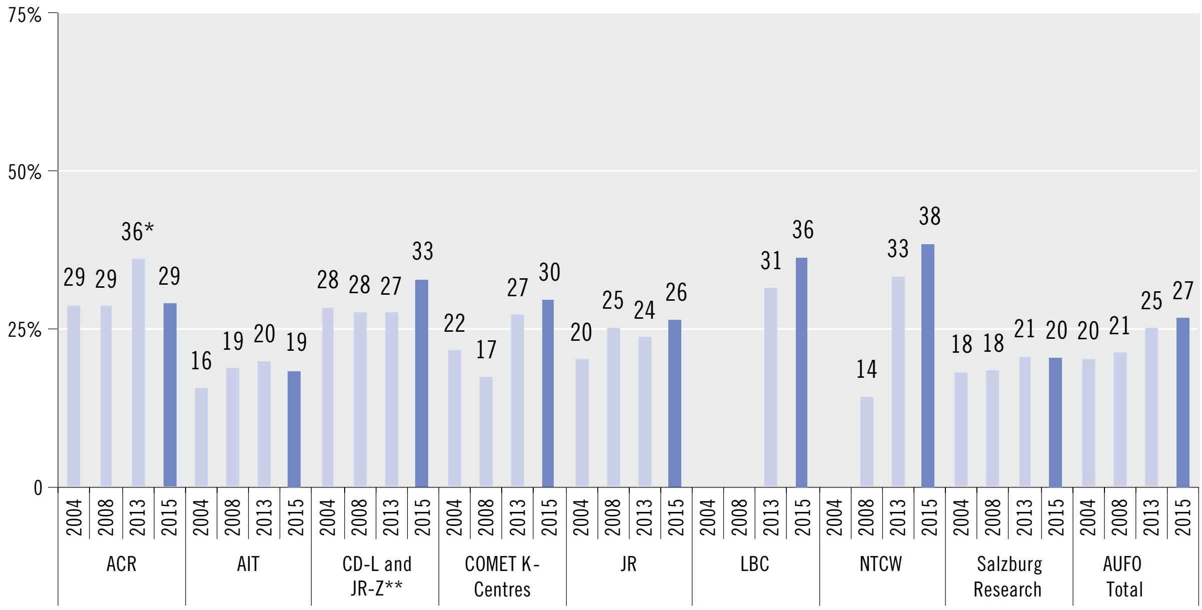
72 See BMBWF (2018).

73 See BMBWF (2018).

74 See ibid.

75 K1 and K2 centres, without K projects.

Fig. 3-7: Development of the proportion of women scientists by research institute, for the years 2004, 2008, 2013 and 2015



Note: * The proportion of women determined for Austrian Cooperative Research (ACR) in the Equality Survey 2013 is above average – however, these data overestimate the development, as not all ACR facilities participated in the survey in 2013. Data for all ACR facilities have been made available for 2015. ** CD Laboratories and Josef Ressel Centers.

Source: Equality survey 2016. Calculations: JOANNEUM RESEARCH.

sectors, the business enterprise sector and the higher education sector.

Among the newly recruited scientists in 2015, the proportion of women is particularly high at 38%. This figure is almost identical to that of 2013 (39%) and shows that increasing attention is being paid to gender balance in recruitment. However, as can be seen from Fig. 3-7, the development of the proportion of women in the individual research institutes varies considerably.

A very positive development can be seen at the NanoTechCenter Weiz, which had a 38% share of women in 2015. At the Laura Bassi Centres, too, there has recently been a further increase in the number of women scientists from a high level to 36% of the scientific staff. The proportion of women in CDG instruments and COMET centres has increased significantly since 2013 and 2008 respectively, following an initial tendency to decline, while the proportion of women at JOANNEUM RESEARCH more or less stagnated between 2004 and 2008. Between 2013 and 2015, the proportion of women rose slightly from 24% to 26%. By contrast, there was little movement in the proportion of women – at many different levels – at ACR, AIT and Salzburg Research. Between 2004 and 2015, there was only a small increase in the proportion of women at Salzburg Research from 18% to 20%. While a small increase in the proportion of women at AIT from 16% to 19% was observed between 2004 and 2008, this proportion has more or less stagnated at this level since then. There has even been a slight decline in the proportion of women at both AIT and Salzburg Research. The proportion of women among ACR members has stagnated since 2004, albeit at a comparatively high level.

This points, on the one hand, to the different courses of development at the various research institutes and, on the other, to the discontinuity of success – and perhaps also of the activities to promote equal opportunities at those respective institutions. Overall, a positive trend can be observed despite quite different developments, which is reflected in the increase in the proportion of women in the entire sector. The positive trend in all non-university research in the natural sciences and technological fields in recent years can be attributed in particular to the increase in the proportion of women in the instruments of the CDG and COMET centres.

The gender equality survey also provides detailed results for the indicators age, income and function. Non-university research is characterised by a young age structure, which is even more true for the employed women scientists than for male scientists. In 2015, 50% of women scientists and 44% of male scientists were aged between 26 and 35. The second strongest age group is the 36 to 45 year-olds. Since 2004, the proportion of women among scientific employees has increased in all age groups. The most recent increase (2013-2015) was in the 46-55 age group. This shows that it is not only among young scientists that things are moving in the direction of a more balanced gender ratio.

Looking at the functional structure of scientific employees, it can be seen that women are clearly overrepresented in the lower function groups such as engineers/specialists (41%) and junior scientists (29%)[76] – in contrast to 10% in the management and 17% in the next management levels. Compared to 2013, there was a slight increase in the proportion of women in lower management positions and among principal scientists in the last equality survey. In contrast, a slight decline from 23% to 20% was recorded among senior scientists. The trend towards a higher proportion of women continues among junior scientists, engineers and specialists. These are also the positions in which young scientists are usually employed in non-university research institutes. In total, 16% of all scientists, but only 10% of all women scientists perform leadership functions[77] in non-university research. Since 2013, hardly any changes have been observed here. It is worth noting, however, that the proportion of part-time management positions is steadily increasing for both men and women.

The glass ceiling index presented above showed a value of 1.7 for non-university science and technology research institutes in 2015. This means that the positive development has continued since 2008. Although leadership positions in non-university science and technology research continue to be mainly occupied by men, women have become somewhat more likely to advance into management positions in recent years.

Looking at the income data, it can be seen that there are proportionately more women in the lower income groups than in the higher income groups. However, this is not related to the higher prevalence of part-time employment among women, as incomes have been collected as full-time income and to this extent effects from part-time work can be excluded. Rather, the younger age structure of women scientists and the higher proportion of women in the lower functional groups[78] are reflected here. However, the proportion of women is increasing in all income groups – with the exception of the income group under €2,000. We will need to keep observing to see whether the positive development of the proportion of women scientists will also be reflected more strongly in the higher income, function and age groups in the future.

The trend towards more part-time employment continued in 2015. Since 2004, the proportion of both women and men working part-

76 The data on the function of the scientific staff do not include scientists from the Austrian Cooperative Research (ACR) institutes, as these could not be made available centrally by the office at the time of the survey.

77 This includes the functions of Management, 1st + 2nd management level and Principal Scientists.

78 These are e.g. junior scientists, engineers or other specialists.

time has increased significantly, with 57% of all women scientists and 30% of all scientists working part-time in 2015. This means that the proportion of female scientific employees working part-time has almost doubled since 2004 (31%) and has even become the predominant form of employment. However, the majority of women scientists working part-time have an employment rate of 50-90% of full-time employment. In 2015, a total of around 37% of researchers worked in non-university part-time science and technology research (compared to 17% in 2004). Although the trend towards part-time work is particularly strong among women, it should be emphasised that a significant increase in part-time employment can also be observed among men.

In addition to monitoring employment, a survey of scientific staff on working conditions and burdens in non-university research institutes was conducted as part of the Equality Survey 2016.[79] Although the monitoring shows clear differences in the representation of women and men in non-university science and technology research, for the most part the working conditions of women and men are assessed to be very similar. Only with regard to the evaluation of the status quo of equal opportunities in the respective research institute do the assessments of scientists differ significantly: women are more likely to believe that there are different opportunities for advancement and unequal treatment of the sexes in their research institutes than their male colleagues.

Full-time scientists work on average about 42 hours per week. According to the results of the survey, they work four hours more than their contractually agreed working hours. In both cases, no gender differences can be found. Men in management and leadership positions report significantly more actual working hours, while the working hours of women in management positions do not differ significantly from women without management positions. On average, full-time scientists and managers would like to see a significant reduction in their working hours, while part-time employees would rather prefer a slight increase in working hours.

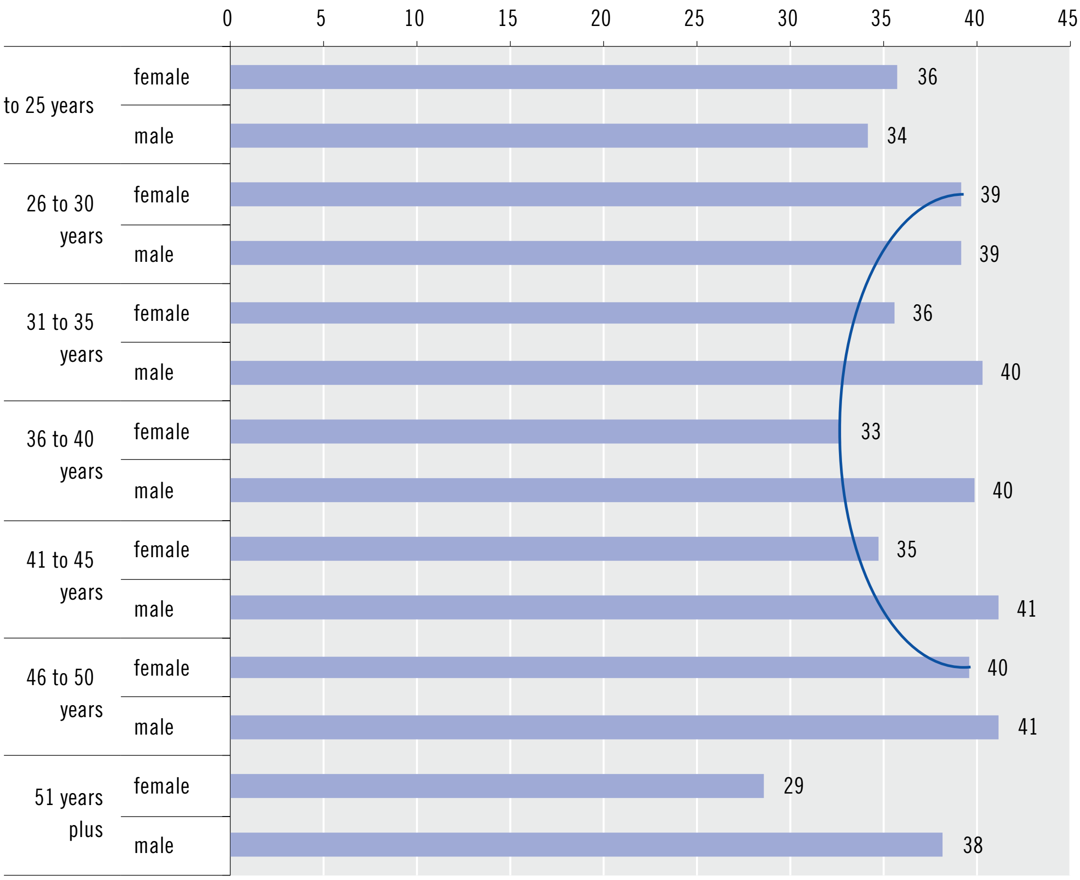
The results of the survey also provide new insights into which groups mainly use part-time work. Differentiated by age group it can be seen that especially scientists in the youngest (under 25 years) and in the oldest age group (51 years and over) have significantly less contractually agreed working hours than scientists in other age groups. It is also clear that gender-specific differences can be observed when looking at actual working hours by age (see Fig. 3-8): women in the 31 to 45 age group have experienced a significant drop in their actual working hours compared to men, but also to their younger colleagues. Women scientists work on average 5.5 hours less per week than their male colleagues in these very important years for career development. This is closely related to childcare responsibilities, for which women scientists with children spend on average twice as much time as male scientists. This confirms, on the one hand, that part-time work is used to a great extent to reconcile work and family life, and, on the other hand, that part-time work is also increasingly used by the youngest and oldest age groups.

Teleworking is proving to be an instrument that correlates strongly with longer working hours and a higher degree of atypical working hours. This form of work is mainly used by respondents to cope with high work demands and does not lead to an improved work-life balance. On the contrary: the more teleworking hours, the worse the compatibility of work and private life is judged.

The majority of scientists (63%) in non-university science and technology research feel

79 See Holzinger and Hafellner (2017). A total of approx. 2,700 questionnaires were distributed to researchers in the fields of non-university science and technology research. The effective response rate is 26%, which means 713 questionnaires were included in the analysis.

Fig. 3-8: Average actual working hours of scientists by gender and in years



Source: Equality Survey 2016, Scientist Survey. Calculations: JOANNEUM RESEARCH.

very strongly or strongly burdened by their professional tasks. In particular, time pressure and stress, tight project budgets as well as acquisition effort and pressure are described as burdensome. Older scientists, persons with children in the household as well as persons with management and leadership functions estimate the burdens of their professional activity to be significantly higher than their colleagues.

Slightly more than 50% of the scientists surveyed think that they also have to deal with their research in their free time in order to maintain their status as scientific experts. Nevertheless, approx. 82% of scientists consider the compatibility of work and private life to be very good to fairly good. The assessment of compatibility does not differ significantly between the sexes.

Overall, most of the scientists are very or rather satisfied with their professional tasks. Women are somewhat less satisfied with their tasks than men. Moreover, compatibility has a significant influence on job satisfaction and is an important topic for non-university researchers. These results make it clear that the long working hours in research are not necessarily associated with intrinsic motivation, but that there is a demand among scientists – both men and women – for shorter working hours and better reconciliation.

3.2.4 Equality in basic research in non-university research

The Austrian Academy of Sciences (ÖAW), the Institute of Science and Technology Austria (IST Austria) and the Ludwig Boltzmann Society (LBG) also collect key figures on the status quo of gender equality in their research institutes.[80]

Although the proportion of women among the real members of the Austrian Academy of Sciences (ÖAW) increased from 8% to 13% between 2011 and 2016, the under-representation of women in leading scientific positions is clearly reflected here. Women are also only marginally represented among the corresponding members within the country and abroad, at 13% and 12% respectively. If we differentiate between the philosophical-historical and the mathematical-scientific classes, it becomes clear that the proportion of women among the real members in the humanities, social sciences and cultural sciences (GSK) is around 20% and thus significantly higher than in the mathematical-scientific class (7%). Although the proportion of women in both classes has increased in recent years, growth has been significantly higher in the philosophical-historical class. The differences in the representation of women by class in the scholarly society are also evident among the corresponding members within the country and abroad. The proportion of women in management positions at the Austrian Academy of Sciences (ÖAW) research institutes and in selected bodies of the Austrian Academy of Sciences amounts to 20% in 2016 and is expected to reach around 24% by 2019 (according to Impact Monitoring, subdivision 31).

The Young Academy of the Austrian Academy of Sciences is in a much better position with regard to equal opportunities: in 2016, 35% of its members were women. In 2011 it was still only 23% and in 2013 24%. In the last three years there has been a significant increase in the proportion of women at the Young Academy. The proportion of women among Austrian Academy of Sciences research assistants is significantly higher than in the Society of Scholars. In 2016, a total of approx. 37% of research assistants – measured in full-time equivalents – were women. This share has been relatively stable since 2011. However, here there are also differences between the natural and technical sciences and the humanities, cultural and social sciences: while the proportion of women among scientific staff in the natural sciences and technology area is around 30%, it amounts to approx. 48% in the humanities, social sciences and cultural sciences (GSK). Here, too, hardly any significant changes can be observed between 2011 and 2016.

Founded in 2009, IST Austria is still in a rapid growth phase: between 2010 and 2016 the number of faculty positions[81] has tripled, the number of post-docs has increased eightfold and the number of PhD students has increased sevenfold. Overall, the proportion of women in faculty positions is significantly lower than among post-docs and PhD students. Between 2010 and 2016, the proportion of women in faculty positions (research group leaders) rose from 8% to 19%, for post-docs from 18% to 28% – with a high of 35% in 2013 – and for PhD students from 37% to 47%. At IST Austria the same phenomenon can be observed as at the universities and at the applied non-university research institutes: the higher the function or hierarchy level, the lower the proportion of women. This is also reflected in the area of management: the management is made up of three men. The Board of Trustees is the most important decision-making body of IST Austria. It consists of 15 members, five of whom are women (33%). In 2010, the proportion of wom-

80 For the Austrian Academy of Sciences (ÖAW) as well as for the IST Austria data can be displayed over time. In the case of the LBG, this is not possible due to a change in monitoring of the scientific staff – only data for the year 2016 are available here.

81 This includes assistant professorships and professorships.

en on the Board of Trustees was still 27%. The Executive Committee – which is a subcommittee of the Board of Trustees – comprises six members of the Board of Trustees, but includes only one woman (17%). The proportion of women in the Scientific Council has also increased from 18% to 36% between 2010 and 2016. All executive bodies of IST Austria are managed by men – with the exception of the Scientific Council. In this body, a woman holds the position of Vice-Chairman.

The institutes (LBI) and clusters (LBC) of the Ludwig Boltzmann Society are active in the life sciences (LS) and humanities, social sciences and cultural sciences (GSK). In 2016, a total of 643 scientists were employed at the LBC and LBI. The proportion of women – measured in terms of headcount – is, at about 58%, above average. In addition, the proportion of women in the life sciences (59%) is slightly higher than in the humanities, social sciences and cultural sciences (GSK) (56%). For salaried scientists, the proportion of women is even slightly higher at 65% (68% in the life sciences and 59% in humanities, social sciences and cultural sciences (GSK)), while it is clearly below average in the other personnel categories. However, the high proportion of women among scientific staff is not reflected at the level of institute and cluster management. In 2016, the share of women in the heads of the institutes and clusters amounted to approx. 15% – in the life sciences it is 15% and in humanities, social sciences and cultural sciences (GSK) 14%. A look at the trend since 2010 shows that the participation of women at management level is stagnating. The proportion of women in the scientific advisory boards is also significantly lower than among the scientific staff. While scientific advisory boards are not established in all institutes and clusters, the proportion of women in the humanities, social sciences and cultural sciences (GSK) area in 2016 amounted to approx. 20% and in the area of life sciences approx. 23%. Some advisory boards are exclusively staffed by men. At the office of the Ludwig Boltzmann Society, two women were appointed to the management in 2016, 27% of the management board and 40% of the scientific advisory board are women, the latter is even headed by a woman.

3.2.5 Equal opportunity at the Austrian Science Fund (FWF)

In its mission statement, the Austrian Science Fund (FWF) commits itself not only to the principles of excellence and competition, independence and internationality, but also to the principles of transparency and fairness as well as gender mainstreaming and equal opportunity.[82] In order to transparently document the status quo on equal opportunity and gender mainstreaming, the Austrian Science Fund (FWF) publishes an equal opportunities monitoring, which not only presents the portion of women and men at the time of application, evaluation and project implementation, but also documents gender-specific participation in the committees of the Austrian Science Fund (FWF).

On the basis of this documentation it can be seen that in the year 2016, approx. 31% of applications to the Austrian Science Fund (FWF) were submitted by women – in 2015 this portion was around 32%. In comparison, measured in terms of headcounts, approx. 40% of researchers in the higher education sector are women. However, there are clear differences in the gender-specific distribution of applications by subject area: while in the natural scientific-technical fields approx. 18% of the applicants are women, the social sciences and the humanities account for about 43% and 44%, respectively, hence they are approximately balanced in terms of gender.

In the funded projects in 2016, approx. 72% were men and 28% were women. The approval rates for men (24.5%) and women (21.8%) var-

82 See https://www.fwf.ac.at/de/ueber-den-fwf/leitbild

ied in 2016. In 2015, the approval rates for women and men were, at approx. 25%, almost on a par. The gender ratio of the project staff financed is somewhat more balanced than in the case of applications: for example, approx. 42% of post-docs financed by the Austrian Science Fund (FWF) and approx. 44% of doctoral students are women.

In 2016 the committees of the Austrian Science Fund (FWF) were largely balanced with men and women[83]. The proportion of women on the Executive Board was 60% and 50% on the Supervisory Board. A slight gender-specific imbalance can be observed at the Assembly of Delegates with a proportion of women of 35% and with 37% on the Board. On the other boards and juries there are approx. 42% women. The office itself has, with a staff of approx. 68%, a high proportion of female employees. The gender-specific gap continues to widen among international reviewers: Women accounted only for approx. 21% of the requested reviews and for approx. 22% of the received reviews. This means that the majority of reviews are written by men.[84] Overall, it can be seen that there have been hardly any significant changes in the participation of women in the peer review process compared to 2015.

3.2.6 Summary

For Austrian universities, it can be stated that the proportion of women in the highest executive bodies and in the collegial bodies is increasing due to the statutory quota. It remains a challenge to fulfil the quota in those fields and subjects where women are also under-represented in scientific staff. Although the proportion of women scientists in the higher education sector (39.9%) is significantly higher than for the entire R&D sector (29.5%), equal representation of men and women is far from being achieved, especially for professorships. In addition, this varies greatly from field to field. The Austrian Science Fund (FWF) shows that committees such as the Board of Trustees, Executive Boards and juries are increasingly balanced by gender.

In the Business enterprise sector, the proportion of women scientists is still very low and in recent years the share of women scientists has stagnated. Compared to the higher education sector, the steering mechanisms and possibilities of the ministries in the business enterprise sector are smaller. The Equal Opportunities Act for Women and Men on the Supervisory Board (GFMA-G) passed by the National Council in June 2017 provides for a minimum proportion of 30% women on the supervisory boards of listed firms and firms with more than 1,000 employees from 1 January 2018. However, this only applies to firms that are active in an industry with a proportion of women of at least 20% and that have at least six chapter representations. Therefore, only a small proportion of firms are affected by this regulation.

In the research institutes of applied as well as in basic research-oriented non-university research, on the other hand, the committees and executive bodies are still relatively far from a balanced gender ratio. This can be seen, for example, in the scientific advisory boards, but above all in leading positions in the area of institute management and research group management in non-university research, which, like the professorships at universities, continue to be strongly dominated by men. This contrasts with the proportion of women among research assistants – especially junior scientists, PhD students and post-docs in both the university and non-university sectors. Despite disciplinary differences, most of which are already evident in the choice of studies, it can be seen that there is potential for young women scien-

83 This is to be considered in the context of Section 4(2) of the Research and Technology Promotion Act, which provides for a gender-equal composition of the executive bodies at the Austrian Science Fund (FWF) .

84 See https://www.fwf.ac.at/de/ueber-den-fwf/gender-mainstreaming/monitoring-chancengleichheit

tists in Austrian research institutes. However, stable career prospects and a change in research culture are needed to keep young women scientists in research over the long term and thus achieve equality at all levels of hierarchy and function in research. At the same time, measures to increase gender equality are an integral part of the STEM initiatives in the education sector, the effects of which are also evaluated externally.

3.3 Open Science and Dark Knowledge

Open Science (OS) describes the opening of scientific production processes and scientific output in the age of digitalisation.[85] From project drafts and data to publications, data and results should be made available promptly online in open formats. The goal of OS is to make production steps, methods and results openly accessible, reproducible, reusable and verifiable. OS also includes the areas of teaching (Open Educational Resources) and civic participation (Citizen Science). Austria has a number of organisations and strategies that are contributing to the implementation and further development of OS – in particular Open Access and Open Data.[86]

With the implementation of OS, knowledge derived from publicly funded research at universities and non-university research institutes can be made openly accessible. Above and beyond the concept of OS, there is the substantive question of the dynamics to which tertiary knowledge production is subject today and what knowledge is not made available or not produced at all. This inaccessible and not generally available knowledge is also called "Dark Knowledge".[87] It leads on the one hand to a discrepancy between knowledge that exists in principle and publicly available knowledge. On the other hand, there is a gap between the knowledge produced and the knowledge that would be socially relevant, but that is currently not published or not produced at all due to the general circumstances or incentive structures. These two conflicting areas point to necessary improvements that go beyond the previous approaches of OS.

In the area of teaching, there have also been initiatives since 2014 for the creation, provision and quality assurance of open education resources that are popular with teachers and students who use e-learning methods in the classroom.

In the following the current developments in the area of OS as well as aspects of Dark Knowledge are presented. Challenges for research agendas are identified against the background of the difference between relevant knowledge that exists in principle and knowledge that is actually publicly available.

3.3.1 Current national developments on Open Access and Open Data

In recent years, a large number of Open Access and Open Data initiatives have been established in Austria to make publications and research data freely available to the public in line with the OS philosophy. The Open Access Network Austria (OANA)[88] coordinates recommendations on OA activities of Austrian research institutes, research funding and research agendas taking international developments into account. At the same time, the OANA portal publishes information on events about OS, Open Educational Resources (OER) and Citizen Science. Within the framework of OANA working

85 Open Science can be divided into different areas depending on the definition approach. See https://www.fosteropenscience.eu/foster-taxonomy/open-science-definition

86 See also the comments on Open Science in the Austrian Research and Technology Report (2017, 90ff) and on Open Access and new social media in the Research and Technology Report (2014, 107ff).

87 See Jeschke et al. (2018).

88 See http://www.oana.at

groups[89], the "Recommendations for the implementation of Open Access in Austria" and "The Vienna Principles: A Vision for Scholarly Communication in the 21st Century" were developed. Furthermore, the HRSM project (higher education structural resources project) called the Austrian Transition to Open Access (AT2OA) project aims at the transformation to Open Access in scientific publications.[90] The HRSM project "e-infrastructures Austria plus" is concerned with making research data available in Austria.[91]

If research is funded by public funds, researchers in Austria and many European countries are increasingly obliged to make their publications available to OA. The authors' strategy plans are determined by the circumstances of the respective funding organisations. In Austria, the Science Fund (FWF) commits and supports all project managers and project staff to make their reviewed research results freely accessible on the Internet and offers information and support for the different publication possibilities.[92][93]

Free access to scientific publications on the Internet is a core element of OS. In principle, a distinction is made between three options for implementing Open Access: Green Open Access, Hybrid Open Access and Gold Open Access. These are briefly introduced below:

- Green Open Access means publication in conventional subscription journals, but allows freely accessible secondary publication of the manuscript version in public repositories within the embargo deadlines defined by the publishers. This approach has not changed the existing subscription system.
- Hybrid Open Access means publication in a conventional subscription journal, but makes it possible to activate individual publications through an additional payment to the publisher. This method has a problem though because a publication must be paid for twice ("*double dipping*"): once with the subscription and again for the activation.[94]
- Gold Open Access means direct publishing in an Open Access medium. Funding can be provided in three ways: (a) by paying an author's fee for a single publication (*Article Processing Charge, APC*), (b) by paying a publisher for packages of publications or (c) by directly supporting a publication body.

Green and hybrid Open Access are seen by many organisations such as the Austrian Science Fund (FWF) as transition models to Gold Open Access. Based on the OA2020 initiative at the Max Planck Society, which is now supported by 100 scientific organisations worldwide, the publication system is currently being transformed. The goal is to change the subscription-based business model so that results are made publicly available and reusable and the costs are measured transparently and are economically sustainable.[95]

3.3.2 Changing market conditions in the publishing system

Even in a transformed publishing system, in which Open Access will in future be organised via direct publication cost contributions, the same situation could develop as in the current subscription system: experts continue to expect price increases and an oligopolistic market concentration, which could lead to very few commercial information providers dominating not only the market for scientific publications but

89 See https://zenodo.org
90 See http://at2oa.at/home.html
91 See https://www.e-infrastructures.at/
92 See https://www.fwf.ac.at/de/forschungsfoerderung/open-access-policy/ and https://www.fwf.ac.at/de/forschungsfoerderung/fwf-programme/referierte-publikationen/
93 The Austrian Science Fund (FWF) has repeatedly been found by external experts to have implemented one of the most effective Open Access Policies of a funding organisation worldwide; see Tonta et al. (2015) and Swan (2016).
94 Consortia in the Netherlands, the United Kingdom, Sweden and Austria have negotiated agreements with publishers in a transitional phase to prevent double dipping or at least to limit significant price increases.
95 See https://oa2020.org

also the entire academic workflow in an estimated 10 to 15 years.[96] This could lead to similar platforms like Google, Facebook or Amazon also establishing themselves in science, which add to the development of lock-in-effects with their tools. This means that one provider offers the complete set of (digital) tools that scientists need for their research.[97]

To counter this trend, it is necessary to create cross-border, non-commercial, digital infrastructures controlled by science.[98] These include new publication models such as Public Library of Science (PLoS), Open Library of Humanities (OLH), OAPEN Library, SciPost or elife. This also includes repositories through which publications and research data are made sustainably accessible over the long-term. So far, the repository landscape is still far too fragmented, with the risk that commercial providers will again take the lead. However, three promising initiatives could remedy this situation. One possibility is the creation of central literary repositories. For example, the literature repository in the life sciences created by PubMed Central and Europe PubMedCentral, which is funded by the Austrian Science Fund (FWF), among others, and now makes almost five million articles freely accessible.[99] Another example is the OpenAIRE project (Open Access Infrastructure for Research in Europe), a pan-European repository with services for locating, storing, linking and analysing research results from EU projects across all fields.[100] In cooperation between OpenAIRE and CERN, a repository was also created with Zenodo, which is open to all scientists worldwide.[101] Last but not least, the European Open Science Cloud (EOSC) is an initiative aimed at linking the existing European repositories for research data and setting common quality standards.[102]

3.3.3 Limits of Open Access and Open Data

The developments in Open Access and Open Data already point to inherent limitations of these guiding principles: Open Access can make the extremely rapidly increasing number of published scientific articles and the underlying data publicly accessible in a broad form. However, this only partially counteracts the conflict between the amount of scientific information on the one hand and the perceived lack of individually manageable and reliable knowledge. The logic of scientific publishing today primarily follows the requirements of scientific careers and not the interest in making one's own research "accessible". In a science system in which the length of the publication list is decisive for future possibilities (i.e. above all positions and funds), the demand for publication possibilities necessarily increases. Whether, in this context, the knowledge that would be of the greatest possible social importance is also made publicly available is controversial.

This is where the discussion about "Dark Knowledge" begins.[103] Three central aspects of this concept are referred to below: the information flood/information shortage paradox, privatisation trends in research and the problem of highly differentiated disciplinary scientific languages that are hardly accessible to the general public.[104]

96 See Larivière et al. (2015); Expert Group "National Strategy" of the Open Access Network Austria (OANA) (2016).
97 See Schofield (2018): Workflow Lock-in, https://scholarlykitchen.sspnet.org/2018/01/02/workflow-lock-taxonomy/?informz=1
98 See Global Sustainability Coalition for Open Science Services (SCOSS)" initiative, http://scoss.org
99 See https://www.ncbi.nlm.nih.gov/pmc/ and https://europepmc.org/
100 37 European partners have established NOADs, National Open Access Desks, for each participating country; in Austria NOAD is located at the University of Vienna.
101 See https://zenodo.org/
102 See https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud
103 See Jeschke et al. (2018).
104 See ibid.

The information flood/information shortage paradox is the perceived divergence of a fast-growing offer of immediately available, digital information and an inadequate provision of this knowledge in adequate form.[105] OS offers the possibility to get secured scientific knowledge more easily. However, an OS strategy must not only make access to scientific methods, data and results simpler and more comprehensible, but also create the prerequisites to be able to handle both digital data and immediately globally available information accordingly.

Privatisation trends in research can also contribute to the Dark Knowledge phenomenon: most investments in R&D today are made in the highly developed industrialised countries by industry,[106] whose share of total R&D expenditure continues to increase. As a result, only a (decreasing) proportion of global investment in R&D is subject to the requirement of public accessibility. In addition, there is a boom in new private foundations for science, often with assets worth billions, especially in the USA, such as the Gates Foundation, Simons Foundation, Chan Zuckerberg Initiative, Allen Institute, Arcadia, Schmidt Fund for Strategic Innovation or Arnold Foundation. Another example of the possible impact of commercial research strategies is the phenomenon of social and political ignorance.[107] The intensive campaign that the tobacco industry led against the consensus of the scientific community to question the health risks of smoking falls into this category.[108] Such attempts to influence science are also evident in the controversy surrounding climate change.[109]

Finally, a third aspect is the tendency towards highly differentiated, disciplinary scientific languages, which are hardly accessible to the general public. Knowledge is often caught in disciplinary contexts, functioning exclusively in their disciplinary logic.[110]

In the context of the discussion about Dark Knowledge we should also mention the traditional question of freedom of science. Although the production of socially relevant and publicly accessible knowledge is a main objective of academic research, this can be limited by the thematic control of research through third-party funding and the simultaneous evaluation of researchers through quantitative performance indicators such as the Hirsch index and the number of publications in journals with a high impact factor. If, for example, research topics that are in demand in journals with a high reputation are given preferential treatment, this may conflict with other priorities. Moreover, the priorities of European research programmes, e.g. in industries such as health and renewable energy, do not necessarily have to coincide with the thematic trends of the most important – often US – science newspapers. In view of the enormous growth in scientific information, breaking out of the logic of these metrics can by no means be taken for granted.[111]

Against the background of these developments, specific proposals can be developed to reduce the gap between accessible knowledge and Dark Knowledge and to expand OS' existing strategies. One starting point would be, for example, the extension of quantitative indicators for the evaluation of researchers and institutions. The usual focus on a few quantitative metrics (money, publications and quotations) is criticised for restricting academic freedom and

105 See Schaper-Rinkel et al. (2013). The US-American futurologist John Naisbitt already mentioned this trend in his book on megatrends from 1984: "We are drowning in information but starved for knowledge."
106 See Jeschke et al. (2018) and the reference there to the assessments of R&D statistics.
107 See Proctor and Schiebinger (2008).
108 See Oreskes and Conway (2010).
109 See Pinto, M.F. (2017).
110 See Plavén-Sigray et al. (2017).
111 Siebert et al. (2017) state: "The need for objective treatment of authors increases as more papers are submitted, but at the same time referees necessarily increase their reliance on subjective proxies such as reputation. It is very hard to see how these opposing forces can be reconciled in the current system". See https://elifesciences.org/articles/10825

also privileging mainstream research and representing a barrier to high-risk, highly innovative research.[112] Inter- and transdisciplinary research can be hindered by conventional indicators. In addition, the evaluation system is criticised for disadvantaging fields in which resources, the total number of publications and thus the citation rates are scarce. Diversification of evaluation systems can counteract these trends by creating incentives to conduct innovative interdisciplinary research and to publish the results.[113]

A further approach is the development of meta-analytical instruments such as knowledge maps, which are able to place the specific knowledge of a research field in a broader context and thus also make this knowledge more easily accessible to outsiders. The visualisation and accessibility of knowledge is linked to the need for new fields focusing on data and models.

3.3.4 Summary

The phenomenon of Dark Knowledge refers to the limits of previous Open Science strategies. Even if extensive information on all phases of publicly funded research will be made available in the future, the question arises as to whether this really is "socially necessary" knowledge. In Austria, no empirical data and systematic observations exist to date as to what knowledge stocks might be lacking and what concrete effects these trends have on the scientific system. For research agendas and research funding agencies, the first task is to improve the empirical database on the developments described. Furthermore, incentives should be provided to ensure that privately funded research results are also published to a greater extent, for example by making research data that are not used commercially publicly available after the end of the project.[114] The diversification of evaluation systems and the development of alternative metrics for evaluating the output of scientific research should also be supported.

3.4 The contribution of universities to innovation in Austria

Universities are central institutions in knowledge-based societies, as they produce new knowledge in the context of their research, impart existing knowledge to students and contribute to applying this knowledge to social and economic problems, for example through spin-offs or the development of applicable technologies. In addition to the first two pillars of teaching and research, the latter has gained importance in the understanding and design of the university's range of services, especially in the recent past, under the term "third mission". All three contributions of universities to knowledge production and diffusion can play a major role in innovation processes of enterprises, whereby there are many different possibilities how university knowledge can be integrated into entrepreneurial innovation processes. This chapter[115] provides a systematic overview of the many different ways universities can contribute to entrepreneurial innovation activities, based on international literature. Subsequently, selected aspects of this contribution are presented on the basis of available data for Austria.[116]

Table 3-3 presents different contributions of universities to innovation activities. A funda-

112 See Stephan et al. (2017), https://www.nature.com/news/reviewers-are-blinkered-by-bibliometrics-1.21877

113 See the analyses of the initiative "The Metric Tide", which critically accompanied the British evaluation system, https://responsiblemetrics.org/the-metric-tide/

114 See Kroop et al. (2016).

115 This chapter is based on the study by Janger et al. (2017), Economic and social effects of universities. It focuses on the role of innovation; further results of the study can also be found in the University Report 2017; see Federal Ministry of Education, Science and Research (BMBWF), 2018).

116 Note: the effects are not always exclusively attributable to universities. In the area of research, however, universities do 88% of the research, in the area of graduates they provide 72% of a graduate year (see Janger et al. 2017). When the effects come from both universities and other tertiary educational institutions such as universities of applied sciences, the term "universities" is replaced by "higher education".

mental distinction is made between knowledge flows with and without personal mobility, i.e. with and without change of employer. Within the knowledge flows without personal mobility, a distinction is also made between engagement and commercialisation.[117] University knowledge can become relevant for innovation processes, e.g. through R&D cooperation between university researchers and business researchers, or through contract research, formal or informal consulting. These mechanisms are summarised under the term engagement, i.e. there must be personal interaction between the firm and university researchers. Universities can also commercialise their knowledge without research interaction with firms, e.g. by patenting research results that are subsequently licensed to firms. Conversely, firms can acquire knowledge without research interaction with universities, e.g. by reading publications or attending conferences.

University innovation contributions, which are characterised by permanent personal mobility, can take three different forms. Firstly, university researchers can establish firms or switch to the R&D departments of firms. Secondly, there is the same opportunity for graduates, whereby this contribution to innovation can also develop outside of actual R&D, for example in production, organisation or marketing. Thirdly, research-oriented universities that train highly qualified graduates are regarded as magnets for the settlement of research-active firms.

Different innovation models set different accents for the possible contribution of universities to innovation. According to the linear innovation model, innovations – i.e. products or processes that have been successfully introduced to the market or are used in production – are a direct consequence of new findings in basic research.[118] In practice, however, university-generated new knowledge is rarely the direct or sole starting point for entrepreneurial innovation. Instead, universities can play different roles in the innovation process of firms along the "chain link". Here, too, it is possible to transfer university inventions directly into commercially viable applications. As a rule, however, corporate innovation processes begin with internal or external ideas for new products or process improvements.[119] Empirically we see that universities are often used to solve problems in innovation processes that have already begun, for example through contract research or collaborative research. For a long time, only knowledge generated by research was given a major role in the innovation process. Recent studies and surveys of firms show, however, that, in addition to informal consulting and reading publications, firms most frequently use graduates as sources of innovation or as carriers of university knowledge.[120] In countries close to the technological "frontier", firms therefore most often cite the lack of qualified personnel as an obstacle to innovation.[121] The knowledge transferred from universities to their graduates benefits all industries. A recent study confirms, for example, a positive effect of university graduates on the technological performance of firms across all industries, while a positive effect of university research can be seen above all in science-related sectors such as pharmaceuticals or electronics.[122]

These empirical studies on the importance of different types of university contributions to innovation show that all three pillars of universities – research, teaching and third mission – can make significant contributions to innovation. In particular, the importance of university grad-

117 See Perkmann et al. (2013).
118 See Balconi et al. (2010).
119 See Kline (1985).
120 See Cohen et al. (2002); Veugelers and del Rey (2014).
121 See Hölzl and Janger (2014).
122 See Leten et al. (2014).

uates is often underestimated, although all universities influence innovation through them. By contrast, the distribution of patent applications and licensing revenues as well as spin-offs is highly unbalanced; the universities with the strongest research, such as MIT or Stanford, have the largest shares.[123] The focus on increasing contributions to innovation at universities through patenting and spin-offs, as strongly emphasised in the so-called "Triple Helix" literature or in the concept of the "Entrepreneurial University",[124] therefore supplements the literature on the contributions to innovation from university research and teaching.

In addition to the contribution to individual innovations, the empirical literature finds a broad spectrum of effects of university activities on the innovation system as such:[125]

- Change in the economic structure towards knowledge-intensive industries
- Diversification of product lines, broadening of the technological competences of firms
- Emergence of new markets through new research results
- Attraction of talents and firms
- Contribution to technology diffusion and absorption through training function
- Local and regional knowledge spillovers, e.g. a high density of highly qualified people in a region facilitates the establishment of innovation-intensive firms

Another field of empirical studies confirms in particular that research-strong universities and their graduates are central location factors for research-active international firms.[126] Research-active firms prefer to settle near universities. The impact of the location also affects not only existing firms but also start-ups. A recent survey of firms in Austria also concludes that the availability of research personnel – most of whom are trained at universities – is the most important location factor for 90% of large enterprises for which location decisions are most relevant.[127]

This holistic understanding of the role of universities for innovation and the interdependencies between the individual impact channels – collaborative research, commercialisation, provision of skills and inter-sectoral mobility – is taken into account by the concept of the so-called "knowledge triangle". This concept focuses on the efficient linking of the three spheres (academic) research and discovery, education and training, and (entrepreneurial) innovation by orchestrating measures along the respective axes under the premise that these also have spillover effects on the respective other areas.[128] This new understanding of the role of universities in the innovation system has recently gained importance at European level, particularly in the understanding of regional innovation systems, where it has become a central component of regional innovation strategies within the framework of Smart Specialisation.[129] In addition, the status and political instruments for shaping the knowledge triangle in various OECD countries were examined in a project of the OECD Working Party on Innovation and Technology Policy (TIP) conducted between 2015 and the end of 2016.[130]

3.4.1 Universities and Innovation: empirical results for Austria

The data situation in Austria is not sufficient to illustrate all the effects mentioned. Selected aspects of universities' contribution to innovation are presented below. At the same time, the

123 See Veugelers and del Rey (2014).
124 See Etzkowitz and Leydesdorff (2000).
125 See Janger et al.(2017); Janger (2015); Reinstaller et al. (2016); Veugelers and del Rey (2014).
126 See Janger et al. (2017).
127 See Ecker et al. (2017).
128 See Polt and Unger (2017), Markkula, M. (2013).
129 See http://s3platform.jrc.ec.europa.eu/hess
130 See OECD (2017c).

Table 3-3: Possible contributions of universities to innovation activities

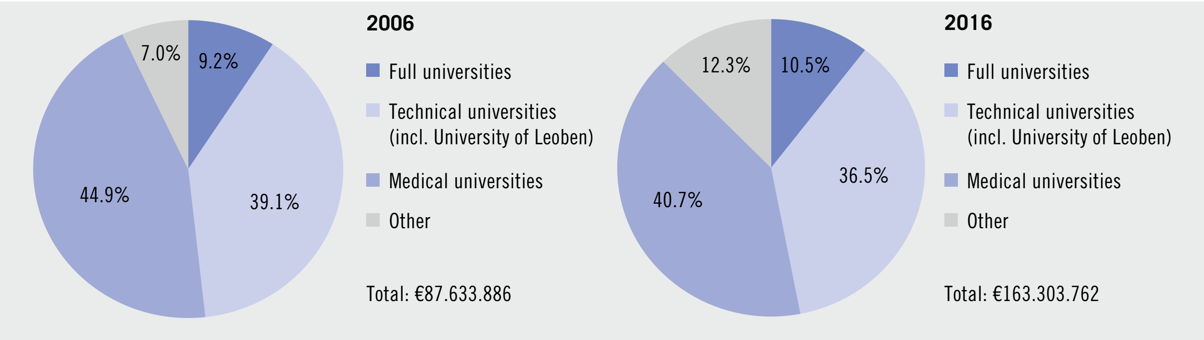
Way of interaction		Type of knowledge involved	University mission
Flows of knowledge			
Engagement (personal interaction)	Collaborative research	Flow of new knowledge	Research and third mission
	Contractual research	Flow of new knowledge	Research and third mission
	(Informal) consulting	Stock of existing knowledge	Research and third mission
Commercialisation by universities	Invention protection through patents and technology licensing	Flow of new knowledge	Third mission
Knowledge absorption by firms	Reading of university publications, attending of conferences by corporate researchers	Flow of new knowledge	Research
Flows of people			
University researchers	Spin-offs	Flow of new knowledge	Third mission
	Student and graduate Start-ups	Flow and Stock	n. a.
Graduates	Attraction of firms	Flow and Stock	Third mission
	University graduates working in corporate research	Flow and Stock	Teaching
	University graduates working in non-R&D corporate functions	Stock of existing knowledge	Teaching
Business enterprises	Settling firms based on proximity to universities	Flow and Stock	Third mission

Source: Janger et al. (2017).

need for additional information collection must be emphasised. First, the area of cooperation and contract research is mapped, i.e. the area of "engagement" (see Table 3-3). Fig. 3-9 first shows the development of revenues from R&D projects (including the advancement and appreciation of the arts, EKK), which are carried out jointly with or on behalf of firms. These are the central indicator for the third-party funding revenues of domestic universities.[131] Over time, these revenues not only rose sharply from €88 million to €163 million (in comparison: the annual funding by the Austrian Science Fund (FWF) amounts to approximately €200 million), there was also a diversification among the universities that generate such revenues. Although medical and technical universities continue to dominate, the share of full and other universities increased by 7 percentage points from 2006 to 2016.

This increase in revenues points to an intensification of cooperation and thus a greater role

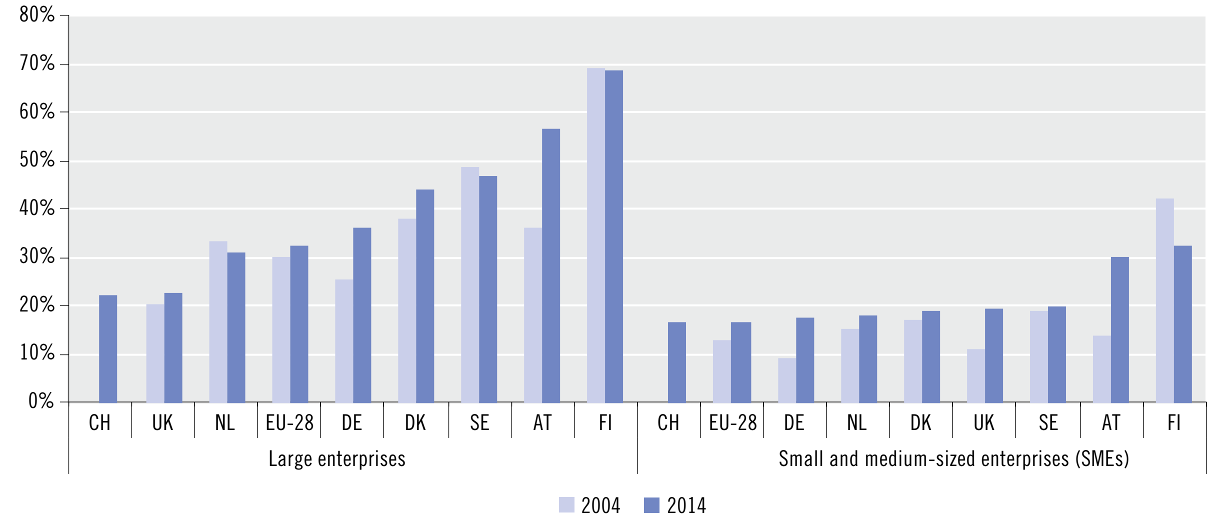
Fig. 3-9: Proceeds from R&D projects or projects for the advancement and appreciation of the arts implemented with universities and firms, 2006 and 2016



Source: uni:data, Intellectual Capital Statements (Wissensbilanz), key figure 1.C.2. Calculations: WIFO

131 See Austrian Research and Technology Report 2017, Chapter 3.3 Federal Ministry of Science, Research and Economy (BMWFW), Federal Ministry for Transport, Innovation and Technology (BMVIT) (2017).

Fig. 3-10: Proportion of SMEs and large enterprises cooperating with universities on innovation projects, 2004 and 2014



Note: For country codes see Table 8.1 in Annex I.

Source: Eurostat, Community Innovation Survey (CIS2004, CIS2014). Calculations: Austrian Institute of Economic Research (WIFO).

of innovation at universities, which is also confirmed by international comparative data (see Fig. 3-10). According to the European Innovation Survey 2014 (CIS), Austria leads the EU behind Finland in the share of both SMEs and large enterprises cooperating with universities and universities of applied sciences to introduce innovations. The momentum since 2004 has also been far above average, especially in the SME sector. The numerous funding programmes that rely on cooperation, such as COMET or COIN, seem to have borne fruit. Cooperation between science and industry, the commitment of both sectors, can be described as intensive in Austria.

Through their networking role, the regional knowledge transfer centres (WTZ) contribute to a further stimulation of innovative networks and cooperation between universities, research institutes and firms. As the work of the knowledge transfer centres to date shows, the strategic requirements of the "Knowledge Transfer Centres and IPR Exploitation" programme have largely been met and have achieved considerable results both from the perspective of the proponents of the knowledge transfer centres and from the perspective of business enterprises.[132]

In the spirit of setting priorities at the various Austrian universities and the networks they have established in recent years, these centres continue to promote close coordination with the regional economy and other regional players concerning the respective research and cooperation priorities.

The CIS data can also provide information on the success of such cooperations. Table 3-4 is based on a microdata evaluation of the European Innovation Survey 2014 (CIS) by Statistics Austria. The population of all firms that introduced an innovation during the survey period is compared with firms that cooperated or did not cooperate with external partners to introduce this innovation. Within those firms that cooperated with external partners, further differentiation is made between firms that cooperated with universities or universities of applied sciences and firms that made innovation efforts with other external partners.

132 See Jud et al. (2017).

Table 3-4: Success in innovation after R&D cooperation partners, 2012-2014

Product innovators with cooperation partners	Share of firms with innovative new products [in %]	Sales share of innovative new products on the market [in %]	Share of innovation expenditure in total sales [in %]
All firms with product innovations	**71**	**8**	**3**
Universities, universities of applied sciences	86	10	4
Small (<50 employees)	90	14	11
Medium (50-249 employees)	83	11	3
Large (>249 employees)	83	9	4
Other partners, but not universities	66	6	2
Small (<50 employees)	69	11	3
Medium (50-249 employees)	60	6	3
Large (>249 employees)	69	4	1
Without cooperation partners	64	7	2
Small (<50 employees)	64	7	2
Medium (50-249 employees)	62	8	2
Large (>249 employees)	77	7	1

Source: Microdata evaluation by Statistics Austria, Community Innovation Survey (CIS 2014).

While there are few differences in the share of innovation expenditure in total turnover (1-4%, with the exception of small enterprises cooperating with universities/technical colleges), firms working with universities/technical colleges show an approximately one-third higher share of turnover with innovative new-to-market products. Products new for the market are innovations that are new not only for the firm introducing them, but for the entire market in which the firm is active. The degree of newness of such innovations is thus higher than with mere "new-to-firm products".

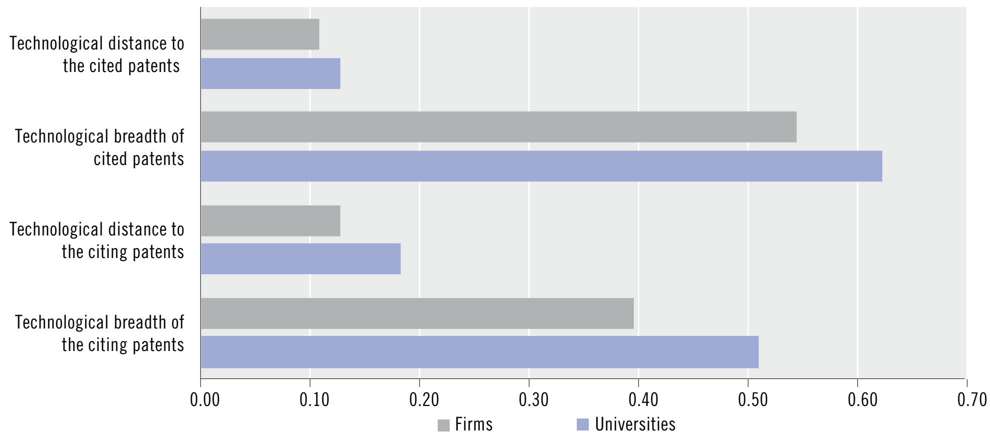
In addition, the share of firms introducing new-to-market products to the market is considerably higher in the group of firms with university cooperation than in the other groups (by approx. 20 percentage points). These figures are based on descriptive statistics and can therefore not be interpreted as causal (i.e. whether the cooperation with a university led to an innovative product or whether the new product would have come about even without university participation). However, universities seem to play a greater role in the innovation efforts of firms that introduce more "radical" innovations more often in the sense of a higher degree of newness and are thus also more commercially successful, in the sense of a higher share of turnover.

Data on the role of universities for innovation are also available in the area of "commercialisation of university knowledge", in particular on the application of patents by universities. The number of university patents has risen sharply since 2002, starting from a low base. The technological breadth and significance of these applications can be characterised by different measurement values.[133] Fig. 3-11 compares these indicators for university and corporate patents. This shows a consistently higher degree of technological breadth and importance (by 10–31%) of university inventions, which are generally closer to basic research. That increases the probability of technologically more radical innovations, whereby inventions do not always lead to new products or processes and technological radicalism does not necessarily lead to economic success.

Finally, data are also available to illustrate the role of universities in structural change and business growth, two important economic effects of innovation. While the economic effect of individual R&D collaborations or university

133 See Janger et al. (2017).

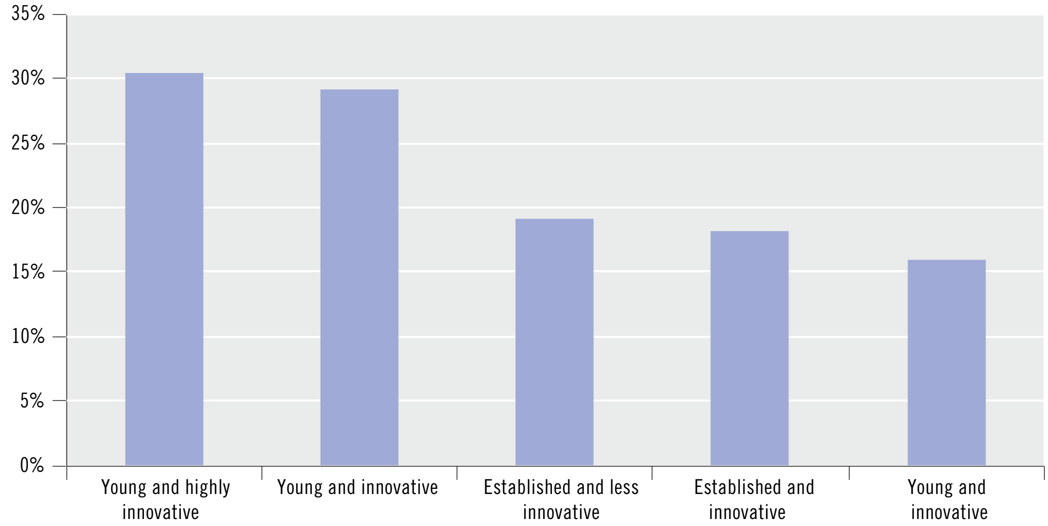
Fig. 3-11: Technological breadth and significance of Austrian patent applications, universities vs. enterprises, average 2002–2014



Note: a value closer to 1 indicates higher technological breadth and significance.

Source: Patstat Autumn 2016, Amadeus. Calculations: Austrian Institute of Economic Research (WIFO).

Fig. 3-12: Proportion of highly qualified people by the age of the firm and innovation intensity, 2016

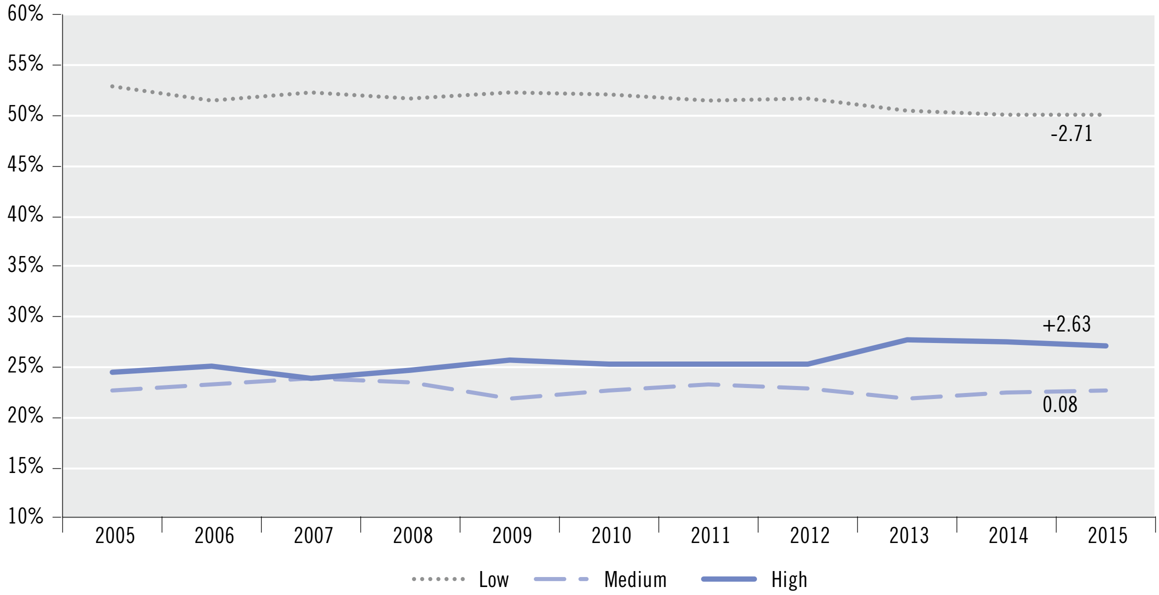


Source: Bock-Schappelwein et al. (2016). Calculations: Austrian Institute of Economic Research (WIFO).

patents is sometimes only visible after several years, data on university or university graduates allow a presentation of the role of universities in business dynamics.

Figure 3-12 shows the relative frequency of use of highly qualified people (i.e. tertiary qualified people) by enterprise age and innovation intensity. Compared to less innovative firms, as well as to established firms, young innovative firms have a significantly higher proportion of highly qualified employees. Universities and universities of applied sciences thus play a greater role for young and innovative firms than for established and less innovative firms. Thus they can potentially make a strong contribution to the structural change of the Austrian

Fig. 3-13: Share of industries grouped by skill intensity in value added, Austria 2005–2015



Source: Eurostat. Calculations: Austrian Institute of Economic Research (WIFO).

economy, an area in which Austria has so far always had deficits vis-à-vis the leading innovation countries.

In Figure 3-13 the perspective changes from the enterprise level to the industry level, where it shows the share of sectors grouped by intensity of skill over time. The changing share of these industries is to be seen as a structural change which, although typically slow, has led to a significant increase in sectors with high skill intensities (+2.7 percentage points) compared to sectors with medium and low skill intensities.

The documentation of the role of universities for innovation activities in Austria could be even more extensive if more data were available. This applies, for example, to university spin-offs, which currently only cover those firms whose activities are also based on university research results. Internationally common is an approach that includes all (innovative) enterprise creations by university researchers and graduates and thus usually includes many more firms. In addition, a database would have to be created for these firms over time, including R&D expenditure, patent activity, turnover, employment numbers and value added.[134]

Several current trends indicate that the contribution of universities to innovation will continue to increase significantly in the future. For example, the proximity of a country to the technological frontier implies that firms must increasingly rely on innovation strategies in order to assert themselves in competition through new products or higher quality. Firms from countries with lower but rising technology levels and lower labour costs will compete with firms from developed OECD countries in the future. This creates increased competitive pressure, particularly on the lower quality segments of industries or, more generally, on all sectors whose competitiveness is based less on innovation, training or quality than on the level of labour costs. The demand for innovation-relevant qualifications will therefore increase. Moreover, the technical progress of the last decades

134 See Janger et al. (2017).

has been characterised by a favouring of more highly qualified compared to less qualified workers (*skill-biased technological change*). In short, the current technological change, particularly in the direction of digitalisation, is leading to an increased demand for well-trained employees, a large proportion of whom are trained at universities in Austria.

Several recent studies[135] also indicate that it is becoming increasingly difficult to develop new ideas: innovation requires more and more effort and resources and is becoming more complex, which usually also forces entrepreneurial innovation efforts to become more scientific. This can also be seen from the increasing proportion of citations of scientific articles in corporate patents.[136]

3.4.2 Summary

The potential contribution of universities to innovation is very large in an environment in which knowledge is increasingly becoming the most important production factor. This contribution can find its way into entrepreneurial innovation processes through numerous mechanisms, with international empirical studies often emphasising the importance of graduates and publications as well as advisory activities, while commercialisation activities by the universities themselves, such as the establishment of spin-offs or the licensing of technologies, generally make up only a small part of the innovation contribution of universities. A selection of data also shows the important role of universities for innovation in Austria: in the EU, Austria, together with Finland, is the leader in terms of the proportion of firms that cooperate with universities (or universities of applied sciences). Cooperation between science and industry is thus very well developed.

The effects of these innovation cooperations also attest to the important role played by universities in innovation activities: universities seem to be more involved where firms develop innovative new products for the market, i.e. technologically "more radical" innovations. University graduates and thus university knowledge are also used disproportionately in young, innovation-intensive firms. Moreover, industries with a high proportion of tertiary qualified workers are growing faster than industries with only a low or medium proportion of these highly skilled workers. Universities can thus play a central role in Austria's efforts to become one of the leading innovation countries.

3.5 Health research and its translation into medical practice

Health systems and health policy on a global level are facing growing social and technological developments and the associated challenges.[137] In addition to demographic change and the growing demand for comprehensive medical care, social trends such as globalisation and urbanisation, environmental aspects (e.g. climate change) and digital progress are gaining increasing attention. At the same time, the human being as an individual, his specific living conditions and needs as well as so-called societal diseases are increasingly coming to the fore.

Social, health and technological trends have a direct impact on the development of topics and the research landscape in the area of health research and the life sciences. Interdisciplinary and transdisciplinary cooperation, which increasingly includes user-oriented, ethical, legal and social aspects in addition to combining basic and clinical research, is an important approach in this area. Concepts such as the "One

135 See Bloom et al. (2017).
136 See Janger et al. (2017).
137 The following is based on information from the World Health Organisation (www.who.int), the United Nations (www.un.org) and its subsidiary bodies and specialised agencies (e.g. FAO, UNDP, UNFPA, WFP, UNEP, UNICEF), the World Economic Forum (www.weforum.org), the Global Alliance for Chronic Diseases (www.gacd.org), the Center for Disease Control and Prevention (www.cdc.gov) and the European Observatory on Health Systems and Policies (www.euro.who.in).

Health" approach, which attempts to take into account the systemic relationships between humans, animals and the environment and health, personalised medicine and systems medicine approaches are becoming increasingly important. In the research process, needs are growing in the context of digitalisation, for example with regard to linking together larger amounts of data for diagnostic purposes and therapy. Digitalisation and patient orientation are also driving forward Citizen Science developments,[138] the involvement of citizens and patients in the research process.

Life sciences and health research are of great importance for Austria, both scientifically and economically. In recent decades, a large number of investments have been made in these industries and a number of measures and initiatives have been taken to position Austria as an attractive location. The "Future Strategy Life Sciences and Pharmaceutical Location Austria"[139] (see Chapter 1.5) aims to further strengthen and structurally improve the domestic science, research and business location in life sciences along the entire value chain. The new government programme also outlines both the implementation of the strategy and the concrete development of specific measures and initiatives.

The following chapter provides an overview of the priorities of domestic life sciences and health research and presents national and European funding initiatives in the field of health research. This is followed by a presentation of measures at the national level aimed at supporting and promoting the translation of findings from basic research into application.

3.5.1 Health research in Austria and in the European context

Austria can look back on a long tradition in life sciences and health research. Among the most important life sciences training and basic research locations in the country are the greater Vienna area (including Klosterneuburg), Innsbruck and Graz. The main research priorities of the public medical universities located in these areas are:

- Medical University of Vienna: immunology, cancer research/oncology, medical neurosciences, cardiovascular medicine, medical imaging
- Medical University of Innsbruck: oncology, neurosciences, genetics-epigenetics and genomics, infection – immunity – transplantation
- Medical University of Graz: cancer research, neurosciences, metabolic, cardiovascular diseases, general topic sustainable health research

The Medical Faculty of the University of Linz is also currently in the process of setting up similar priorities. The main research priorities are defined and developed within the framework of the performance agreements with the universities. Over the last performance agreement periods (the current one runs from: 2016-2018), the research priorities have remained rather constant, mainly because the major fields of disease continue to have the same importance in society. In addition, personalised medicine has become a fundamental topic in almost all research priorities, which is also explicitly anchored in the performance agreements of the three medical universities.

A large number of the molecular biological research institutes of the Faculties of Life Sciences at the Universities of Vienna, Graz, Innsbruck and Salzburg also work with a biomedical focus and often cooperate with the medical universities. In this context, the private medical universities, a number of universities of applied sciences and the University of Continuing Education in Krems, which also have a focus on health research, should also be mentioned. There are also

138 See Austrian Research and Technology Report 2017, Chapter 3.3 Federal Ministry of Science, Research and Economy (BMWFW), Federal Ministry for Transport, Innovation and Technology (BMVIT) (2017).

139 See https://www.bmbwf.gv.at/forschung/national/forschung-in-oesterreich/zukunftsstrategie-life-sciences-und-pharmastandort-oesterreich

non-university research institutes that prioritise life sciences and health research. Examples are to be mentioned in particular:

- Institute of Molecular Biotechnology – IMBA/Austrian Academy of Sciences (ÖAW): stem cell research, RNA biology and epigenetics, research into diseases in model systems
- Institute of Molecular Pathology – IMP/Boehringer-Ingelheim: stem cell research and development, immunology and cancer, neurosciences
- Center for Molecular Medicine (CeMM)/Austrian Academy of Sciences (ÖAW): immunology, infectious diseases, cancer, rare diseases
- IST Austria: e.g. neurosciences, immunology

Other non-university research institutes such as JOANNEUM RESEARCH (JR HEALTH, JR COREMED) and the Austrian Institute of Technology (AIT Center for Health & Bioresources) also maintain corresponding focus centres.

In the following, three strategic objectives of domestic life sciences and health research are described below as examples, which are anchored both in the "Future Strategy Life Sciences and Pharmaceutical Location Austria" (see Chapter 1.5) and in the national action plans of the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK).

Stem cell research

Stem cell research is one of the areas of medical research from which society expects a revolution in the treatment and therapy of diseases over the next 20 years. This is due to the findings in the field of cell reprogramming and the CRISP/Cas technology, which makes it easier to genetically modify cells than with previous technologies. The area is currently still strongly focused on research, but there are already isolated clinical fields of application (haemato-oncology) and a few international pilot studies in humans.

The establishment of a stem cell research institute at the IMBA and other research activities at the medical universities and the IMP have created a critical mass in this field of research in Austria. In addition, a stem cell biobank is being established at IMBA, which offers the preparation and archiving of stem cell clones as a service to the scientific community. The Federal Ministry of Education, Science and Research (BMBWF) and the City of Vienna are funding this initiative with a total of €22.5 million for the next five years.

Personalised medicine

The topic of personalised medicine is also one of the latest trends in today's medical research. In this priority area, research, coordination, funding and strategic measures at national and European level go hand in hand. On the one hand, personalised medicine was anchored as a general topic in the performance agreements with the medical universities. On the other hand, the Federal Ministry of Education, Science and Research (BMBWF) also supports cooperation between the relevant domestic universities and research institutes and the development of a work programme in this area by supporting a networking platform for personalised medicine (ÖPPM).[140]

Both the Federal Ministry of Education, Science and Research (BMBWF) and the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK) are members of the European Strategy Platform for Personalised Medicine (ICPerMed),[141] in order to be an interface and communication hub between national and European activities in the field of personalised medicine in the research and health sector. Furthermore, the Austrian Science Fund (FWF) is participating in ERA-Net

140 See http://www.personalized-medicine.at
141 See http://www.icpermed.eu

Personalised Healthcare and joins in transnational calls for proposals concerning this priority. Regional sponsors also support this topic - for example the Vienna Science and Technology Fund (WWTF) with a specific call for proposals on Personalised Medicine, or the Province of Styria and the Province of Tyrol who are both co-financing COMET projects funded by the Austrian Research promotion Agency (FFG), such as CBMed and Oncotyrol.

Rare diseases

Commissioned by the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK), the National Contact Point for Rare Diseases prepared a National Action Plan 2014-2018. An inter-institutional advisory board (including the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK), Gesundheit Österreich GmbH (GÖG),[142] the Federal Ministry of Education, Science and Research (BMBWF), patient organisations, universities, social insurance agencies, Pharmig) supports the implementation of the action plan and improves coordination between various policy areas. With regard to research, there are numerous activities at the medical universities, often at the paediatric clinics but also in other specialist departments. In addition, the Ludwig Boltzmann Institute for Rare and Undiagnosed Diseases (LBI-RUD) was established at the Center for Molecular Medicine (CeMM) and the Medical University of Vienna in 2016. The Austrian Science Fund (FWF) also regularly participates in transnational calls for proposals of ERA-Net E-RARE. Currently, a co-financed European Joint Programme for Rare Diseases is under development, in which the Austrian Science Fund (FWF), the Ludwig Boltzmann Institute for Rare and Undiagnosed Diseases (LBI-RUD), and the St. Anna Children's Cancer Research Institute in particular are co-ordinating a European reference network.

National and European funding initiatives in the area of health research

All these research priorities are supported by national funding measures (in particular the Austrian Science Fund (FWF) and Austrian Research Promotion Agency (FFG)) and EU programmes, in addition to institutional funding. Apart from stand-alone projects, this is done at the Austrian Science Fund (FWF) in particular through highly funded promotion instruments such as Special Research Areas and Doctoral Programmes, which lead to the formation of critical mass in specific areas. Apart from the bottom-up funding instruments, the Austrian Science Fund (FWF) also offers a specific funding scheme for clinical research – the KLIF programme.

It should also be mentioned that funding instruments aimed at improving cooperation between science and industry, such as COMET (Austrian Research Promotion Agency (FFG)) and the CD laboratories, also promote research projects in basic research and thus support the establishment of strategic objectives.

Specific programmes at EU level (2014-2020) in the field of health are, on the one hand the European Research Framework Programme Horizon 2020's programme on the social challenge "Health, demographic change and quality of life" (DG-Research, DG-CONNECT) with a total budget of €7.26 billion, and on the other hand the third action programme[143] in the field of health (DG-Santé) with a budget of €450 million.

In the "Health, demographic change and quality of life" programme in Horizon 2020, Austria has so far been able to acquire around €45 million in funding, with 96 approved par-

142 Gesundheit Österreich GmbH (GÖG) was established in 2006 as a national research and planning institute for the health sector and as a corresponding competence and funding body for health promotion.
143 See https://ec.europa.eu/health/funding/programme_en

ticipations from 2014 to 2017.[144] Six projects were led by Austrian coordinators. In Horizon 2020, European Research Council (ERC) grants also represent a source of funding that ensures a large amount of research funding for projects over several years. By 2017, 29 Austrian applications for ERC projects related to health topics had been successful and were funded with about €61 million. Between 2014 and 2017, a total of approx. €154 million in funding for projects in Horizon 2020 related to health were allocated to Austria.

Horizon 2020 also supports a number of EU initiatives in the field of health research that require national co-financing. These include, for example, the Article 185 initiatives "European and Developing Countries Clinical Trials Partnership – EDCTP2" (supported by the Federal Ministry of Education, Science and Research (BMBWF)), and "Active and Assisted Living" (supported by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Austrian Research Promotion Agency (FFG)). The Austrian Science Fund (FWF) plays a major role as a financing partner in transnational calls for proposals in so-called ERA networks (currently in a total of seven initiatives):[145] ERA-Net EuroTransBio is financed and administered nationally via the Austrian Research Promotion Agency (FFG).[146] The Federal Ministry of Education, Science and Research (BMBWF) and the Austrian Research Promotion Agency (FFG) are also involved in the Joint Programming Initiatives "Neurodegenerative Diseases", "A Healthy Diet for a Healthy Life" and "More Years, Better Lives".

The Innovative Medicines Initiative is also an important programme in the context of Horizon 2020. In a public-private partnership around €1.6 billion are available under the "Health" programme and the same amount "in kind" from the pharmaceutical industry and other relevant industrial sectors for cooperative, transnational projects through competitive tenders.

With regard to the third action programme in the field of health (DG Santé; 2014- 2020), there are joint actions in particular which address health policy issues that the European Commission (EC) and the EU member states regard as priority. In recent years, the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK) has supported or participated as a partner in the establishment of several so-called "Joint Actions" with regard to health at EU level. Central joint actions with Austrian participation in the thematic area include or included:

- Joint Action Antimicrobial Resistance and Health Care Associated Infections – AMR/HCAI. Duration 2017–2019. The Joint Action addresses the issues of antimicrobial resistance and health system associated infections and supports member states in implementing the EU Action Plan on AMR and national AMR action plans. The project is divided into ten work packages, Austria participates in four of them (AMR, HSAI, Awareness, Evaluation). The Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK) participates in the Joint Action in coordination with Gesundheit Österreich GmbH (GÖG).
- Joint Action to Support the eHealth Network – JAseHN.[147] Duration: 2015-2018. eHealth Network is the highest political body in the field of eHealth at EU level in which all member states are represented. The Joint Action focuses on the preparation of the content of the eHealth Network and is therefore its primary preparatory body. The Federal

144 See Austrian Research Promotion Agency (FFG) (2017).

145 The Austrian Science Fund (FWF) is a partner in the ERA-Nets E-RARE for rare diseases, ERA-CVD for cardiovascular diseases, ERA-Neuron for neuroscience, ERA-Transcan for cancer research, INFECT-ERA for infectious diseases, ERA-CoSysMed for systems medicine and ERA-PerMed for personalised medicine.

146 Focus on applications of modern biotechnology (of which approx. 75% are health research).

147 See http://jasehn.eu

Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK) acts as project coordinator of this joint action.

- Joint Action Support to the Implementation of Council Recommendation and Commission Communication on Rare Diseases. Duration 2015–2018. The primary objective of this Joint Action is the continuation of the Orphanet database. Furthermore, it is searching for a solution for a corresponding coding of rare diseases for health information systems. The Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK) is represented in this joint action by the Medical University of Vienna and Gesundheit Österreich GmbH (GÖG).
- Joint Action Chronic Diseases – CHRODIS. Duration: 2014-2017. The Joint Action supported the exchange of experience between member countries in the field of chronic diseases. Health service providers, decision-makers and health policymakers were supported in implementing measures to improve the living conditions of chronically ill people by setting up a targeted knowledge exchange system.
- Joint Action Cancer Control – CANCON. Duration: 2014–2017. To improve cancer care and prevention, a European Guide on Quality Improvement in Comprehensive Cancer Control was developed and an exchange of knowledge and experience between member countries on cancer issues was facilitated.

All of these funding initiatives show that there is a certain alignment of national funding along European initiatives in health research, which ensures that not only bottom-up funding but also specific funds for health research is allocated in Austria.

3.5.2 Translation measures at national level

Despite increasingly better technical and financial circumstances, the transfer ("translation") and meaningful integration of new medical research findings into practice is proving protracted and can sometimes take decades. For example, in biomedical research, only 25% of research results are published internationally. Less than 10% could be implemented in patient care within 20 years.[148] Problems in the validity and reproducibility of research paired with a lack of incentive mechanisms for basic researchers to implement research results in practice contribute to this trend. The transition to clinical research is also confronted with a lack of incentives with regard to everyday medical care. In addition, a stronger involvement of patients represents a special challenge. Finally, the development costs of new drugs are rising and their approval rates are tending to fall.[149]

In recent years, these circumstances have led to the emergence of more research fields on questions of translating research findings into application. In this context, translation stands for those tasks in (bio)medicine that aim to intensify patient-oriented research and thereby increase the scope, success and speed of research and technological development. The focus is on the rapid and effective introduction or improvement of health-promoting interventions, particularly in the form of new active substances and medical practices.[150]

Various international measures and initiatives are being discussed on the topic of translation, including infrastructures in the sense of technical facilities and buildings, own funding programmes, specific training programmes and the coordination of various stakeholders, for example through strategic orientation and by setting priorities.[151] An example of the latter initiatives is the "Future Strategy Life Sciences and

148 See Drolet and Lorenzi (2011).
149 See Vignola-Gagné and Biegelbauer (2013); Woolf (2008).
150 See Vignola-Gagné and Biegelbauer (2013).
151 See Vignola-Gagné et al. (2014).

Pharmaceutical Location Austria" (see Chapter 1.5) with the central focus on scientific and economic cooperation and the goal of effectively and efficiently applying the translation of findings from basic research in the life sciences.

The programmes and measures administered by the Austrian Research Promotion Agency (FFG), such as BRIDGE and COMET, the Research Studios Austria (RSA) and the Laura Bassi Centres, have provided a foundation for this for several years now. Cooperations, for example on the basis of instruments of the Christian Doppler Research Society (CDG) and Ludwig Boltzmann Society (LBG), offer further channels of direct knowledge transfer between business and science. Around 40% of CD laboratories are actively involved in the topic clusters "life sciences" and "medicine". The share of Ludwig Boltzmann Society (LBG) institutes and clusters related to the life sciences or medicine is approx. 70%. On a regional level, the five Austrian life sciences clusters should be highlighted: ecoplus (Lower Austria), Gesundheitscluster (Upper Austria), LISAvienna (Vienna), Human Technology Styria (Styria) and Standortagentur Tirol (Tyrol). The largest of these initiatives is the Life Sciences Vienna platform (LISAvienna), a cooperation between the Austria Wirtschaftsservice (aws) and the Vienna Business Agency. The platform supports and promotes biotechnology, pharmaceutical and medical engineering firms in Vienna that introduce innovations in the form of products, services and processes. LISAvienna's services include information and advice on government funding, private funding opportunities, infrastructure, research partnerships, networking activities, and the development of decision-making bases for the expansion of the life sciences in Vienna.

At the national level, the Life Science Austria (LISA)[152] initiative coordinates the international location marketing of the Austrian life sciences sector, including the preparation of the industry statistics "Life Science Report" and the industry directory "Life Science Directory". Together with the clusters, firms in the therapeutic, medical technology and diagnostic areas as well as suppliers of key technologies and associated service providers are represented here. LISA acts as a contact for cooperation, location and funding of projects and firms in the field of life sciences in Austria. Firms are supported with regard to business models, structuring, business plan development, financing, promotion and patents as well as through training and further education. LISA also organises the business plan competition BoB (Best of Biotech). In addition, Austria Wirtschaftsservice GmbH (aws) uses aws PreSeed and Seedfinancing to administer financing programmes for high-tech enterprise creations, which are open in principle to all industries and sectors but have a special focus on the life sciences. LISA is commissioned by the Austria Wirtschaftsservice (aws) on behalf of the Federal Ministry for Digital and Economic Affairs (BMDW).

Regional funding bodies also support the transfer of basic research into application in the life sciences and health research sector. For example, the Vienna Science and Technology Fund (WWTF), which in recent years has carried out several calls for proposals, from basic research to translational research, with a thematic focus on various research areas: from topics such as "Molecular Mechanisms and Methods", "Personalised Medicine" to "Imaging" and "Nutritional Sciences". The tenders are aimed at researchers in various disciplines such as biology, biotechnology, medicine, veterinary medicine, pharmacy and bioengineering. Great importance is attached to interdisciplinary and collaborative research in order to bring researchers from different industries and institutions together. The regional governments of Tyrol and Styria also support the topic of trans-

152 See http://www.lifescienceaustria.at

lation with their co-financing of COMET projects and centres. These include, for example, Oncotyrol (Innsbruck, a COMET centre funded by the federal and state governments until 2016, operated privately since 2017) and the competence centres for industrial biotechnology (ACIB) and biomarker research (CBMed) in Graz – both with branches in Vienna.

The Clinical Research (KLIF) programme of the Austrian Science Fund (FWF) is also relevant for translation research. Funding is available for projects in the field of clinical research. The project teams may not pursue any direct commercial interests. The studies must therefore aim to gain scientific knowledge and insights to improve clinical practice or to improve diagnostic and therapeutic procedures.

A further possibility for exchange between clinical questions and their investigation as well as the returns of new realisations into support and therapy is offered by research institutes at universities and/or institutes of the Austrian Academy of Sciences (ÖAW). One example of this is the Centre for Knowledge and Technology Transfer in Medicine (ZWT),[153] founded in Graz by the Province of Styria and the Medical University of Graz, within which life sciences firms cooperate in particular with the Medical University. Part of the centre is the Life Science Incubator (LSI), which provides founders from the life sciences sector with infrastructure and know-how. The LSI focuses on supporting enterprise creation in order to bring research results from pharmaceuticals, biotechnology and medical engineering to the market.

Another example is the Austrian Drug Screening Institute (ADSI), a research firm of the Leopold-Franzens-University Innsbruck.[154] The central task of ADSI is drug screening, i.e. the systematic search for new active substances. These substances are primarily intended to treat inflammations and metabolic diseases effectively and gently. The institute investigates natural substances and simulates diseases in test systems to monitor the effectiveness of substances in the laboratory. ADSI works closely with firms and the Oncotyrol Center for Personalized Cancer Medicine.[155]

The Anna Spiegel Research Building of the Medical University of Vienna is a centre for translation research and the most extensive university infrastructure to date.[156] A part of the building houses the Center for Molecular Medicine (CeMM) of the Austrian Academy of Sciences (ÖAW). These adjacent centres are situated on the grounds of the Medical University of Vienna and the Vienna General Hospital (AKH), putting them close to the university clinics in the Vienna General Hospital. The Center for Molecular Medicine (CeMM) is a translational research institute with a strong collaborative and interdisciplinary research culture. Its mission is to pick up on questions from the clinic and feed the findings of research back to the clinic. Research activities focus primarily on cancer research, immunology and rare diseases. The individual research teams in the Anna Spiegel Research Building were selected internally from existing research groups in a competition held by the Medical University and finance their research work primarily with external third-party funding. As is common in translation research, the different fields, chemists, biologists and physicians also cooperate here. On the one hand, the projects should benefit from clinical experience and on the other hand, new findings, for example in the field of diagnostics and biomarkers, can be transferred directly into clinical practice. The research projects carried out at both centres benefit from local infrastructures such as imaging, genomics, proteomics, chemical biology and bioinformatics.

153 See http://www.zwt-graz.at
154 See http://www.adsi.ac.at
155 See http://www.oncotyrol.at
156 See Vignola-Gagné et al. (2014).

An incubator is the cooperative interaction of academic life sciences institutions and biotech firms at the Vienna Biocenter. Here, too, all stakeholders benefit from the cross-fertilisation of scientific knowledge and translational entrepreneurial know-how as well as shared infrastructure.

In a comparison of different infrastructure measures for translation, the Anna Spiegel Research Building in Vienna was compared with the Oncotyrol in Tyrol and the Translationsallianz Niedersachsen (TRAIN). The Viennese institution performed particularly well in the integration of laboratory and clinic, the Tyrolean Centre in investments in areas of research that hitherto showed gaps and the German translation alliance proved especially strong in the new division of labour between different research partners.[157]

The "Knowledge Transfer Centres and IPR Exploitation"[158] programme of the Federal Ministry of Education, Science and Research (BMBWF) and Federal Ministry for Digital and Economic Affairs (BMDW) created three regional knowledge transfer centres (WTZ East, South and West) and a thematic knowledge transfer centre for life sciences in 2014 in order to further intensify and make more efficient the transfer of knowledge from science in business and society. During implementation, the main focus was on cooperation, networking and community building in order to make academic research results quickly commercially viable. The programme was organised and managed by the Austria Wirtschaftsservice (aws).

As a result of the thematic knowledge transfer centre Life Sciences, there is a business plan for a Translational Research Center (TRC) available at the end of the funding period. The aim of this institution is the systematic exploitation of discoveries made by Austrian research institutes and the rapid and efficient transfer of these projects into product development. Projects developed in the TRC and prepared according to industry standards are licensed out and are thus available to firms for product development and production, for example of new drugs, therapies and diagnostics. The aim of the TRC is in particular to counter the identifiable market failure in the area of initial preclinical development (lack of financing for high-risk projects, lack of development skills in the academic sector).

The TRC should help to increase and secure the visibility of excellent academic research and the attractiveness of Austria as a location for research, business and enterprise creation. In addition, young scientists are to be increasingly involved in TRC projects and cooperation projects and an "Entrepreneurial Spirit" of the Translational Research Center is also to provide incentives for enterprise creation not only at the TRC, but also in similar areas.

Building on the internationally positively evaluated business plan for the TRC, the Federal Ministry for Digital and Economic Affairs (BMDW) and the Austria Wirtschaftsservice (aws) surveyed the parameters relevant to state aid and public procurement law in the reporting period and determined the foundations of the TRC's institutional setting. The detailed structure of the TRC and its implementation can only take place after the current negotiations of public and private financing have been completed and a corresponding financing firm established. The operational work is expected to begin in the course of 2018.

3.5.3 Summary

Over the past few years, life sciences and health research have developed with great dynamism as a field of science, particularly in light of growing social and health challenges. In Austria, improved coordination processes and

157 See Vignola-Gagné et al. (2014).

158 All Austrian universities are cooperation partners in the programme. The total funding volume amounts to approx. €20 million.

cooperation efforts between the stakeholders in science and industry, health policy and the funding bodies have helped form a strategic orientation. Participation in international funding initiatives, research networks and strategic partnerships are important components of priority setting. At a European level, Austria can point to a large number of successful participations and project coordination in the health-related programmes of Horizon 2020 to date.

Despite increasingly better technical and financial circumstances, the translation of basic research into application remains a challenge. Translation is characterised by a complex interplay along the entire value chain, from academic and clinical research to the industrial sector. With the "Future Strategy Life Sciences and Pharmaceutical Location Austria" (Zukunftsstrategie Life Sciences und Pharmastandort Österreich), a further step has been taken to coordinate and orchestrate measures in the field of translating findings from basic research into medical practice. While some instruments promote cooperation between science and industry and thus support translation, further measures have also recently been taken in the area of infrastructures by establishing appropriate research institutes at universities, the knowledge transfer centres and the emerging Translational Research Centre.

4 Research and Innovation in the Business Enterprise Sector

Industrial innovation processes are constantly changing. In order to stay competitive in the future and successfully manage these structural changes we need to find a coherent way to develop innovation practice and innovation policy in the face of these changes in society and technological innovation. With this in mind, Chapter 4.1 first of all outlines the competitive strategies of Austrian industrial firms with a focus on the efforts being made in R&D and innovation, followed by an outline of current practices in innovation management and the wider innovation environment ("innovation ecosystem") of Austrian and European firms.

The development and potential of selected future technologies in the context of progressive digitalisation are presented and discussed in Chapter 4.2. These technologies are automated or autonomous driving, digitalisation and networking in the context of the Internet of Things (IoT) and Industry 4.0 as well as blockchain transaction technology.

Finally, Chapter 4.3 focuses on the role of innovation in the agricultural and food industry. It provides an international comparison of productivity in the Austrian farming industry, positions innovation along the agricultural value chain, and discusses the motives and objectives behind agricultural innovation in the context of the market economy.

4.1 Competitive strategies and innovative practices among Austrian firms

Industrial innovation processes are currently undergoing fundamental changes. In the context of increasing international competition and the growing significance of cross-cutting technologies such as digitalisation, adjustments in strategic processes, technological positioning, innovation practices and general processes for the innovative environment can frequently be observed accordingly among firms operating in Austria. This Chapter first of all outlines the competitive strategies of Austrian industrial firms with a focus on efforts in R&D and innovation based on a current survey[1] and discusses recent changes to the product and service portfolio, their backgrounds, and the way firms shape their "search radius" as they look for new skills relevant to them.

The results of a survey[2] at European level are presented next that is dedicated to the internal company organisation and management of innovation processes, and thereby discusses associated implications within the context of a wider innovative environment. The concept of the innovation ecosystem (IES) is also highlighted with its relevance for Austrian firms subsequently discussed. Finally there is an insight provided into the opening up of the corporation

1 See Hölzl et al. (2016): study as part of the "Austria 2025" research programme entitled "Industrie 2025: Wettbewerbsfähigkeit, Standortfaktoren, Markt- und Produktstrategien und die Positionierung österreichischer Unternehmen in der internationalen Wertschöpfungskette" (Industry 2025: competitiveness, location factors, market and product strategies and the positioning of Austrian firms in the international value chain).

2 See Ormala et al. (2017): "Industrial Innovation in Transition (IIT)", supported as part of Horizon 2020 (2014-2017). http://www.iit-project.eu

innovation processes in the context of Open Innovation activities.

4.1.1 Strategies and technological positioning of Austrian industrial firms for retaining competitiveness

Although Austria has been able to maintain its good position as a place for industry in Europe over recent years,[3] "competitiveness" indicators, such as those for the European Innovation Scoreboard (EIS), which specifically cover innovation performance, point to some increasing challenges. Austrian industrial firms continue to expect some key changes in their environment on the road towards the group of leading innovation countries, such as increased international competition, the emergence of new business models and value chains, as well as the impact of the steady advance in digitalisation.[4]

The question of how industrial firms face up to these challenges strategically in Austria in order to maintain their competitiveness was followed up in a recent survey[5] in light of innovation and technology policy. Around 80% of the firms surveyed are from the manufacturing sector. While some firms can be allocated to the industry-related service sector, some firms were also recorded from the mining and energy and water supply sectors in isolated cases. Almost all describe themselves as "industry-related" in the broader sense.

Strategies for retaining competitiveness

The strategic approach of the firms surveyed provides the starting point for analysing the relevant positioning. According to the survey, one-third of enterprises primarily follow the objective of quality leadership, followed by a close focus on customer groups and/or product segments (niche strategy: 29%). Around 1 in 6 of the firms surveyed reacts flexibly to the strategic requirements of the markets, and 14% pursue a broad strategy of differentiation. Only 7% have an objective of price and cost leadership.

In an estimate of the importance of individual strategic elements, a majority of firms consider improvements to the technological content of products in the sense of upgrading as very important (55%) or important (40%). Product development for new markets also plays a significant role (45% very important, 41% important). The development and introduction of new production methods is also seen as a key strategic element (31% very important; 52% important). Somewhat less important appear to be the bundling of products with services (29% very important; 34% important) and improving the product design (27% very important; 49% important).

The firms surveyed primarily see their ability to adapt their products and service to customer requests (customizing: 64%) and their reputation and/or trust placed in them by customers (62%) as competitive edges against their most significant competitors. The proportion of firms is also very high that see product quality (59%), the technological content of their products (51%), the quality of their workforce (47%) and their product portfolio (depth and breadth 42% each) as competitive advantages. The firms state competitive disadvantages primarily in the pricing area, with around 50% of firms at a disadvantage, as well as in the size of the

3 See Hölzl et al. (2016).

4 See Tichy (2015).

5 The survey was carried out in summer 2016 with the support of the Federal Ministry for Digital and Economic Affairs (BMDW) (previously the Federal Ministry of Science, Research and Economy (BMWFW), the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Austrian National Bank (OeNB). The objective of the survey was to review the diversification, specialisation and value creation strategies of industrial firms in Austria. The gross sample was made up of 1,005 Austrian industrial firms (response rate: 32.1%). The sample actually realised included virtually all major industrial firms and covers a majority of those firms that raise R&D expenditure in the business enterprise sector in Austria. The assessments are based on the own perception of the firms surveyed. The overwhelming majority of the sample firms belong to a group of firms. Strategic management, e.g. in relation to innovation, only takes place abroad in just a few cases.

firm (39%), marketing (28%), digitalisation (21%) and efficiency in their production and/or production methods (20%).

With respect to the significance of competitive factors, the survey shows the pricing (64%), digitalisation (62%), efficiency in production and/or production methods (68%), customizing (65%) and the quality of the workforce (64 %) will become more important in future. Yet numerous firms also expect that the quality and technology level of the products (58% in each case) and the importance of reputation and customer trust (54%) will also become more significant in future. These results are in line with a recent survey of managers in the German-speaking world.[6]

The assessments of the firms surveyed in relation to corporate competitiveness as compared with the most important (international) competitors can also be linked with those factors which they consider to be significant for their competitiveness in future. As such the existing strengths and weaknesses are compared with those competitive factors that are likely to become more important. allowing opportunities and unused potential to be derived as a result.

Fig. 4-1 summarises this comparison in an overview of the strengths and requirements profile for Austrian industrial firms.[7] The upper right quadrant contains those competitive factors the significance of which will (continue to) increase in future according to corporate assessments, and in which a disproportionately high proportion of firms state that they already have a competitive edge today. The lower right quadrant includes those factors that will become more significant in future according to corporate assessments, but in which relatively few firms still believe that they currently have a clear edge over the competition. Those factors that will presumably become less significant in future can be found in the two left quadrants.

One of the central strategic elements of the firms surveyed, i.e. improving the technological content of products in terms of upgrades, appears to have been implemented successfully already and will continue to occupy a key role in future. Customising products to customer requests, the reputation of firms, and the qualification and abilities of the workforce will also be seen as a competitive advantage.

Increased pressure on prices is seen in particular as a competitive disadvantage. Although the development and introduction of new production methods and "digitalisation" are seen as key trends, a below-average number of firms currently see these as providing a competitive edge over competitors. The perception of a competitive disadvantage in the area of digitalisation is particularly worrying, as there is a positive correlation between the use of modern information and communication technologies and the competitiveness and productivity of firms.[8] Wider use of communication technologies can also eliminate barriers to internationalisation.[9] Furthermore cross-cutting technologies such as information and communication technologies promote the spread of innovations. Existing technological skills can be applied more easily to new business areas. The critical own perception of firms as regards their competitiveness in the area of digitalisation also reflects other findings, such as the sub-index of

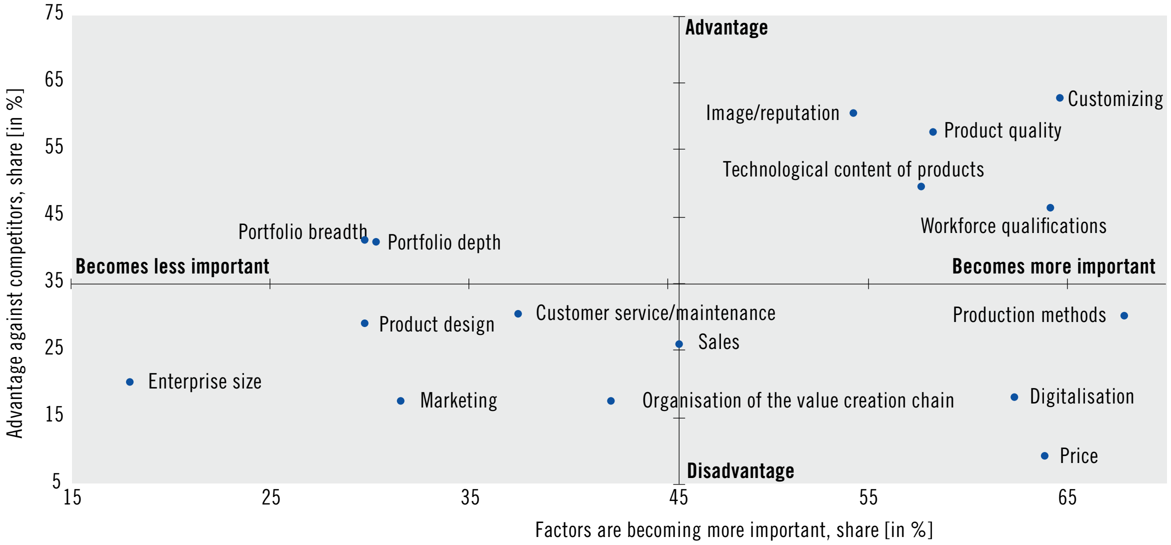
6 See Hoffmann and Unger (2015).

7 This illustration is based on a SWOT analysis, a tool used by firms to analyse the situation and develop their strategy. The original use involves a comparison of a firm's internal Strengths and Weaknesses with its external Opportunities and Threats. This concept is transferred to the positioning of industrial firms in this article and the own perception of current strengths and weakness are compared with expected changes in the industry, with no explicit assessment made in terms of strengths and weakness.

8 See Europe's Digital Progress Report (2017); Brynjolfsson et al. (2003); Arvanitis (2005); Hempell (2005); Austrian Research and Technology Report (2015, 91 et seq.).

9 See Aspelund and Moen (2004); Hamill and Gregory (1997); Simpson and Docherty (2004); Europe's Digital Progress Report (2017). This tends to affect the industrial firms discussed here less and primarily affects Austrian SMEs, whose use of digital technologies is well below the average of the EU-28 and in an OECD comparison.

Fig. 4-1: Strength and requirement profile for Austrian industrial firms



Note: The figure shows the proportion of firms that expect a future increase in significance for certain factors in their industry (x-axis), compared with the proportion of firms that already see a competitive advantage in relation to their competitors (y-axis). The average shares across all categories are represented by the black lines as a guide.

The illustrations are based in Question 18 (How do you assess your firm compared with your biggest competitor?) as well as Question 20 (What factors in terms of competitiveness in your industry will be more important or less important in future than they are today?). These questions feature the same options for response. The proportions of those firms that reported the categories "At an advantage" (Q18) or "Will become more important" (Q20) are displayed. The black lines represent the average values across all categories of response.

Source: Hölzl et al. (2016).

the European Commission's Digital Economy and Society Index (DESI) on the Integration of Digital Technology by Businesses. Austria was in 14th place here in 2017 out of the EU-28.[10]

Changes in the product portfolio through building up skills and expertise

The question that now arises is how the firms surveyed themselves respond to perceived competitive disadvantages and what attempts they make to retain and expand any existing competitive advantages. The expansion of core skills for the purposes of implementing "knowledge-based corporate strategies" is central to this question. This is particularly relevant in light of the perceived competitive disadvantage "digitalisation": 41% of firms surveyed expect a widening of internal company knowledge bases and skills as a result of Industry 4.0.

Around four-fifths of the firms surveyed have changed their product and service portfolios substantially in the last five years before the survey was carried out. The firms built heavily on existing core technological skills developed in the past with this. Four-fifths of those enterprises that had made changes to their product portfolios had also built up new skills and expertise. Of these firms, just under three-quarters have intensified their skills in traditional fields of technology, and approx. 60% are attempting to broaden their core skills through new fields of technology. Only one-third of these firms has developed new core skills away from traditional technological skills.

Changes to the product portfolio therefore are based heavily on existing core technological skills along with those developed in the past. The development is therefore "path-dependent", i.e. the temporal progress of the skills

10 See Europe's Digital Progress Report (2017).

has remained consistent structurally, and is therefore similar to a "path". Path dependencies result in stabilisation in processes and thereby reinforce continuity. This affects both existing competitive advantages as well as weaknesses. A problem can potentially arise if the existing core skills are challenged – e.g. through technological trends such as digitalisation. It is then difficult to leave these behind and firms are locked into existing skills because changing the skills would be a relatively costly process. Any migration of the core skills involves radical changes to the business concept and high risk for a firm.

The path dependencies are weakened in the firm through new knowledge and expertise, i.e. through the availability of new skills. This can mean that by building up skills, attempts can be made to develop new technologies or at least to expand existing core skills. This is reflected in the "search radius" of firms. The results of the survey show that the search for new skills takes place close to existing skills in 46% of the firms surveyed. The "search radius" at these firms if therefore consistently focused.

Among many firms that have expanded their product portfolio in the past, clear efforts can be identified aimed at continuing to develop and broaden their technological skills beyond their existing core skills (see cells 1a–3c in Table 4.1). 39% of firms that have concentrated on intensifying their key skills in the traditional fields of technology over the last five years (cell 1b) wish to establish skills in new fields of technology over the next five years in order to broaden their core skills.

On the other hand, more than 43% of firms that have concentrated on widening their core skills over the last five years by developing new fields of technology (cell 2c) intend to establish skills in new fields of technology over the next five years, in order to develop entirely new core skills. This equates to an expansion in the technological search radius, which results in a weakening of the path dependencies – with new skills established further away from existing skills, which can give rise to major changes both technologically and economically, but also generally involves more risk.

Expanding and consolidating professional skills

The results of the survey indicate that the technological skills of the most important Austrian industrial enterprises are likely to widen steadily in future. Internal R&D used for systematic establishment of knowledge is the most important source for establishing new skills across all firms. Further training initiatives for staff and networking with customers were also stated. Partnerships with specialised suppliers were also frequently stated as an important measure aimed at establishing skills by those firms that can be categorised as technological and quality leaders based on the survey. In addition to internal corporate R&D, those firms that have pursued the objective of establishing new core skills and thereby broadening their technologi-

Table 4-1: Widening of technical skills

		Strategy over the next 5 years [in %]		
		a. Consolidation of core skills	b. New technologies to widen core skills	c. New areas of technology for new core skills
Strategy over the last 5 years	1. Consolidation of core skills	46.4	39.3	14.3
	2. New technologies to widen core skills	4.8	51.6	43.5
	3. New areas of technology for new core skills	9.2	9.2	81.5

Note: The assessments are based on questions no. 40 (What strategic objective has your firm pursued over the last five years aimed at establishing skills?) and no. 46 (What strategic objective will your firm pursue over the next five years aimed at establishing skills?), which feature the same options as a response. The proportions of those firms are displayed that selected a particular category of response in the first questions (row adds up to 100%. Rounding differences not compensated).

Source: Hölzl et al. (2016).

cal base also stated significant increases in R&D partnerships with universities and customers, cooperation with customers, recruitment of experts from abroad and also joint ventures as significant measures in establishing skills according to the survey.

Public funding for research[11] plays an essential role for the firms surveyed in broadening, expanding, and subsequently incorporating skills into internal company activities in a targeted manner, and was also given a positive testimonial overall. This assessment reflects the well-developed funding portfolio for corporate R&D in Austria (see Section 1.2.2), which can also be highly relevant in terms of establishing knowledge in the area of digitalisation given its predominantly open-themed design.

One of the biggest obstructions to innovation in countries that are in the process of becoming an innovation leader is the availability of highly qualified employees.[12] A higher proportion of the population of people with tertiary education aligned to the local conditions can weaken the path dependencies and promote new areas of specialisation.[13] This being the case, it seems hardly surprising that the firms surveyed see activities such as education and further training aimed at establishing knowledge as key to the efforts to establish skills and thereby maintain their competitiveness. 83% of firms see improvements in the education system as "very important" or "important" in securing Austria as a place for business over the long term. This result is also underpinned by the desire for improved availability of expert staff.

Digitalisation in particular – in which the firms surveyed currently see themselves at a competitive disadvantage – requires corresponding trained expert staff. Barriers in adapting digital applications (e.g. e-commerce) are less attributable to the access to information technology with this, and more to a lack of knowledge and a lack of or inadequate training of people in business and of employees.[14] This is particularly significant given the impact of Industry 4.0 (see Section 4.2.2), where the firms surveyed expect a widening of internal company knowledge bases and skills. The results of the survey also point to familiar challenges in the infrastructure area: just under half of firms see an improvement in telecommunications networks as an "important" or "very important" factor in securing their presence at the location over the long term.[15]

4.1.2 Innovation practices and innovation environment for European firms

The growing challenges in international competition, the digital transformation, as well as the growing significance of customer-specific knowledge and expertise increase the requirements on the internal company organisation and innovation management. This has played an increasing role in recent years in individual firms no longer being responsible for innovation processes alone, as is also confirmed by the survey in the previous section, but increasingly being designed and developed within the scope of national or international partnerships and networks. Based on a current investigation[16] in-

11 See Janger et al. (2016) and Jud et al. (2013). There are also points of contact with other levers in economic policy which do not relate solely to industrial firms but which also affect the economy as a whole. These include for instance the availability of funds for young innovation-intensive firms. These enterprises ideally move the industrial structure close to the economic, technological and innovative frontier, which contributes towards strengthening their competitiveness in the long term.

12 See Hölzl and Janger (2014).

13 See Reinstaller et al. (2016).

14 See Arendt (2008).

15 See Austrian Research and Technology Report 2015, Chapter 4.1. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2015).

16 The objective of this Horizon 2020 (2014-2017) project with Austrian participation (partner: JOANNEUM RESEARCH) was to achieve a comprehensive survey and analysis of innovation practices among firms in Europe, and to discuss the latest challenges in innovation management and the wider innovation environment (innovation ecosystem). The study is based on a data record of more than 694 qualitative interviews with firms that were carried out between 2015–2016 in eleven European countries. 75 firms were surveyed in Austria.

sights into the current innovation practices and innovation management in firms in Austria and Europa[17] are provided below. The firms covered originate from the industries[18] of agriculture and food, biopharmaceutical production, "Cleantech" (clean technologies), information and communication technologies (ICT) and manufacturing.

Managing the innovation process

Innovation processes are primarily organised in accordance with the Stage-Gate model[19] in the European countries examined, irrespective of the relevant industry. This strategy is applied in just over half of the Austrian firms surveyed (46.7%) as well as in the majority of firms in Finland (55.1%), Germany (68%) and Spain (78.8%) (see Fig. 4-2). Larger firms tend to use the Stage-Gate model more frequently than small and medium-sized enterprises (SMEs). The second most frequently stated method is the customer-oriented "lean start-up" principle.[20] Around one-third of Austrian firms organise their innovation processes in accordance with this principle, which is also becoming increasingly important in Austria and in the other companies examined.

Business units within large firms especially that organise innovation processes in accordance with the Stage-Gate model can in particular become dominant "gatekeepers" within their own firm.[21] If the same business units lead both the innovation activities as well as the business strategies, and therefore control all activities in relation to their direct business impact, this could also impact the development of long-term innovation prospects. Radical innovation projects that could lead to a reorganisation of existing business units sometimes then take a backseat. Although this is not necessarily a problem in itself, it could act as a brake on or even prevent medium and long-term innovation decisions in firms.

The situation is similar with respect to general business strategies. These are traditionally designed in firms in such a way as to support further development of the current product range and expand existing markets (see Section 4.1.1). If firms focus exclusively on improving current products and services, however, they run the risk of missing radical innovations, which could lead to problems, particularly in periods of economic transition. On the other hand, disproportionate investment in radical innovations can result in sustained setbacks in terms of the firm's own competitive position if economic success is not achieved to the same extent. The Good Practice Guide[22] developed as part of the study therefore recommends corporate strategies in which short-term incremental innovations can be combined with long-term radical innovations.

Another strategy for counteracting "operational short-sightedness"[23] involves relying more heavily on the customer-oriented lean start-up principle. This way of organising innovations includes rapid prototype generation and including customers at an early stage in order to implement innovation in line with their requests. Treating increment and radical innovations separately in their own departments is

17 These countries were: Austria (AT), Czechia (CZ), Germany (DE), Spain (ES), Estonia (EE), Finland (FI), Ireland (IE), Italy (IT), Netherlands (NL), Portugal (PT) and the United Kingdom (UK).

18 The data record is arranged by industry as follows: 14.3% agriculture and food industry, 13.3% biopharmaceutical production, 16.7% cleantech, 19.0% ICT, 36.7% manufacturing.

19 See Cooper (2002). The Stage-Gate model was developed by Robert G. Cooper in order to optimise innovation and development processes significantly.

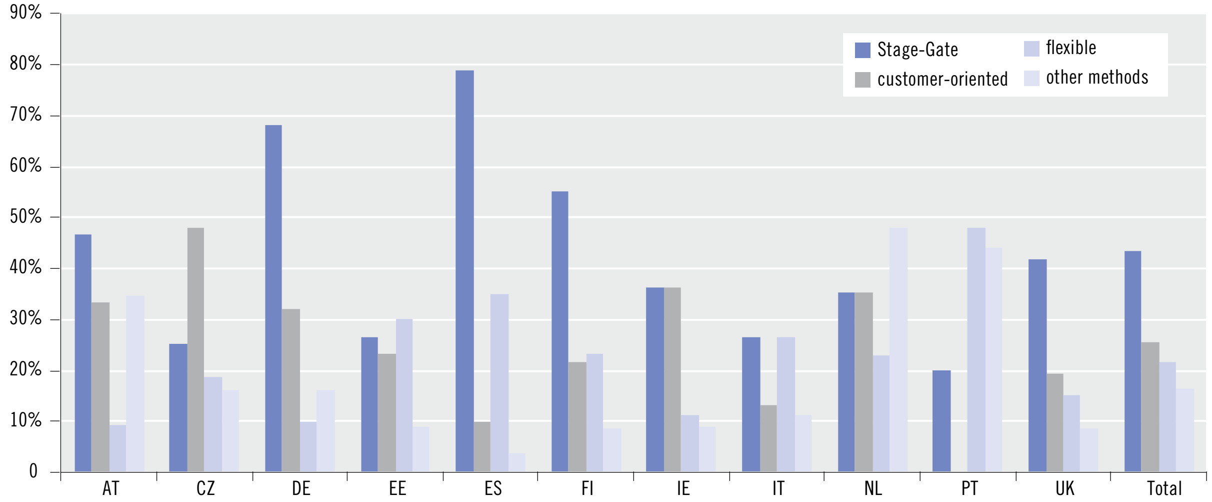
20 See Ries (2011). The lean start-up model was developed by Eric Ries and was first mentioned in his blog "Start-up Lessons Learned" in September 2008. The objective is to identify the desires and requirements that the own target group really has using this method. This takes place using targeted testing of the most important hypotheses that represent the elementary factors for the success of the idea. As a result the lean start-up method allows rapid adjustments to the product and thereby drives optimisation of the business model.

21 See Cooper et al. (2012).

22 See Ormala et al. (2017).

23 See March (1993).

Fig. 4-2: Proportions of applied methods in the organisation of innovation processes, selected countries



Source: Survey as part of the Industrial Innovation in Transition (IIT) project (2015–2016). AT: n=75. Multiple responses possible.

beneficial here. Autonomous organisational units can thereby also act autonomously from other business units in order to drive forward the development of radical innovations.

According to the study, innovation activities take place equally in different corporate units as well as within a central R&D department. The key stakeholders in R&D-related decisions are typically the managing director (over 70% in all areas), followed by representatives from the R&D departments. A lively discussion between the individual divisions is normal, however, e.g. with executive management advised by the R&D department or other employees on the trends and new requirements among customers and markets.

A further important aspect related to organisation and management of the innovation process is coordination of the general business strategy with any existing innovation strategy. While just under 55% of Austrian firms in the study stated that the innovation strategy is derived from the business strategy, this figured amounted to 83.3% in the Netherlands and even 92% in Germany. The reverse case whereby the business strategy is derived from the innovation strategy is not very widespread among the Austrian firms surveyed.

With respect to the further development of the business and innovation environment, European firms regularly see progress in (company-related) technologies (67%), competition (55%), customer behaviour (52%) as well as the appropriate directives and regulations (40%). More systematic approaches are used to determine trends, new opportunities and risks, as well as competition and alliances. These approaches include structured processes such as patent analyses and creating scenarios and road maps, as well as informal elements such as taking part in conferences and trade fairs, personal and professional networks and relationships with customers and business partners. The fact that only around one-quarter of the firms surveyed in Europe monitor economic development and only around one-sixth of firms the developments in other markets and industries is a remarkable finding. Although these aspects are not relevant to the same extent for all firms, this harbours the risk of potentially identifying new challenges too slowly and thereby missing opportunities.

In Austria the technological developments in the industries studied are monitored more intensively primarily in Cleantech or clean technologies[24] (80% of firms), in information and communication technologies[25] (68.4%) and in manufacturing[26] (60%). New directives and regulations are primarily of interest to representatives from the biopharma industry[27] (66.7%) followed by cleantech (60%). Customer behaviour is particularly relevant for firms in the agricultural and food industry[28] (66.6%) as well as those in the ICT industry (63.2%) (see Fig. 4-3). The findings are used in particular to initiate new projects, develop new strategies and identify new market opportunities. A small number of firms examine their business and innovation environment in order to expand or refresh their innovation ecosystems by looking for new partners.

European IT firms such as SAP use design thinking to provide the optimum support for operational innovation processes.[29] These procedures are also made available to the educational sector through partnerships, in order to support and accompany innovations at VET colleges with respect to the challenges of digitalisation and Industry 4.0.[30]

Innovation ecosystem

Consideration of interacting firms' innovation ecosystems (IES) promotes the creation and successful economic exploitation of innovations.[31] Functioning innovation ecosystems not only permit firms to cooperate with other firms or research institutes, but also enable discussion with other stakeholders, e.g. investors, business associations, regulatory authorities, advisers as well as political decision-makers. While customers are generally stated as the most common partners according to studies in Europe, public research institutes represent the most important stakeholder in their IES in Austria (92%), followed by regulatory authorities (65%) and customers (60%).[32]

Timely identification and use of potentials and contexts in the IES have become more important in recent years for firms in all industries in Austria. In the context of the study, this applies in particular to manufacturing, the agri-

24 The Cleantech sector in the IIT project is derived from the definition by Kachan et al. (2012) and Tierney (2011): "not one tidy group, but rather an array of distinct sub-sectors: solar, wind, and geothermal energy generation, biofuels, energy storage (power supplies such as batteries and uninterruptible power supplies), nuclear, new pollution-abatement, recycling, clean coal, and water technologies". The cleantech industry thereby includes all industrial areas related to energy storage, energy efficiency, and water, air and environmental technologies.

25 The OECD (2011) delimitation of the ICT sector was selected in the IIT project: "The production (goods and services) of a candidate industry must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display". It is based on the NACE classification of economic sub-sectors, and includes the ICT manufacturing industry, ICT trade and ICT service providers.

26 A collection of industrial sectors were selected in the IIT project for the "manufacturing" industry that "… are engaged in chemical, mechanical, or physical transformation of materials, substances, or components into consumer or industrial goods". The NACE classification of economic sub-sectors forms the basis.

27 The demarcation from Xia (2013) was used in the IIT project for the definition of biopharmaceutical production: "Biotechnology is defined in a single definition recommended by OECD (2003) as the manufacture of products by or from living organisms usually involving bioprocessing. We differentiate biopharmaceutical from this broader view of biotechnology as a sector with a specific focus on pharmaceuticals inherently biological in nature and manufactured by biotechnology methods". As a result biopharmaceutical production includes the production of pharmaceutical primary products, the production of pharmaceutical products and R&D in biotechnology.

28 Building on the NACE classification of economic sub-sectors, the definition of agricultural and food industry for the IIT project consists of the following industries: "cultivation of perennial and annual plants"; "plant reproduction techniques", "mixed agriculture, provision of agricultural services and harvest-related tasks", "food and beverage production", "wholesale of agricultural primary products and living animals".

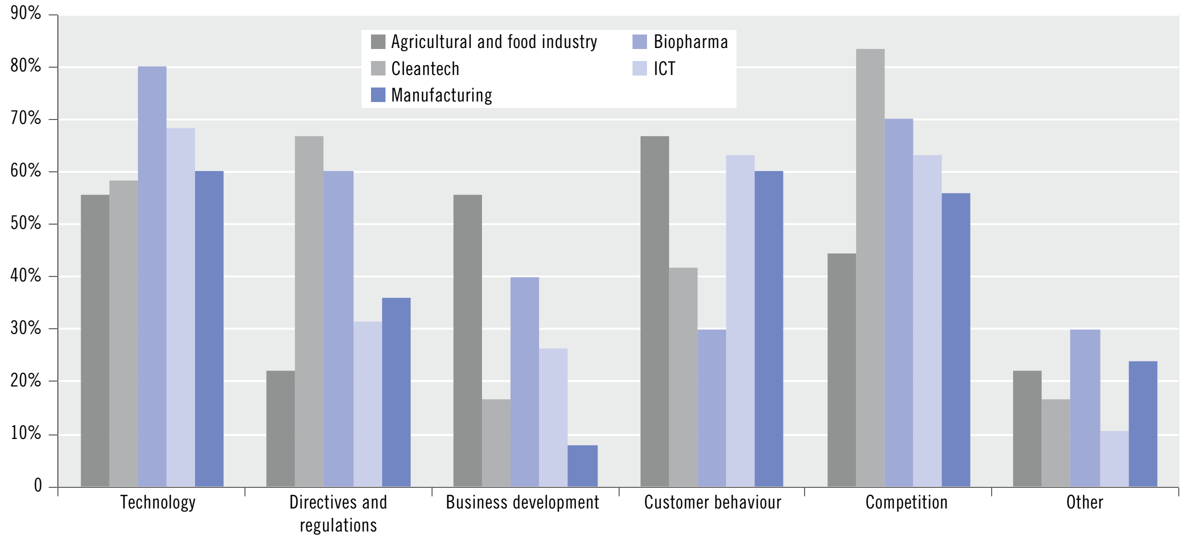
29 See http://design.sap.com/designthinking.html

30 See http://www.berufsbildung40.at

31 See Adner (2006). The Innovation Ecosystem (IES) perspective models complex dynamics around a product or technology based on flows of resources such as knowledge, capital, humans and materials. IES are defined as "…collaborative arrangements through which firms combine their individual offerings into a coherent, customer facing solution […] When they work, ecosystems allow firms to create value that no single firm could have created alone."

32 See Austrian Research and Technology Report 2017, Chapter 3.1. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

Fig. 4-3: Design and configuration of the future business and innovation environment and the most important factors for Austrian firms



Source: Survey as part of the Industrial Innovation in Transition (IIT) project (2015–2016). AT: n=75. Multiple responses possible.

cultural and food industry, cleantech and biopharma production, where one in two firms in the study highlighted the growing importance of their own IES. In the cleantech industry this figure even amounted to two-thirds of enterprises surveyed. Only in the ICT industry did more than half of firms state that the significance of the IES had not grown. One reason for this could be that open arrangements are typical in the ICT industry and ICT firms are therefore already closely interconnected within their IES.

There are lots of different approaches for selecting the form of cooperation between firms and therefore for designing their individual IES.[33] A majority of the firms surveyed in Europe develop company-related strategies aimed at influencing their IES. These strategies include e.g. participation in committees, the development of strategic interest groups, and joint development of new technologies. External partners overwhelmingly tend to be incorporated into the innovation process at an early stage with innovation partnerships. Firms rely predominantly on their own capabilities and skills in order to drive innovation forward and bring it to subsequent fruition (see Section 4.1.1).

Exchanging knowledge represents the key factor at the overall European level for the firms surveyed for cooperation within an IES. The firms surveyed state that the large number of innovation inputs support them in understanding current and future customer requirements, along with technological, legal and societal challenges, and in incorporating these into their own work. Around 75% of the Austrian firms surveyed named sharing knowledge, 25.3% sharing services (e.g. joint use of web-based platforms), 18.7% personal mobility and 16% financial support as important for cooperation in the IES. More recent studies[34] in the context of Open Innovation (OI) and knowledge transfer

33 See Killich (2002).
34 See Austrian Research and Technology Report 2017, Chapter 3.1. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

at the European level paint a similar picture: aside from improving existing products and/or services and developing new ones, the acquisition of knowledge, abilities and ideas represent the important effects for firms of cooperation with external partners.

Firms use their IES as more than a mere source for knowledge. They influence its development at the same time through passing on their own (future) requirements, e.g. to political decision-makers or regulatory authorities, and through developing a common vision for the future with partners. Around one-third (28%) of the Austrian firms surveyed in Europe develop company-related strategies aimed at influencing their IES.

In order to bolster their position in the IES, the firms focus primarily on improving the quality of their products or developing new technological applications (see Section 4.1.1). Attempts to influence the (political) design of standards and regulations or to establish interest groups, e.g. within the scope of industrial associations, are another important strategy for positioning within the IES. Marketing initiatives such as advertising and pricing strategies are used somewhat rarely. Knowledge generation within the IES can be organised in different ways with this and is not necessarily limited to the ongoing innovation activities, but can be based on potential follow-up activities.

Open Innovation

Opening up innovation and participation with external parties in the IES is closely linked to the concept of OI. Around 70% of the Austrian firms surveyed stated their involvement in OI processes. This percentage is considerably higher in some countries such as the United Kingdom (90%). The most important motives for OI activities include solving technical problems for 40% of Austrian manufacturing and half of cleantech firms. In the agricultural and food industry (33.3%) and the ICT sector (31.6%) the motivation for OI activities on the other hand is more in the expansion of marketing options for their products. Recent surveys[35] include the identification of new technological trends, improved information on customer requirements, a reduction or diversification of technological risks, saving time and improved market access as the major motives for Austrian firms in taking part in Open Innovation models.

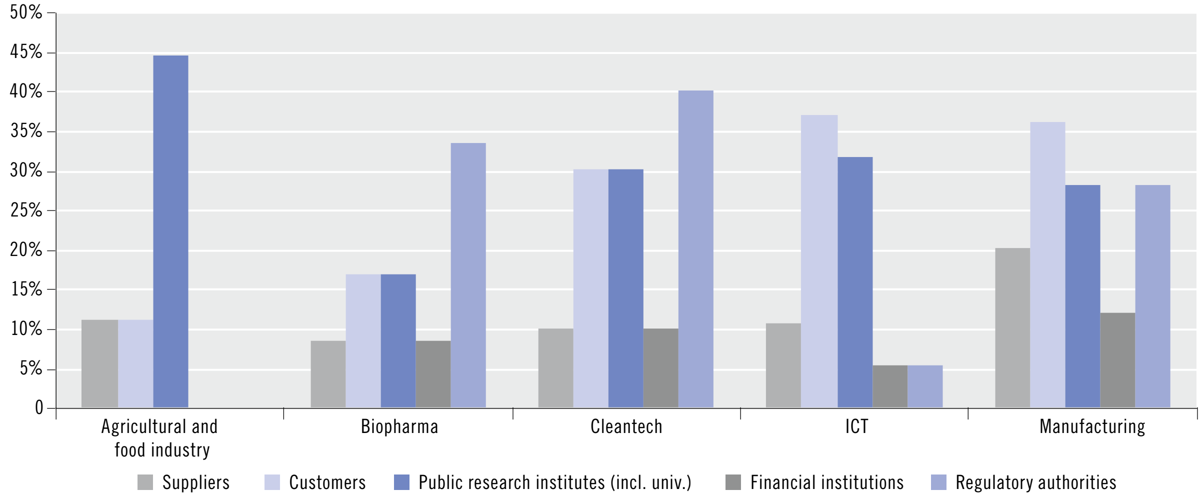
In general it can be stated that OI activities can be supported through cooperation between suppliers and manufacturers, through strategic partnerships with universities, through collaboration with customers, end-users or clusters, and through the knowledge that makes its way into this process. The Austrian firms surveyed stated here that knowledge flows most frequently between the firms and their customers, with interaction with suppliers and public research institutes also often stated (see Fig. 4-4). This largely corresponds with the findings from previous studies on OI in Austria.[36] According to this the most sources from which Austrian firms absorb external knowledge are cooperation projects with customers as well as universities and research institutes.

Many of the firms surveyed foster strategic partnerships with universities that support the organisation of their internal company innovation processes both structurally and over the long term. The partners benefit equally from these types of long-term relationships: while firms gain knowledge and access to current research results, universities obtain more resources and opportunities for market testing of their prototypes. Co-funding for PhD and Master's students was also frequently stated as an

35 See Austrian Research and Technology Report 2017, Chapter 3.1. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

36 See Austrian Research and Technology Report 2017, Chapter 3.1. Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).

Fig. 4-4: Importance of the stakeholders in the Open Innovation process for Austrian firms



Source: Survey as part of the Industrial Innovation in Transition (IIT) project (2015–2016). AT: n=75. Multiple responses possible.

OI activity in the survey. Common research and innovation infrastructures can also be created through these strategic partnerships. Combinations of public and private funding often form the financial conditions for this type of OI.

4.1.3 Summary

In order for firms operating in Austria to stay competitive they must on the one hand make continuous adjustments given the growth in global competition and in particular digitalisation. Innovation activities based on partnership, shorter timeframes for product innovations, appropriate examination of the business and innovation environment as well as new models for innovation, such as Open Innovation, represent growing challenges for firms.

As the survey of Austrian industrial firms shows, businesses are working on creating competitive advantages by developing and offering products with high technological content (upgrading) and with good quality. A further competitive advantage can be seen in adapting products to meet customer requests. Competitive disadvantages can be perceived in particularly in pricing, implementation of new production processes and also in digitalisation. Establishing new skills and broadening existing ones is seen as key in dealing with the challenge of "digitalisation". This is in line with the principle of knowledge-based competitiveness.

The firms surveyed appeared to be extremely dynamic: the product and service portfolio has been recently modified, with new skills also established in the firms for this. Aside from through internal enterprise R&D – an expression of the systemic process of building up knowledge within the firm – the new knowledge and skills required come primarily from further training initiatives and networking with customers, such as through cooperation projects. Partnerships with other firms and universities and acquiring experts from abroad are becoming more important, particularly for the quality leaders and those firms that plan to broaden their skills significantly.

While research funding by firms was rated well overall, challenges are still stated in the economic policy areas of education and telecommunications infrastructures. Activities that are generally aimed at establishing knowledge, such as further training and education, are generally seen as key to building up skills and thereby remaining competitive. This is particularly relevant for the area of digitalisation, for which firms identify a lack of trained expert staff.

In terms of broadening their core skills, many of the firms surveyed state on the one hand that they wish to continue focusing on existing core skills or only plan to broaden these gradually. On the other hand, expanding the technological search radius counteracts this "path dependency". It is not just firms that have previously relied on expanding their core skills by developing new areas of technology that intend to develop skills in new areas of technology in the future. Firms that have focused on their key skills in the past are also increasingly looking for new ways of retaining their competitiveness over the long term through new areas of technology.

New management systems and organisational regulations are required in order to manage the growing complexity of the innovation processes. As the study at the European level demonstrates, the Stage-Gate model is the one most frequently used. The customer-oriented lean start-up process is less widespread, and is used more for radical innovation projects in (semi-) autonomous innovation units. In terms of the strategies for retaining competitiveness, the pattern is largely similar to the survey outlined above. Firms are accordingly pursuing business strategies that are more aligned towards further development of their current product range and existing markets.

The results of the survey also show that enterprises certainly make use of their IES, e.g. in order to generate knowledge and findings regarding the technological possibilities, develop new knowledge through cooperation or also to obtain information on future regulations. IES thereby not only represent a source of knowledge and information: they also shape the development of these. They communicate future requirements to policy decision-makers or regulatory authorities, and develop common visions with external partners as well as new business models within the ecosystem. These correlations are becoming increasingly relevant for firms in all industries.

In a knowledge landscape that is increasingly fragmented and often features shared responsibilities in the innovation process, new models and methods of innovation management are required for a precise analysis of the innovation landscape and its future development. This analysis focuses on new markets, customers, opportunities, dangers, competitors and alliances. Firms combine very different sources, methods and pieces of information with this in order to develop an understanding of their future business environment. Informal elements such as taking part in conferences and trade fairs and building personal and professional networks are becoming increasingly important. According to the survey, more than half of companies regularly use knowledge generated outside of the firm for their innovation activities and operate OI as a fixed component in their business strategy.

In summary, the results indicate that the technical knowhow and capabilities existing within Austrian (manufacturing) firms represent a good starting point for establishing new technological skills and developing new products and business areas from traditional strengths. Opening up innovation processes helps small open national economies such as Austria in particular to obtain new and effective forms of sharing knowledge, ideas and value and to exploit these within and outside of a firm. These aspects are relevant in terms of technology policy, as translating innovation output and/or new knowledge into economic success is one of the key points for Austria in the EIS ranking. The distinction between "upgrading" and "structural change" also requires demarcation of the research, technology and innovation policy measures that differ in terms of their objectives and effective channels.[37]

4.2 Key technologies for digitalisation

Some key technologies and applications play a particularly major role as part of the digitalisation of industry and society, and have the potential to transform individual or even multiple industries in a fundamental way. Three important technological developments are outlined in more detail below that currently receive much attention and are addressed by the different private and public stakeholders. We look first of all at developments on the way towards automated driving, which is relevant and promises growth potential for the entire mobility sector and for sections of the manufacturing sector. The "Internet of Things" is rapidly diffusing many industries. Applications in the production sector are usually referred to as "Industrial Internet of Things", and regarded as a key technology in the context of development towards Industry 4.0 for the years to come. The latest developments in Austria are presented in the corresponding section. Finally, there is a disruptive potential seen for many sectors in the blockchain transaction technology. There follows a description and discussion of the fundamental principles, applications and initial initiatives in Austria aimed at promoting this technology.

4.2.1 Automated driving in Austria

New technological developments in the areas of automation, networking and digitalisation also cover the mobility sector and are changing the entire value chain and mobility behaviour of individuals. This affects all modes of transport as well as the intermodality between the different modes of transport. In the context of this development the topic of "Automated Driving" (AD) is subject to much attention in the international and national discussion surrounding transport and technology policy. All well-known carmakers around the world are working intensively on achieving automated vehicles and launching these on the market. Numerous test initiatives, pilots and development projects are also either ongoing or being prepared in Austria.

There are high hopes for this area, related on the one hand to the implementation of technological visions, and on the other to transport and environmental policy as well as economic potential. However, there are also risks and socio-technical challenges that are often associated with legal, ethical and socio-political issues.

The topics surrounding AD are outlined in this section from a transportation and technology policy point of view. Following a demonstration of the status quo, and a definition and outline of the expectations associated with AD, the international and specifically national initiatives as well as the RTI policy measures are described, with a subsequent discussion of the future challenges and prospects for action. The focus here is on automated or autonomous vehicles.

Moving towards automated driving

AD essentially means movement by robots and driverless transportation systems. The five levels of the SAE Standards (Society of Automotive Engineers) have been accepted for the purposes of classifying automated/autonomous vehicles (see Table 4-2).[38]

At level 0 the human driver controls the vehicle independently for all driving tasks with support from technological systems in particular in risky driving moments (e.g. braking and changing lanes on an icy road). At level 1 to level 2 the human driver continues to be required to monitor the driving environment carefully, while automated systems make the driving comfortable and reduce the risk. At the same

37 See Janger et al. (2016).
38 See https://www.bmvit.gv.at/verkehr/automatisiertesFahren/faq/hintergrundinfos.html#faq2

time the driver must remain ready as the fallback option on an ad hoc basis. From level 3 the vehicle's automated system takes over the monitoring of the vehicle's environment, the human driver becomes obsolete as an absolutely necessary fallback option from stage 4. The human driver is replaced by the technological system at the fully-automated level 5. He or she is a passenger from this point onwards.[39]

Depending on the facilities and usage in a vehicle it should be possible for it also to switch between the different levels (e.g. between levels 4 and 5).

Current and future fields of application for AD in road transportation include e.g. traffic jam assistants, lane departure warning systems, motorway pilots, driverless parking, driverless sharing vehicles, pick-up and shuttle taxis (first and/or last mile logistics), autonomous shuttle buses, driverless delivery services, platooning[40] in lorry transportation or autonomous maintenance and cleaning vehicles.[41]

In the premium segment in particular, assisted and semi-automated driving (levels 1 and 2) represent the latest technology in some industries. Functions already available include lane departure warning systems, autonomous cruise control systems, automated parking and motorway pilots. Expansion to medium-sized vehicles is foreseeable. Partly-automated cars (level 3) should be available on the market in the near future, i.e. from 2020. The level of their technical maturity equates to close-to-production development. This form of automation where the vehicle completes functions independently such as triggering the blinker, changing lanes and lane departure warnings, is technically feasible on motorways in particular. The introduction of highly-automated vehicles (level 4) is expected in the first half of the 2020s, depending on the usage case and deployment area. Aside from motorway travel, first and/or last mile logistics or shuttles are applications at this level, with driverless parking in car parks already possible at this level. Start of production for fully-automated or autonomous vehicles (level 5) is currently anticipated within the next eight to twelve years, i.e. general technical implementation is not expected prior to 2030, although this depends on the deployment and application area.[42]

Areas of application for automated vehicles are provided not only for the transportation of goods and individuals by road, but also specifically for local public transportation and rail travel. Public modes of transportation should in future be equipped with sensors, cameras and a network of interconnected systems. This should enable transport companies to control and monitor their routes more effectively. The trams, underground trains and buses of the future should also move automatically or autonomously.

Automated vehicles should also provide the option of combining public transport with individual mobility. In future for instance, small driverless buses or vehicles should act as shuttles to existing public modes of transport, and thereby close the gap of the last kilometre to the next stop and vice versa. As such automated driving should also provide a close interlock between local public transportation, sharing systems, neighbourhood transportation and taxi systems.

Expectations surrounding automated driving

Different expectations are linked to AD internationally and nationally, and these have been described recently in the "Austrian Research, Development & Innovation Roadmap for Auto-

39 See Nikowitz (2015).
40 Platooning involves a system in which multiple vehicles are able to drive automatically one after the other at very narrow distances.
41 See Nitsche et al. (2017).
42 See https://www.bmvit.gv.at/verkehr/automatisiertesFahren/faq/hintergrundinfos.html#faq4

Table 4-2: Classification of automated/autonomous vehicles according to SAE standards

SAE level	Name	Description
Human driver monitors the environment		
Level 0	No automation	The driver controls the vehicle independently, even if supporting systems (e.g. ABS or ESP) are in use.
Level 1	Drive assistance systems	Assistance systems help in operating the vehicle with longitudinal or transverse control (including autonomous cruise control system).
Level 2	Partial automation	One or more drive assistance systems help in operating the vehicle with longitudinal and simultaneous transverse control (e.g. traffic jam assistant, automated parking). The driver must intervene as necessary independently and without being requested.
The automated system monitors the environment		
Level 3	Conditional automation	Automated driving (e.g. on motorways and freeways) with the expectation that the driver will respond to a request to intervene. The driver receives a time reserve before he or she must assume the driving task. The driver no longer needs to monitor the system continuously.
Level 4	High automation	Automated driving of the vehicle with the expectation that the driver reacts or takes over the driving task following a request to intervene. The vehicle continues to control the vehicle autonomously without a human reaction (e.g. until is has safely stopped at the roadside).
Level 5	Full automation / driverless	Autonomous or "driverless" driving, whereby the dynamic driving task is carried out under all roadway and environmental conditions that can be managed by a human driver. The human driver can input control options (e.g. destination, route, driving mode). All people in the vehicle are passengers.

Sources: Federal Ministry for Transport, Innovation and Technology (BMVIT) and SAE, AIT graphic.

mated Vehicles".[43] From a transport policy point of view, increasing traffic safety and the vision of accident-free travel in particular are at the forefront and are stated as key motivators for the public commitment in this topic area. AD should result in accidents being avoided as a result of fatigue, distraction, failure to pay attention or excessive speed. According to studies nine out of ten traffic accidents are attributable to human failure, and automated vehicles should eliminate this source of error.

AD should also significantly reduce energy consumption through efficient and anticipatory driving, and therefore also reduce negative environmental effects considerably. Reductions in traffic jams and more efficient freight traffic are stated as potential benefits in this context. Further anticipated increases in consumer benefits arise through relieving the strain on drivers: the driver becomes a passenger and is able to use the time gained for other activities. Autonomous vehicles could also help elderly and disabled people to become more mobile and thereby gain independence and a better quality of life.

Combining automated vehicle and sharing concepts should also enable a reduction in vehicles in the long term, and therefore allow public spaces to be regained. This involves a potential improvement in the overall transportation system in Austria, and a change in people's mobility behaviour.

If nothing else, industry and RTI policy hope to achieve an increase in value creation and to create and/or secure jobs as a result of marketable innovations. Austria has an internationally competitive automobile supply and electronic industry, which is already in demand globally in many industries related to AD and the electronic and sensory systems required for this.

National RTI policy measures and test environments

AD has been an RTI-policy priority area at the Federal Ministry for Transport, Innovation and Technology (BMVIT) since 2015, with the objective of ensuring the strategic establishment of system and technological skills in this area. The "Automatisiert-Vernetzt-Mobil" (Auto-

43 See https://www.bmvit.gv.at/verkehr/automatisiertesFahren/faq/oesterreich.html#faq1 und https://www.ffg.at/sites/default/files/downloads/call/austrian_roadmap_automated_vehicles_0.pdf

mated-Linked-Mobile) action plan was developed for this in a broad stakeholder process.[44]

Nine measures were developed as part of this action plan that have either already been implemented or are currently at the implementation stage. These measures include (1) establishing a contact point for AD, (2) amending the Vehicle Act and preparing a regulation on AD (2016), (3) developing a Code of Practice, (4) preliminary studies on test environments and (5) establishing test environments and key projects, (6) establishing the digital infrastructure to support tests, (7) developing the technology portfolio (R&D projects), (8) establishing a professorship to expand scientific skills and expertise and (9) putting evaluations and studies on systemic impacts and effects out to tender (e.g. jobs, safety and security, efficiency and environmental sustainability). An interdisciplinary expert advisory committee was also deployed in the aim of providing advice and support to the Federal Ministry for Transport, Innovation and Technology (BMVIT), with an AD strategic planning and coordination team also enshrined within the Ministry.

The Federal Ministry for Transport, Innovation and Technology's (BMVIT) "Automated Driving" initiative was also launched in the spring of 2016 based on the action plan, with a focus that spans all programmes and with a content aligned towards the priority focal areas in the RTI funding programmes "Mobilität der Zukunft (Mobility for the Future), "Information and Communication Technologies (ICT)" and "KIRAS – safety research".

The Federal Ministry for Transport, Innovation and Technology (BMVIT) plans to provide around €20 million in public funds by 2018.[45]. Of this €6 million is planned for investment in national technology promotion (R&D projects in interacting research areas), €11 million for proposals for test environments with preliminary studies (fast track and normal track), between €1-3 million for expansion of the scientific skills at Austrian universities (endowed professorship) and €0.3 million for evaluations and studies (impact analyses on system effects).[46] Follow-up investments amounting to between €20-30 million from industry and other regional entities are anticipated from these public investments by the federal government.

Aside from promoting R&D activities, test environments and comprehensive analyses of systemic effects, the Federal Ministry for Transport, Innovation and Technology (BMVIT) considers itself an active public stakeholder that promotes and coordinates dialogue between all parties involved, and thereby assumes responsibility for leadership of the dialogue in the area of "Automated Driving". The set-up and use of test environments by different test partners for the various usage cases within the scope of R&D projects are key to successful introduction of automated vehicles and the technologies, infrastructures and system applications upon which these are based. The legal circumstances for testing automated vehicles on Austria's roads were created at the end of 2016 in light of this fact. Since then, initial test drives have already been completed on public roads, including with self-driving minibuses, highway pilots[47] with lane switching assistants and self-driving army vehicles.

Austria's first test environment for testing and developing self-driving road vehicles has been set up in Styria with the title "ALP.Lab". Test drives are planned for the future on sections of the A2 and A9 roads. The "Zentrum in Berg" (Centre in the Mountain) based in Leoben in Styria is also incorporated into the test envi-

44 See https://www.bmvit.gv.at/innovation/publikationen/verkehrstechnologie/automatisiert.html
45 This does not take into account the Austrian involvement in corresponding EU funding programmes such as Horizon 2020.
46 See https://www.bmvit.gv.at/verkehr/automatisiertesFahren/faq/oesterreich.html#faq3
47 A highway pilot allows a vehicle to drive fully automatically on freeways and motorways. Distance controls and keeping to as well as changing lanes take place automatically.

ronment, meaning that tests can also take place in tunnels. The "Dynamic Ground Truth" and "LiDcAR" research projects are also taking place within the test environment. The former project is concerned with high-precision measurement and reference systems for identification of the environment, while the latter project is concerned with the development of light sensors for ascertaining distance and speed in self-driving vehicles. This will make "ALP.Lab" one of the most comprehensive test environments in Europe.

A further test environment by the name of "DigiTrans" was launched at the end of 2017 in the central area of Austria North (Linz – Wels – Steyr). Efforts to expand this test environment were started in the first half of 2018. "DigiTrans" focuses on commercial and special-purpose vehicles, particularly in the area of logistics hubs and lorries.

Additional test options are being created in Vienna and Salzburg as part of key projects. The focus here is on small self-driving buses and how these can be used to complement public transport and/or energy-efficient automated convoys of trucks.

Aside from setting up and operating test environments for road vehicles, Europe's first test environment for self-driving trains has been created in Burgenland. Railway technologies for self-driving trains are tested in the "Open.Rail. Lab". The entire process for developing the engineering for self-driving trains can be executed on the test line between Friedberg in Styria and Oberwart in Burgenland.

International initiatives

In addition to its national activities, the Republic of Austria is also represented on numerous international platforms and bodies by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry for Digital and Economic Affairs (BMDW) for the purposes of taking part in harmonisation processes. The aim is to use the combined effects from the European funding instruments in R&D such as Horizon 2020 and ECSEL to ensure optimum use of synergies with European RTI policy. Strategic cooperation also takes place on European technology and infrastructure platforms such as ERTRAC,[48] EPoSS,[49] ERTICO,[50] CEDR,[51] EIP[52] (BMVIT) and GEAR2030[53] (BMDW). Research and technology roadmaps as well as strategic research agendas and AD are some of the items also developed on these European platforms, with work also provided aimed at ensuring harmonised introduction of AD and the infrastructures required for this. The latter item of development and implementation of digital infrastructures for automated and connected driving is also being promoted with Austrian involvement in the multilateral European initiatives C-ITS Corridor,[54] C-Roads[55] and Digi-Roads[56].

A large number of relevant initiatives can also be found internationally: corresponding roadmaps and strategic plans are currently being implemented in stages with pilots carried out and test environments established in several other European countries, as well as in South-East Asia, the USA and Canada, the Arabian countries, Australia and New Zealand.[57]

48 European Road Transport Research Advisory Council.
49 European Technology Platform on Smart Systems Integration.
50 ERTICO – ITS Europe: network of around 100 firms and institutions involved in the development and implementation of Intelligent Transport Systems (ITS).
51 Platform for cooperation between National Road Authorities.
52 European Intelligent Traffic Systems (ITS) Platform.
53 High Level Group on the Competitiveness and Sustainable Growth of the Automotive Industry in the European Union (EU platform on the harmonised introduction of automated driving).
54 Implementation of first Cooperative Intelligent Transport Systems (C-ITS) at the EU corridor between Rotterdam – Frankfurt – Vienna.
55 Implementation of joint C-ITS services in eight countries in Europe (AT, DE, FR, NL, BE, UK, SL, CZ).
56 Pilot implementation of digital infrastructure elements with evaluation and Impact Monitoring of these.
57 See CARTRE (2017).

Roadmaps and strategy documents have been developed e.g. in Germany, the Netherlands, Finland, the UK, France and Spain, as well as in the USA, Canada, Japan and Korea. Pilots are taking place in several European countries or with the involvement of several states. Examples include L3Pilot,[58] AUTOPILOT,[59] TrustVehicle,[60] Brave,[61] Trans Aid,[62] Future Bus[63] and InfraMix.[64] Test environments are being established e.g. in Sweden (AstaZero), Finland (Aurora Snowbox), Spain (CARNET) and Germany (A9 Digitale Autobahn).

Sociotechnical challenges

The technology behind AD is already highly advanced. However, additional technical challenges still need to be overcome, for instance in connection with data security, data protection, networking/communication, fault detection and rectification in real time, fail-safe and reliable software, precise location, sensor/actuator systems and identification of the environment in bad weather, snow, unclear road markings and signage, as well as interaction between humans and AD/automated machinery.[65] There are also doubts remaining regarding the practical feasibility in all driving situations and under all driving and environmental conditions. The issue of a mix of transportation between autonomous vehicles and conventional ones driven by humans arises in particular this regard, along with the extent to which a driverless vehicle features the flexibility in crisis situations to ignore the road traffic regulations or road makings if this is necessary in order to prevent accidents.

Ethical issues also arise associated in particular with dilemmas, i.e. if the technological system can no longer avoid damage but has to evaluate the damage caused. What criteria does a technical system actually use to decide e.g. whether to run over a person or drive over a precipice? Fundamental questions also arise regarding the role and task of machines and robots in social contexts, e.g. when and under what conditions human self-determination skills can or have to be relinquished.

A major need to clarify the legal issues also remains (e.g. in connection with liability, registration, road traffic regulations, driving licences) in order to ensure harmonisation internationally. A discussion could also arise in the future regarding whether and what point conventional cars are banned in order to reduce potential risks from mixed traffic. The latter pint is also relevant in the context of the affordability of automated vehicles, which remain very expensive.

Although the expectations related to the future of mobility with digitalisation and automation are positive, more recent studies and potential future scenarios also show that possible adverse effects of automation restrict or could even endanger the positive effects. Several traffic assessment simulations on automated and mixed vehicles show e.g. that although the number of vehicles would be lower, the amount of traffic could rise by up to 80%[66] as it would be on the road practically all the time. Changes in behaviour are not yet considered in this (e.g. longer distances for a more comfortable journey, switch from footpaths and cycle paths to automated services) which could result in an

58 See http://www.l3pilot.eu/
59 See http://autopilot-project.eu/
60 See http://www.trustvehicle.eu
61 See http://www.brave-project.eu
62 See https://www.transaid.eu/
63 See http://www.daimler.com/innovation/autonomous-driving/future-bus.html
64 See http://www.inframix.eu/
65 See https://www.bmvit.gv.at/verkehr/automatisiertesFahren/faq/hintergrundinfos.html#faq5
66 See OECD (2015a).

additional increase in the amount of traffic.[67] Even with more efficient flows of traffic through connected and automated vehicles, these simulations reveal that current capacities on traffic routes would rapidly reach their limits, particularly in urban areas and at peak times, with the areas that have become "free" not capable of being used for other purposes and instead having to absorb the rise in traffic.

In summary it can be stated that the topic of AD is subject to major attention in terms of transport and technology policy, and positive expectations are linked to further developments in this area. Austria is very well positioned and competitive internationally in this context. The public sector is working closely with industry, mobility service providers, science/research and other regional authorities to develop and implement AF successfully from a transport policy and economic point of view. Corresponding strategies, measures and activities are being developed and already implemented for this. Austria is also actively represented on international bodies and platforms.

Automated driving also involves ethical, legal and social issues at the same time that demonstrate the required improvements and address the potential risks and adverse effects. Any possible rebound effects[68] require a systemic consideration of automation in transportation and its potential socioeconomic interactions.

A key challenge for politicians involves defining and implementing appropriate measures which allow them to leverage the positive potential wherever possible, and as far as possible to avoid any negative effects that could also lead to problems of acceptance.

4.2.2 Internet of Things and Industry 4.0: Industrial Internet of Things (IIoT)

The digitalisation of the economy encompasses many sectors and enables a range of new applications. Manufacturing leads the way here, a development known as Industry 4.0 in the German-speaking world. The core principle behind industry 4.0 is the comprehensive digital networking between various production stages, goods, machines and vehicles within firms and between firms at different levels of the value chain. The digitalisation of industry is of major significance for Austria, as the manufacturing sector is disproportionately significant in Austria with a share of 18.1% (2017) as compared with an EU average of 16.1%.[69]

Data transmission and sensor systems in the form of cyber-physical systems as well as robotics and production planning and control at various levels therefore form the technological basis for Industry 4.0. The underlying linkage between physical and virtual things is thereby known as the Internet of Things (IoT), with the term Industrial Internet of Things (IIoT) also used for IOT applications in industry. Moreover, industrial applications of artificial intelligence (AI), augmented reality, as well as the phenomenon of the platform economy,[70] big data or additive manufacturing processes are also often discussed under the umbrella term Industry 4.0. The concept of the platform economy expresses the idea that technical or institutional platforms upon which information, data, products and services are exchanged have become important market factors. These developments are not, however, limited to the manufacturing sector. The example of Building Infor-

67 See Millonig (2014) and Millonig (2017).

68 Rebound effects in the energy economy refer to those effects that result in the potential for savings from increased efficiency (e.g. improved utilisation rates for autonomous vehicles) not being realised or only partially being realised. Increased efficiency ensures that the consumer has less expenditure and can therefore consume additional products and/or services. Increased efficiency that results in increased consumption is referred to as "backfire".

69 See Eurostat (2018): Breakdown of gross domestic product and income by economic sectors. [nama_10_a10]

70 See Kenney and Zysman (2016).

mation Modelling (BIM), i.e. digital modelling of buildings for better planning and management, shows for instance that these technologies have also long been used in industries such as the construction industry. These technologies also enable new business models and services in the energy, transport and logistics industries in other service sectors.

The development towards Industry 4.0 is targeted at increasing productivity, quality and utilisation rates at the firm level and at reducing waste through improved control over the production process. The long-term objective here, however, is largely to achieve self-control over industrial manufacturing processes. At the same time these new production concepts are also intended to increase the flexibility of manufacturing processes significantly. The general principle here is to combine the cost advantages of industrial mass production with the flexibility required for the production of individual products (single units).

Ultimately, Industry 4.0 opens up various potentials for innovation,[71] such as in the form of new business models and data-driven services which manufacturing firms can offer on top of or instead of their physical products. Examples here include for instance operator models in which it no longer machines that are billed but instead the services provided by these machines (e.g. a certain number of machine hours, energy produced, compressed air provided, etc.). Predictive maintenance is another example. Attempts are made here to use data from the production process in order to predict the failure of important parts and thereby avoid production outages by replacing these in good time. Austrian firms with more than 20 employees generated 11.7%[72] of their revenues form services in 2015, with these services predominantly billed indirectly through the price of the product or a system offering.

The proliferation of Industry 4.0 in Austria

Recent studies do not provide a complete picture currently of the status of the proliferation of Industry 4.0 in the Austrian business enterprise sector. Different surveys such as the European Manufacturing Survey reveal that the prevalence of Industry 4.0 in Austrian industry is still at the initial stages. Major international firms and serial manufacturers are at the forefront of Industry 4.0 in Austria.[73] Firms in the mid-range technology segment (electronics, vehicles, metal, plastics) currently use Industry 4.0 technologies with greater frequency than firms in the high technology or low technology segments.[74] Automobile construction, plastics production and processing as well as mechanical engineering are leading the way here. Industry 4.0 technologies are evidently particularly in tune with the requirements of Austrian manufacturing, which is focused in the mid-range technology segment. Customer requirements are a key driver for the use of Industry 4.0 concepts and/or technologies with this. This is why the use of Industry 4.0 technologies is significantly greater among upstream suppliers. These technologies help suppliers meet customer requirements for quality, flexibility and documentation of the production process more effectively and improve coordination with their customers' production processes. The strong interlock between Austrian suppliers once again highlights the importance of Industry 4.0 to Austria.

However, there is not much evidence yet of the diffusion of Industry 4.0 at a macro-economic level. Increased expenditure for Industry

71 See Reischauer and Leitner (2016).
72 Calculations by the AIT based on the results of the European Manufacturing Survey 2015.
73 See Austrian Research and Technology Report 2017, Federal Ministry of Science, Research and Economy, Federal Ministry for Transport, Innovation and Technology (2017).
74 See Zahradnik et al. (2016).

4.0 would have to be reflected in higher gross investments in machinery. Data from the national accounts, however, shows that investments in machinery have been stagnant in Austria since 2012.[75] Investments accelerated considerably from 2014 to 2015. Any such stagnation does not fit in with the image of a dynamic diffusion of Industry 4.0, but does not necessarily mean that Austrian firms are sceptical towards Industry 4.0. On the contrary, the long service lives of many machines and cautious investment demand following the financial crisis explain the reticence shown by Austrian firms. The Industry 4.0 concept alone is evidently not an adequate incentive for many firms to renew their fleets of machinery. Investments in replacements and enhancements are, however, often already Industry 4.0-compliant.

Industry 4.0 has also not yet left its mark on productivity development over recent years. Aggregate total factor productivity has only experienced slow growth in Austria in recent years, as it has in most other industrialised nations.[76] Hopes for a significant acceleration in productivity growth through Industry 4.0 have therefore not yet been fulfilled. One possible explanation for this is measurement issues, such as quality improvements that are not reflected in the calculation of gross domestic product. Secondly the current low diffusion levels for Industry 4.0 technologies may be a reason for the negligible impact at present. Empirical studies show that only a small group of firms have already achieved a high level of maturity in their use of Industry 4.0, while most other firms are still at the initial stages of implementing new production concepts. Aside from other factors such as globalisation, these differences in the use of information and communication technologies lead to the leading firms and the late adopters drifting increasingly apart in terms of productivity development at the firm level.[77]

Some findings even point to Austria lagging behind in digitalisation. A current OECD report sees Austria behind comparable European countries in various indicators,[78] such as the proportion of people who use computers with internet access in firms, machine-to-machine (M2M) communication, fast broadband in firms, cloud computing, digital management systems such as Enterprise Resource Planning (ERP), or the proportion of firms that order and purchase items via the internet. It should be noted here, however, that apart from the indicator on digital management systems, none of the statistics used measure the prevalence of Industry 4.0 technologies directly. Initial approaches aimed at a direct comparison of the prevalence of Industry 4.0 technologies between countries show no essential gap for the Austrian machinery and metal goods industries between firms in Germany and Switzerland.[79]

Initiatives and programmes at the national level

Policy can promote the distribution of digital production technologies and IoT solutions through various activities. For instance, the internal and cross-company linkage of production steps requires an efficient infrastructure. The expansion of mobile and wired broadband connection is therefore an important pre-condition for blanket distribution of Industry 4.0 and IoT applications in general. IoT and IIoT also raise new issues related to data protection and data ownership. Inadequate data protection regulation could cause firms not to open up their internal networks to customers and thereby obstruct the distribution of the IoT. With industrial applications, for instance, it does not appear to be clear in advance who owns the pro-

75 See Stöllinger (2016).
76 See Weyerstraß (2018).
77 See Berlingieri et al. (2017).
78 See Gönenç and Guérard (2017).
79 See Gönenç and Guérard (2017).

duction data accumulated; major customers in manufacturing and machine producers could exploit their market power in order to enforce data access among suppliers or customers. Lastly there may also be barriers to firms wishing to develop Industry 4.0 applications. Government support could help here in overcoming these obstacles.

The "Broadband Billion"[80] is available for expansion of the broadband infrastructure, and is being used among other things to develop rural areas with fast internet and to update the existing infrastructure. The objective is to provide almost comprehensive speeds of at least 100 mbps by 2020. The future 5th generation mobile network (5G) will also ensure significantly faster wireless internet connections. The first auction of frequencies for future 5G services is planned by the Austrian Regulatory Authority for Broadcasting and Telecommunications (RTR) for 2018.

The Federal Ministry for Transport, Innovation and Technology (BMVIT) provides around €185 million annually for R&D in the area of Industry 4.0.[81] Most of these funds are allocated via the Austrian Research Promotion Agency (FFG); some of the projects receiving funding in 2016 included €66.4 million of funding in the area of industrial production, €47.4 million for ICT expenditure and €19.4 million for funding in the area of automation.[82] Two now pilot factories were also funded in 2017 at Graz University of Technology and the University of Linz with endowed professorships also established. Various innovative applications which enable artificial intelligence, big data and augmented reality in the industrial context also receive support within the scope of this funding. The Federal Ministry for Transport, Innovation and Technology (BMVIT) also promotes the proliferation of Industry 4.0 via the "Plattform Industrie 4.0" association[83], formed by ministries, social partners and other stakeholders. The Platform's responsibilities include providing information to firms, research institutes, politicians and the media on new developments in Industry 4.0, and creating a broad consensus in the public discussions on this topic.

The Federal Ministry for Digital and Economic Affairs (BMDW) promotes Industrial Internet and Industry 4.0 applications as part of various initiatives, such as the ProTrans programme as well as Research Studios Austria. Firms can also obtain advice on the use of Industry 4.0 via the SME Digital advice and qualification programme,[84] implemented in conjunction with the Austrian Federal Economic Chambers (WKO). The "Forschungskompetenzen für die Wirtschaft" (research skills for industry) programme sets priorities for Industry 4.0 and digitalisation in tourism in order to enable expert staff and research staff to gain higher qualifications. A focal point was established in the ERP Fund for digitalisation and Industry 4.0,[85] meaning that firms are able to obtain funding through loans for these types of projects. Lastly the Federal Ministry for Digital and Economic Affairs (BMDW) uses the Smart and Digital Services-Initiative[86] (SDS-I) to promote projects of a R&D nature in all industries that lead to the development of new services. Industry 4.0 and the blockchain have been made the priorities within SDS-I.

Reference can also be made to the Austrian Research Promotion Agency (FFG) programme ICT of the Future[87] with respect to innovative applications outside of industry. Key projects were advertised in 2017 on the topic of "Inter-

80 See https://www.bmvit.gv.at/telekommunikation/breitband/foerderungen/
81 See https://www.bmvit.gv.at/presse/aktuell/downloads/leichtfried/industrie4_massnahmen.pdf
82 See Austrian Research Promotion Agency (FFG) (2017).
83 See http://plattformindustrie40.at/
84 See https://www.bmdw.gv.at/Innovation/Foerderungen/Seiten/KMU-DIGITAL.aspx
85 See https://www.aws.at/foerderungen/aws-erp-wachstums-und-innovationskredit/
86 See https://www.ffg.at/programme/smart-and-digital-services
87 See https://www.ffg.at/iktderzukunft

net of Things – Safe, Secure and Usable" for the purposes of developing new technological approaches that enable safe and practical use of IOT in various applications areas, such as construction and living (smart city and smart home), health, transport and energy. Reference can also be made to the Austrian Research Promotion Agency (FFG) funding priority of 5G applied research[88] with the objective of further development of the 5G mobile standard which is an important component in future IoT applications.

4.2.3 Blockchain transaction technology

Increasing digitalisation in industry has the potential to initiate some fundamental changes in market and organisational structures in some industries.[89] Distributed ledger technologies (DLT)[90] such as blockchain technology which, on account of their special features, enable transactions to be made without an intermediary provide brand new opportunities and challenges for the construction of cooperative and trading structures. The first blockchain application in 2008 for instance formed the basis for the cryptocurrency bitcoin.[91] There are, however, many other application areas.

From a technological point of view a blockchain is a list of transaction data records that grows constantly and is saved in a distributed database[92] (distributed ledger). The list is expanded on a linear basis in a similar way to a chain to which new elements are added at the bottom end (hence the term "blockchain"). Each block contains a checksum of the previous block, enabling a cryptographically-secured, historical chronology, and entries can no longer be amended without the manipulation being discovered. One particular feature of a blockchain is the decentralisation.[93] "Smart Contracts" which allow contracts to be processed or transactions such as purchase and sales decisions to progress automatically are important applications areas for blockchain technology.[94]

Innovations featuring blockchain solutions can be found in an increasing number of sectors (e.g. Internet of Things, administration, the sharing economy, energy supply, the finance industry, insurance), particularly where data security plays a major role. From an economic point of view, one of the key arguments for the use of blockchain technologies is the possibility of offering peer-to-peer solutions that can be implemented with no trusted institutions acting as intermediaries. As such, the blockchain can allow unique documentation of the legal ownership and possession relationships as a result of its special data structure, without involving costly third parties, thereby changing the manner in which transactions are administered. Companies normally develop trust in regulatory institutions for the exchange of goods and monetary values, which determine and guarantee the legality of the relevant title. With the concept of the blockchain, however, this authentication takes place decentrally via a series of network nodes that can be distributed all over the world (distributed consensus building).[95] The underlying transaction model shifts therefore from a centralised structure (banks, stock exchanges, energy companies, etc.) to a distributed system (end-customers,

88 See https://www.ffg.at/5Gfoerderschwerpunkt
89 See Gawer (2009).
90 Distributed ledger means a distributed database managed remotely that grants participants in a network common write and read access rights.
91 See Nakamoto (2008).
92 A distributed database contains data records with associated content that are saved at different locations distributed geographically (see Renz 2017).
93 See http://www.datenbanken-verstehen.de/lexikon/blockchain/
94 See Kaltofen (2016).
95 See Prinz and Schulte (2017).

consumers, individual producers, etc.), in which intermediaries are no longer required, as the transactions can be initiated and implemented directly from peer-to-peer. The global payment system bitcoin works for instance based on the blockchain without any involvement whatsoever from banks.[96]

The peer-to-peer transactions administered via the blockchain technology should guarantee greater security, efficiency, speed and transparency in a large number of market transactions. The disruptive potential of blockchain technology, also known as "institutional governance technology",[97] is seen as being very high. New business models and stakeholders based on blockchain technology are increasingly competing with traditional models and established stakeholders.[98] A range of industries and sectors are therefore in line for major changes and need to prove themselves against the innovations using these technologies. The World Economic Forum forecast in 2015 that a total of 10% of global gross domestic product would be generated using blockchain by 2027.[99]

Many blockchain pilot applications have already been produced or are in development in recent years for various sectors of industry and in public administration. Aside from the financial industry the energy sector has seized upon the topic in particular.[100] For instance local energy producers and end-users can process transactions using blockchain in a peer-to-peer contractual relationship in real time[101], enabling energy to be supplied with citizens and firms as active market participants.[102]

Some stakeholders in Austria from research, industry and public administration have started to address the topic in recent years and also to begin testing in pilot applications. Wien Energie for instance has tested pilot projects for the trade in gas and electricity.[103] Pilot systems are also being set up in public administration which, in the case of the City of Vienna for example, are aimed at safeguarding the integrity of open government data, and simplifying administrative processes and other forms of democratic interaction.[104] Some start-ups are also dedicated to the topic of blockchain. The Blockchain Hub Graz[105] in Styria organised a "Blockchain Start-up Contest"[106] in the autumn of 2016 with the support of the Austrian Research Promotion Agency (FFG). As the technology is still at the early implementation stages, a range of challenges still need to be overcome in order to exploit the potential of the blockchain in its entirety (e.g. scalability, high processing powers, security issues associated with the programming code).[107] There are also several statutory and supervisory requirements which blockchain projects also need to meet. There is still a considerable need for research and development in any case.

In light of this, Austrian RTI policy has also started to dedicate itself to this topic. Block-

96 See https://www.bmvit.gv.at/innovation/downloads/blockchain_technologie.pdf
97 See Davidson et al. (2016).
98 See Ibid.
99 See WEF (2015).
100 See PwC global power & utilities (2016).
101 A real-time transaction involves the processing of a digital transaction that is accepted or rejected immediately once the customer has completed and sent the online order form.
102 The international "Event Horizon" conference organised in Vienna in February 2017 showed the potential and the challenges in the area of the blockchain for energy, and allowed established and new stakeholder groups to exchange information.
103 See https://www.ots.at/presseaussendung/OTS_20171203_OTS0014/blockchain-mitten-in-wien
104 See https://science.apa.at/rubrik/politik_und_wirtschaft/Wiens_Verwaltung_setzt_auf_Blockchain/_SCI_20171212_SCI39491352039634444
105 See https://blockchainhub.net/graz/
106 See http://blockchainstartupcontest.com/
107 See Scherk and Pöchhacker-Tröscher (2017).

chain technology is mentioned in the Digital Roadmap Austria[108], accompanied by a series of initiatives and measures. The Federal Ministry of Science, Research and Economy (BMWFW – now the Federal Ministry for Digital and Economic Affairs (BMDW)) for instance launched the "Blockchain Austria" initiative in 2017 with a 9-point plan for Austria. The Blockchain Austria Roadmap was created with the involvement of experts from Austria and abroad and from different industries as part of an Open Innovation approach.[109] Sustainable basic and applied research in this area is one of the items that is awarded top priority in this. Aside from interdisciplinary research, application-oriented best practice examples are also pushed forward in the form of "lighthouse projects", along with pilot projects dedicated to the legal uncertainties facing the blockchain-based projects (e.g. taxation, insurance, liability, applicable legal standards and regulations). A Blockchain Summit[110] was held at the Vienna University of Economics and Business in December 2017 organised by the Federal Ministry of Science, Research and Economy (BMWFW) as part of Blockchain Austria. The opportunities and risks in various industries related to blockchain technology were discussed with pilot projects considered in different workshops. A new research institute for the cryptoeconomy, funded by the Federal Ministry of Science, Research and Economy (BMWFW), was also opened at the Vienna University of Economics and Business as part of the event,[111] which led the efforts to submit a new initiative known as the "Austrian Blockchain Center" as part of a COMET K1 centre.[112] The innovation potential of blockchain for public administration is also being examined in GovLabAustria from the Federal Ministry of Civil Service and Sports (BMÖDS) and University for Continuing Education Krems.[113]

In terms of funding and promoting research and technological development within the scope of public programmes, reference can be made to the additional blockchain priorities set by the Austrian Research Promotion Agency (FFG) since October 2017 as part of the Smart and Digital Services-Initiative (SDS-I). Research into and development of service innovations with blockchain procedures can be funded as part of the initiative, irrespective of the topic areas. SDS-I is an initiative by the Federal Ministry for Digital and Economic Affairs (BMDW) aimed at promoting service projects of a R&D nature with additional budgetary funds and is being administered by the Austrian Research Promotion Agency (FFG). The initiative is specifically targeted towards small and medium-sized enterprises, large firms, universities, universities of applied sciences, centres of excellence, research institutes and start-ups.

A topic-based dossier on blockchain technologies was commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT) in 2017 and made available to the public.[114] Projects that address the topic of the blockchain were also considered in the latest proposals in the "IKT der Zukunft" (ICT of the Future) programme. A system for handling data, services and brokerage in Austria is being set up for instance as one of the projects in the three-year "Data Market Austria" key project running since October 2016, in the application areas earth observation and mobility based on

108 See https://www.digitalroadmap.gv.at/en/
109 See Blockchain Austria Roadmap of the Federal Ministry of Science, Research and Economy (BMWFW) V1.0. https://www.blockchain-austria.gv.at/
110 See http://bit.ly/BC_Summit_WU
111 See https://science.apa.at/rubrik/politik_und_wirtschaft/Blockchain_Summit_als_Auftakt_fuer_neues_Kryptooekonomie-Forschungsinstitut/SCI_20171206_SCI40111351039541212
112 See https://www.blockchain-center.at/
113 See http://www.govlabaustria.gv.at/veranstaltung/ilabsymp_2018/
114 See https://www.bmvit.gv.at/innovation/downloads/blockchain_technologie.pdf

blockchain technologies. The blockchain was also made a priority in the 9th proposal for the "Mobilität der Zukunft (Mobility for the Future) project (spring 2017) in the area of mobility. The proposal priority areas for R&D services in the basic mobility and transport research were among other things aimed specifically at the blockchain in mobility and transportation.

The topic of the blockchain was addressed in the energy research programme of the Climate and Energy Fund (KLIEN) in the area of "energy systems and networks", in order to promote further development of the electricity systems with particular regard to the decentralised approaches, and in particular to safe technologies for market participation by prosumers[115]. Aside from targeted R&D funding, measures are required in future by the pubic sector that also cover topics such as education and further training, regulation and data protection in order to exploit the potential of this new technology and absorb the risks.

4.2.4 Summary

Digital technologies are changing the industry on a broad front and imposing new strategic and organisational requirements on firms and policymakers. Individual key technologies not only have an impact on productivity and economic growth: they also have the potential to change entire areas of life and society. The Internet of Things (IoT) and blockchain are cross-cutting technologies here that promise new applications for a range of industries and affect the manufacturing sector as well as the energy and construction industries as much as the services sector and financial industry. While IoT applications can already be found in production and there are some empirical findings on this for Austria, blockchain transaction technology is still at a very early stage. There are some initial pilot applications here and some start-ups that are focusing on the blockchain. The extent to which blockchain is actually able to develop its disruptive potential is still highly uncertain. In any case, the potential needs to be explored and innovative applications also need to be tested. Aside from IoT and blockchain, automated driving (AD) also has a broad impact on Austria which covers the transport industry, logistics and parts of the manufacturing sector. Areas of application for AD are provided not only for the transportation of goods and individuals by road, but also for local public transportation and rail travel. The set-up and use of test environments for different usage cases within the scope of R&D projects are key to successful introduction of AD.

RTI policy has implemented a series of initiatives and measures in recent years aimed at promoting the key digital technologies listed. In addition to the traditional funding of R&D, new requirements and action areas are emerging for all three digital technologies which must also address legal, ethical and social issues. Important initiatives include e.g. expansion of the infrastructure, with broadband networks needing to be stated here along with transport infrastructures. There is also a major need for standardisation, with some open issues related to regulation. Data protection and security are an important cross-sectional matter that affects all three digital technologies equally. Lastly there are numerous challenges in the area of education and further training and in the design of jobs and working time models. It is only by taking a coordinated approach which involves the various stakeholders and interest groups that digitalisation can be designed in such a way that competitiveness is fostered and any potential negative effects on employment and the working environment can be avoided. Corresponding guiding principles for the design

115 A prosumer is someone who is a consumer and producer at the same time. They either produce their own products through customisation of existing products or through a voluntary disclosure of their preferences. As such the prosumer is able to influence the product characteristics and is incorporated into the producer's production activity.

of digitalisation in Austria were also set out in the Digital Roadmap Austria[116].

4.3 Innovations in the agricultural and food industries

Agriculture plays a key role in human society. It forms the basis for human nutrition and faces major challenges in light of global increases in population numbers. Efficient agriculture is required in order to secure food for the future. Embedded within the global market, the Austrian agricultural industry also faces the challenge of implementing continuous adjustments in order to remain competitive. This is also reflected in the emphasis on innovation as the paramount objective in the current Austrian Rural Development Programme[117]. The European Innovation Partnership for Agricultural Productivity and Sustainability (EIP AGRI) is a concrete example of this.

On the other hand, agriculture is responsible for retaining and fostering the ecosystems used. Agriculture plays an important role in combatting climate change. This includes new procedures for reducing emissions in production and approaches in the bioeconomy aimed at replacing fossil fuels with sustainable resources. The food supply also needs to be secure at the same time through the production of biological raw materials. The implementation of measures that increase productivity, including through the use of digital technologies on the one hand and ecological and/or sustainable objectives on the other, requires intelligent use of the innovation potential of agricultural businesses. The Federal Ministry for Sustainability and Tourism (BMNT) has implemented some important steps towards this through establishment of the Platform for implementation of the innovation strategy in agriculture. Funds from the Climate and Energy Fund are also used to fund tools aimed at driving investments that are beneficial economically and also bring environmental benefits.[118]

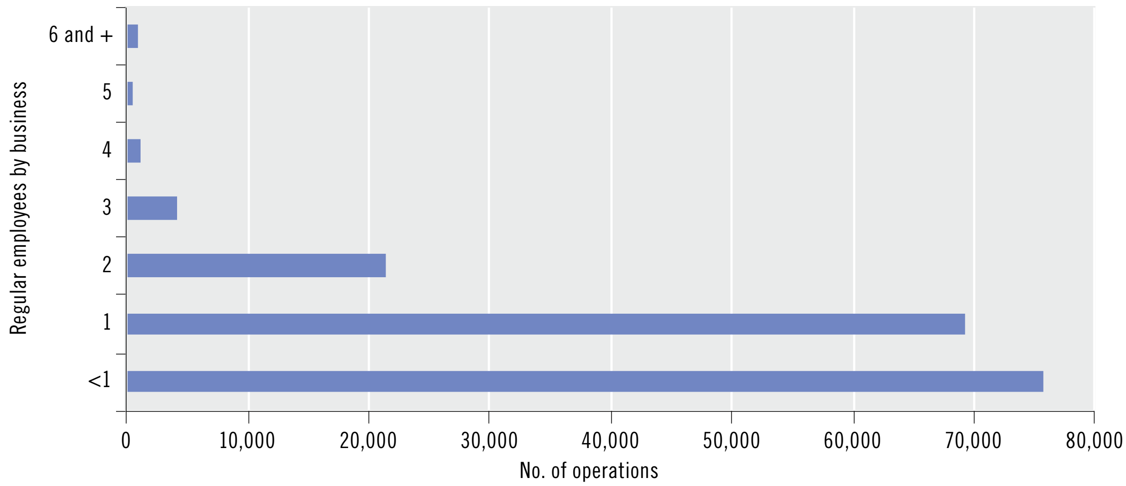
4.3.1 The level of innovation in Austrian agriculture

Innovation plays a major role in agriculture. Unlike other economic sectors, however, this is barely evident in the products. There is barely any change in the appearance and taste of fruit, vegetables, cereals or milk. On the other hand, the production methods are fundamentally different from those used in earlier times. Building on the scientific foundations laid in the middle of the 19th century, the proliferation of mineral fertilisers and pesticides, as well as targeted breeding and cultivation methods in animal husbandry and crop production, combined with mechanisation in agriculture, have brought major changes over the course of the 20th century.

On the other hand, agriculture is frequently seen as far less innovative today than the production methods, and is generally not taken into account in scientific analyses of corporate innovation. Agricultural businesses are not even addressed for instance in the European Innovation Survey (CIS). This is partly based on the fact that agricultural business are generally small and only have a few employees when compared with other firms.[119] In the last comprehensive survey by Statistics Austria in 2010, agriculture and forestry had just over 170,000 businesses in which around 100,000 people were at least employed half the time.[120] This means that just under 60% of agricultural businesses in Austria were managed by less than half a full-time employee.

116 See https://www.digitalroadmap.gv.at/en/
117 See Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) (2016).
118 See The chapter is based in large part on the "Innovation – der Motor für Wachstum und Beschäftigung in der ländlichen Wirtschaft" (Innovation – the engine for growth and employment in the rural economy) study (Sinabell et al. 2017).
119 The European Community Innovation Survey (CIS) only takes account of firms with at least ten employees.
120 See Statistics Austria (2016).

Fig. 4-5: Agricultural and forestry businesses in Austria by number of regular employees in 2010



Note: "regular employment" means employment of at least one day per week.
Source: Statistics Austria (2013).

Fig. 4-5 shows the results of the agricultural structural survey on the distribution of employees per business. Small firms (with fewer than ten employees) feature considerably less propensity towards innovation than larger firms according to a current study for Germany[121]. The result of this is that low innovation frequency can be expected in agriculture as compared with other industries based on the corporate demographics.

In the case of Austria a recent study[122] shows that agricultural business are introducing innovations and developing existing processes. Around 78% of the businesses surveyed as part of this study stated that they have either introduced innovations in products or services, production-related processes or in the organisation in the period between 2011– 2015. The proportion of actively innovative firms is extremely high compared with other industries surveyed as part of the European Innovation Survey (CIS) (see Table 4-3). It should be noted, however, that the results can only be compared to a limited extent. The reference periods are different for both surveys on the one hand, while on the other the focus and core concepts for the agricultural survey were adjusted to the particular features of the agricultural industry, in order e.g. to account for the close interlock between the Austrian agricultural industry and upstream and downstream industries which play a major role in the innovation activities of agricultural businesses. The survey tool and way that individual questions are formulated also differ in order to meet the specific conditions applicable in agriculture.

Despite the differences in the design of the survey and the specific features of the agricultural industry, the empirical results provide a strong indication that agriculture is also subject to on-going change in Austria. The number of businesses that are changing or introducing new production-related processes in particular is high when compared with other industries. For instance, while 39% of firms in manufacturing and 28.5% in the service sector stated in the European Community Survey (CIS) that they are implementing new processes, this fig-

121 See Kritikos et al. (2017). Firms in the manufacturing industry and in knowledge-intensive services are analysed in this study.
122 See Sinabell et al. (2017).

Table 4-3: Innovations in agriculture and innovation activities from other sectors

Economic sub-sectors (ÖNACE 2008)		Firms surveyed Total	Innovations in the industries				
			total*	Products	Processes	Organisational workflows	Marketing
			as % of firms				
"Innovations" in agriculture[1] – 2011–2015							
01	Agriculture	386	77.8	42.3	54.8	36.6	41.7
European Community Innovation Survey[2] – 2012–2014							
Total		**16,645**	**59.5**	**30.8**	**32.8**	**37.3**	**29.8**
Economic sub-sectors							
05–09	Mining and quarrying	109	59.6	35.8	36.7	29.4	15.6
10–33	Manufacturing of goods	6,397	64.1	37.9	39	35.8	31
35	Electricity, gas, steam and air conditioning supply	138	76.8	32.6	44.2	59.4	42.8
36–39	Water supply; sewerage, waste management and remediation activities	292	44.2	13.4	30.8	35.6	19.5
46–73	Services	9,709	56.6	26.5	28.5	38.1	29.4

Note: * Firms with product, process, marketing innovations, organisational innovations or ongoing innovation activities that have not been completed or have been suspended. The relevant percentages must be interpreted differently as a result of the different type of survey and the divergent survey periods. 1 Sinabell et al. 2017. 2 Statistics Austria.

Source: Statistics Austria, European Community Innovation Survey (CIS 2014) and Sinabell et al. (2017).

ure is 54.8% for the agricultural businesses surveyed. However, these percentages reveal nothing about the level of any innovation. Businesses that have only implemented minor changes or adopted ideas from neighbours are also considered as active under this definition. Fundamental innovations such as those in high-technology industries rarely occur in the agricultural industry.

The changes in agriculture are becoming particularly evident based on increased productivity. Using continuous development in production processes, Austrian agricultural businesses are managing to use less and less surface area and work effort[123] to produce virtually the same amount of 14 million tonnes of biomass[124] per year.[125] In contrast the use of capital goods and variable intermediate services increased.[126]

4.3.2 Austrian agriculture in international comparison

Aside from this substitution of production factors, further productivity gains can also be observed that cannot be explained purely by shifts between the production factors stated. Measured against total factor productivity, where the innovations are also reflected in the production process, the Austrian agricultural industry has also performed very positively over the last 20 years as compared with the average of the EU 15 (see Fig. 4-6).

This has resulted among other things in nominal prices for agricultural products being lower in Austria today than they were at the start of the 1990s. The reduction in nitrogen emissions and release of greenhouse gases also

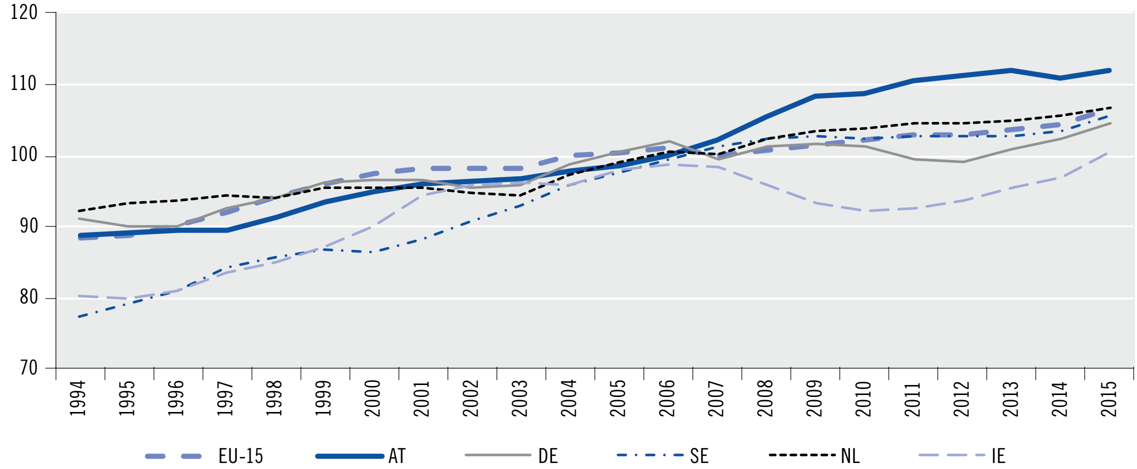
123 Between 1999 and 2013 the area used for agriculture fell by approx. 1.5% annually, and the number of workers (in full-time equivalents) by 2.2% (see Sinabell 2016).

124 The production amount stated relates to the production of biomass in agriculture (i.e. not including forestry).

125 See Kettner-Marx et al. (2016).

126 In relation to the production value, the percentage of intermediate services rose from 54% to 61%, and of capital consumption from 23% to 26%; see Sinabell (2016).

Fig. 4-6: Development of Total Factor Productivity (TFP) in agriculture in the EU 15 and in selected Member States



Note: The Total Factor Productivity (TFP) is a measurement of technical progress. The ratio of the production quantity to the amount of inputs is used for the calculation. That section of the increase in production is identified that is not attributable to increased inputs. Sliding three-year averages are used in order to compensate for the influence of the weather (Ø 2005-2007 = 100). See Table 8.1 in Annex I. for country abbreviations.

Source: Illustration of the Austrian Institute of Economic Research (WIFO) based on the European Commission (2016b).

point to positive developments in important environmental areas.[127] This is the result of more cautious and more targeted use of production factors, with Austria following the trends in agriculture here that can be observed in the EU and many other countries.

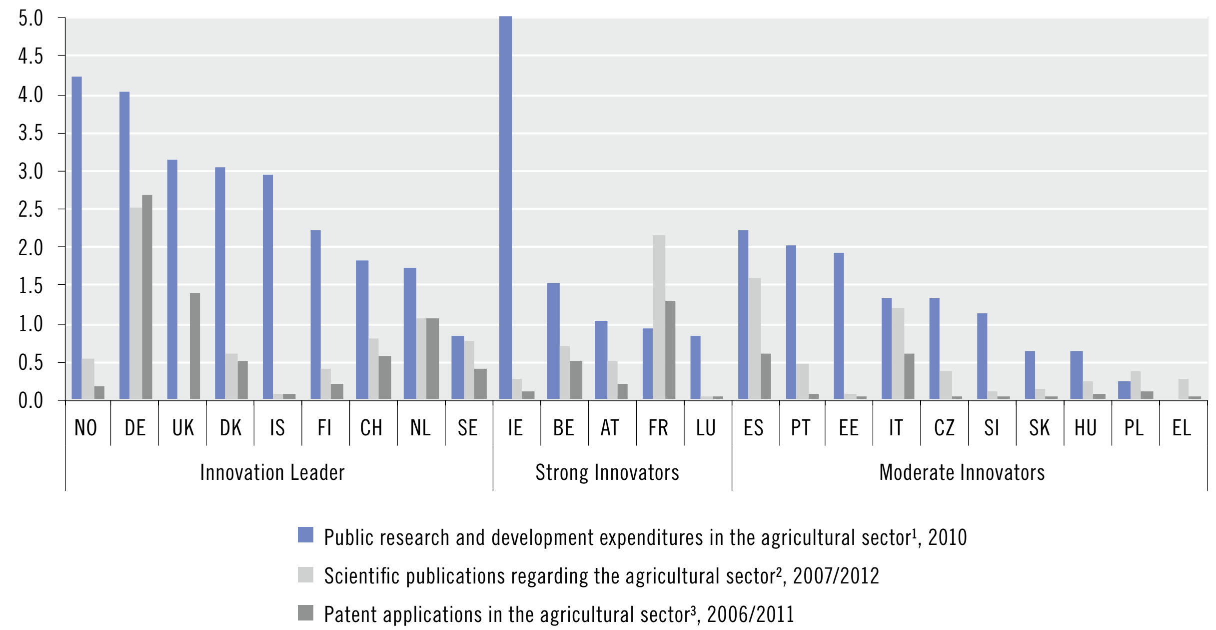
However, if we look at the indicators frequently used to assess the level of innovation in a national economy,[128] in particular through the measurement of inputs (e.g. R&D expenditure) or outputs that are easy to identify (e.g. scientific publications or patents), there is evidently potential for Austrian agriculture to catch up. Other countries of a comparable size and at a comparable stage of economic development feature higher values in these indicators. Fig. 4-7 shows the shares of the countries depicted as a percentage of all global agricultural patents (dark grey) and quality-weighted publications (light grey), as well as the share of public expenditure for agricultural research as a percentage of agricultural gross value added (blue). The figure is sorted by country groups on the Innovation Union Scoreboard.

Within the EU Member States and associate countries that are also members of the OECD, Austria was ranked 11 in agricultural patents in 2016. Countries of a comparable size such as the Netherlands (at position 4) and Switzerland (at position 7) were ranked considerably above Austria.[129] One explanation for this is the medium-sized structure of Austrian firms that are input suppliers. There are only a few Austrian multinationals in the food processing area that also feature a comparatively small product portfolio. Innovations in the marketing area are of higher importance there than innovations in products and processes. Another possible explanation is that Austria was only ranked in 11th position with respect to the number and quality of scientific publications. The Netherlands, Switzerland and Sweden are ahead of Austria based on this ranking.[130]

The public sector plays a crucial role in fi-

127 See Kettner-Marx et al. (2016).
128 See OECD (2010).
129 See OECD (2016b).
130 See OECD (2016b).

Fig. 4-7: Precedence of input and outcome indicators on agricultural innovation of selected countries, as %, by IUS country groups



Note: ¹) Proportion of public funds for R&D in the agricultural sector relative to the gross value added in agriculture, 2010; ²) Agricultural publications with international collaboration as a proportion of the total amount of agricultural publications (estimate); ³) Proportions of countries of agricultural patents globally, 2006–2011. See Table 8.1 in Appendix I for country abbreviations.

Source: Illustration of the Austrian Institute of Economic Research (WIFO) based on the OECD, 2013, 2016b.

nancing agricultural research in Austria given the compartmentalised operating structures in the private sector (see Fig. 4-7). Government expenditure on R&D in the agricultural industry relative to agricultural gross value added was only around 1% between 2000–2010. It had risen slightly prior to this in the 1990s.[131] In an international comparison, at 1.5% the Netherlands e.g. spent significantly more on public agricultural research in 2010. Public research expenditure relative to agricultural value added was even higher in Ireland (5%) and Finland (2.1%).[132] At 1.6% the share of agriculture as a percentage of total value added for all economic sectors together in the Netherlands was also significantly higher than in Austria (0.8%). It is also noticeable that compared with other countries with similar or lower innovation performance in the overall national economy (measured against the IUS country groups), Austria is in the middle of the table of the strong innovators with public R&D expenditure in agriculture, but is overtaken by some countries classified as moderate innovators. On the other hand, Sweden (as a member of the group of innovation leaders) is behind Austria here.

The comparatively lower proportion of agriculture-related public R&D expenditure as a percentage of total expenditure reflects the low significance accorded to agricultural research in public opinion. According to a current Eurobarometer survey the agreement rate for agricultural research is lowest in Austria as compared with the rest of the EU.[133] For the international

131 See OECD (2013).
132 See The proportion of agricultural added value as a percentage of gross domestic product is 0.7% (Finland) and 1.1% (Ireland); see European Commission (2016b).
133 See European Commission (2016b).

comparison it should also be noted that expenditure in the biotechnology sector in Austria is used almost exclusively for health research.[134] In other countries significant parts of the expenditure on biotechnological research are dedicated to agricultural topics. Genetically modified organisms cannot be used in Austrian agriculture. The applied research focuses therefore on other issues, such as environmentally-friendly production procedures.

Public funds are also used in Austria, however, in order to support public R&D of inputs and engineering that are useful for agricultural production. The focus here more heavily concentrated on support for training and knowledge transfer, as well as on improving the educational and IT infrastructure, rather than on own innovative efforts for which staff and financial capacities are limited. Public R&D plays a key supportive role in Austria based on the corporate demographics. Given the capacities in business, losses of public R&D expenditure would not be capable of being compensated to some extent.

The indicators addressed, which are also used most frequently to measure innovations in manufacturing companies, such as number of patents, the total sum of R&D expenditure, as well as the number of new brands or of research staff, are only of limited use in examining the innovation performance in Austrian agriculture. The Austrian agricultural industry is a significant user of innovations that were developed elsewhere. Accordingly the standard indicators of measuring innovation from manufacturing and the service industry tend to underestimate the innovation rates in Austrian agriculture. The number of agricultural and forestry business as well as businesses with aquaculture with R&D expenditure (there are only a total of six businesses with a total of €2.26 million in R&D expenditure in 2015, see Table 4-4) does not reflect the comparatively high rates already addressed of agricultural businesses with innovations, as can be seen from Table 4-3. However, R&D expenditure in agriculture also rose continuously between 2007 and 2013 – although this was at a high level in absolute terms. Following a strong increase between 2011 and 2013 – in 2013 businesses in the agricultural, forestry and fisheries industries invested around €3.5 million in R&D – there was another fall to €2.3 million in 2015.

4.3.3 Innovations in the agricultural value chain

A large part of the innovations in agriculture take place in cooperation with or through adaptation of developments in upstream or downstream industries. The upstream industries of mechanical engineering (in particular ÖNACE 2008 C283 manufacture of agricultural and forestry machinery) and agricultural chemicals (C2015 manufacture of fertilisers, C2020 manufacture of pesticides). The manufacture of food and feed products (C10) as well as wholesale and retail (various sub-groups of G46 and G47) of food and related products play an important role downstream.

As Table 4-4 shows for 2015, the industries directly upstream and downstream of the agricultural industry feature significantly more intramural R&D expenditure than agriculture and forestry and fisheries themselves. The manufacture of agricultural and forestry machinery stands out here in particular with €43.8 million of R&D expenditure, as do the wholesale of agricultural raw materials and live animals (G462) with €10.8 million and dairy products (C105) with €10.7 million. Of the total €103.4 million in R&D expenditure from the industries upstream and downstream of the agricultural industry, 70.7% was spent on experimental development, 21.12% on applied research and 8.1% on basic research.

With respect to the impact of R&D efforts of the upstream and downstream industries, it should be emphasised that to some extent the

134 See KBI 10 in OECD Key biotechnology indicators. http://oe.cd/kbi

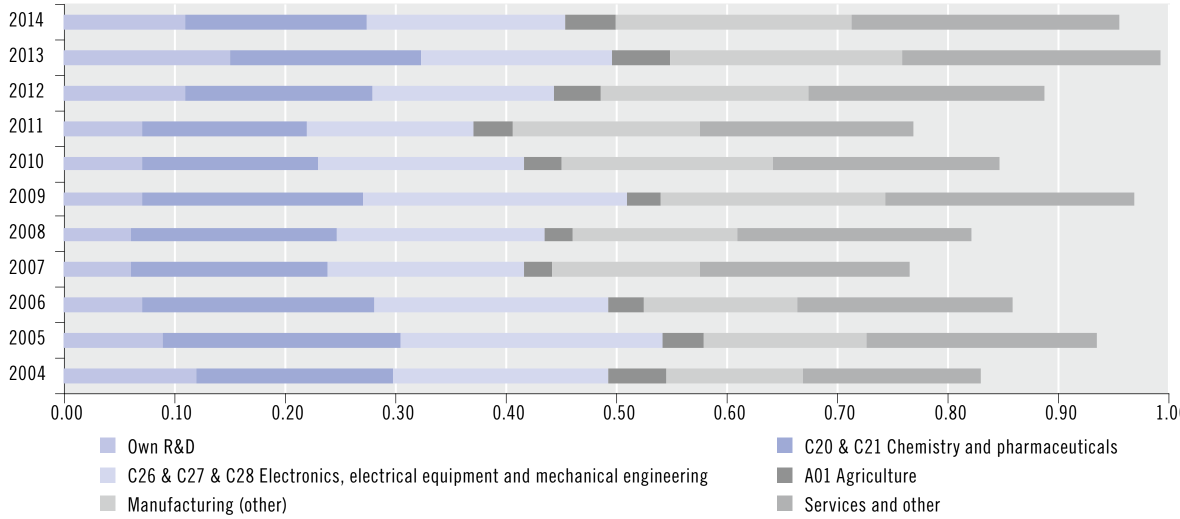
Table 4-4: R&D expenditure and research staff in agriculture and forestry, fisheries and in the value chain of upstream and downstream industries, 2015

	Economic sub-sectors (ÖNACE 2008)	Number of survey units performing R&D	Headcounts				Intramural R&D expenditure								
			Total	Scientists and engineers	Technicians	Other Human resources	Total	Staff expenditure	Other Material expenses	Buildings and property	Plants, machinery and equipment	Basic research	Applied Research	Experimental development	Socio-economic objective: Agriculture and forestry
							in €1,000								
Agriculture															
01-03	Agriculture and forestry, fisheries	6	**80**	12	6	62	**2,262**	838	1,333	91	-	0	468	1,794	2,124
Downstream with no trade		**69**	**443**	**233**	**162**	**48**	**35,163**	**16,702**	**12,641**	**495**	**5,325**	**1,158**	**7,326**	**26,679**	**1,907**
101	Processing and preserving of meat and production of meat products	17	**115**	64	35	16	**4,062**	2,707	1,077	10	268	100	1,242	2,720	755
103	Processing and preserving of fruit and vegetables	8	**58**	24	27	7	**3,190**	2,431	550	54	155	10	1,459	1,721	-
105	Manufacture of dairy products	13	**53**	30	18	5	**10,670**	3,054	5,595	247	1,774	691	1,995	7,984	76
106	Manufacture of grain mill products, starches and starch products	5	**45**	16	22	7	**3,445**	2,280	1,026	38	101	230	459	2,756	4
107	Manufacture of bakery and farinaceous products	9	**78**	38	30	10	**7,178**	3,348	860	146	2,824	53	516	6,609	-
1082	Manufacture of sugar confectionery (not including long-life bakery products)	4	**22**	16	4	2	**363**	335	16	-	12	-	235	128	-
1084	Manufacture of condiments and sauces	2	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
1085	Manufacture of ready meals	2	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
1086	Manufacture of dietary food products	1	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
1089	Manufacture of other food products not stated elsewhere	5	**35**	15	20	-	**3,579**	748	2,796	-	35	-	65	3,514	-
1091	Manufacture of animal feeds for farmed animals	3	**14**	11	3	-	**1,072**	707	365	-	-	-	781	291	1,072
Downstream trade		**23**	**194**	**67**	**68**	**59**	**20,935**	**7,182**	**9,826**	**2,888**	**1,039**	**43**	**1,932**	**18,960**	**10,050**
4617	Trade brokerage – food and beverages	1	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
462	Wholesale of agricultural raw materials and live animals	7	**74**	30	23	21	**10,798**	4,057	2,995	2,888	858	2	1,081	9,715	9,982
4,631	Wholesale of fruit, vegetables and potatoes	1	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
4632	Wholesale of meat and meat products	1	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
4634	Wholesale of beverages	2	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
4638	Wholesale of other food products	5	**18**	14	4	-	**1,206**	590	446	-	170	-	375	831	-
4711	Retail sale of food	2	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
4724	Retail sale of baked goods and confectionery	1	**C**	C	C	C	**C**	C	C	C	C	C	C	C	C
4729	Other retail sale of food products	3	**8**	8	-	-	**518**	317	195	-	6	34	349	135	-
Upstream		**35**	**541**	**178**	**302**	**61**	**47,269**	**27,802**	**15,969**	**6**	**3,492**	**7,211**	**12,577**	**27,481**	**29,675**
2015	Manufacture of fertilisers	3	**14**	11	3	-	**1,319**	567	517	-	235	7	1,255	57	71
2020	Manufacture of pesticides	3	**33**	20	9	4	**2,142**	1,219	876	-	47	-	634	1,508	2,142
283	Manufacture of agricultural and forestry machinery	29	**494**	147	290	57	**43,808**	26,016	14,576	6	3,210	7,204	10,688	25,916	27,462

Note: * SEO = Socio-economic objective. No R&D activities in 2015 in the following industries: Manufacture of sugar (C1081), Agents involved in the sale of agricultural raw materials (G4611), Wholesale of dairy products, eggs and edible oils and fats (G4633), Wholesale of sugar and chocolate and sugar confectionery (G4636), Non-specialised wholesale of food, beverages and tobacco (G4639), Retail sale of fruit and vegetables in specialised stores (G4721), Retail sale of meat and meat products in specialised stores (G4722), Retail sale of beverages in specialised stores (G4725). C = confidential

Source: Statistics Austria.

Fig. 4-8: R&D expenditure in agriculture vs. R&D content in intermediate services by industry origin, 2004–2014



Source: Calculations: Austrian Institute of Economic Research (WIFO) based on Timmer et al. (2015).

firms driving R&D in these sectors dedicate very significant parts of their research activities directly to the socio-economic target of "promoting agriculture and forestry". Firms that manufacture pesticides in particular pursue to target of promoting agriculture 100% with their R&D expenditure, while in the manufacture of agricultural and forestry machinery this amounts to 62.8% and in the industries attributed to trade to just under 50%. Furthermore the industry dedicates €8.8 million of R&D with the focus on agriculture in the manufacture of computer, electronic and optical products (not including electronic components and boards, C26 not including C26.1)

The close interlock between agriculture and upstream industries with respect to innovation is also evident when we look at the technological and research content of the intermediate services. Assuming that the R&D expenditure in the upstream industries also resurfaces in the products sold (to agriculture), the "R&D content" determined statistically can be calculated in the intermediate services. Fig. 4-8 shows the R&D expenditure included in the intermediate services as a percentage of the value added broken down by intermediate service sectors.[135] The figure shows that there is significantly more R&D in the intermediate services than agriculture contributes itself. The industries manufacture of chemical products (C20), manufacture of computers, electronic and optical products (C26) and machinery and equipment (C28) stand out here.

By geographical origin it can be seen that the intermediate services originating from Austria play a major role in the R&D content of intermediate services[136]. The Austrian intermediate services are also responsible for around 50% of the total R&D content of the intermediate services[137]. While the EU countries are also responsible for a large share of the technology

135 The length of the bars depends on the one hand on the R&D activities in the relevant industries, as well as on the amount of intermediate services procured from these industries on the other.

136 The shares of R&D content in the intermediate services in Austrian agriculture by geographical origin remained very constant in the period between 2004–2015.

137 Plus approx. 10% share of own R&D.

transfer from other industries to Austrian agriculture (around 35%), countries outside the EU are of minor significance in this regard (approx. 5%). It is evident from this that Austrian agriculture indirectly benefits heavily from the national and EU-wide innovation and research funding programmes.

4.3.4 Motives and objectives of agricultural innovation in the context of the market economy

One important finding from the survey of innovations in the Austrian agricultural industry is the fact that maximising short-term profit is only one element among many that concern farmers. Other aspects such as quality of life and awareness of nature are important motives for innovation. The most important motive for farmers is long-term stability for their business: managing the business in such a way that enables survival in an uncertain, natural and economic environment. The timeframe for the decision-makers of a typical Austrian farm is therefore a long one.

The most important matters also include working conditions, family situation and succession of the generations. Among the smallest of business, a severe illness or the death of an employee generally requires fundamental changes to be made on the farm. According to a current study[138] one-third of the businesses surveyed have implemented fundamental changes to the work organisation over the last five years. Large investments are not made very frequently on account of the long timeframe involved. Once these are made, the processes and capacities also need to adapt to the new set of circumstances. Other innovations are hardly ever implemented at times like these. The programme for developing rural areas comes into play here by supporting many of the agricultural investments. The investment plans should be reviewed with respect to the innovation capacity of the business, as the timeframes for innovations are relatively short. In terms of innovation policy objectives it would be advisable to place more importance on the more innovative plans when evaluating projects. The EIP AGRI funding initiative should support a more rapid transfer of innovations through the interactive knowledge transfer between research and practice.

Agricultural business are under the influence of market-based competition-related framework conditions in order to achieve the objectives stated. Innovation efforts and competitive pressures are closely connected with this. The competitive pressure is particularly high for those firms or business that produce disposable raw materials that are traded internationally. This includes sugar beet, corn or milk from conventional production methods. There are no monopolies in agriculture to represent the other end of the spectrum. There is a comparatively high level of market concentration in just a few industries (e.g. pure breeding of pigs, breeding queens with bees), although the barriers to entering these markets are relatively low as compared with monopolies in the processing industry.[139]

Those business that stand out from their competitors through product differentiation (e.g. through quality features) and are able to occupy niche markets as a result, have a greater incentive to undertake innovation efforts (introduction of new or modified products).[140] If the firms or business are aiming for a price premium compared with disposable standard products with this and are able to recoup the costs of their innovation efforts as a result of this, then greater innovation efforts can be expected. To much competitive pressure leads in turn to major pressure on prices, with innovation efforts potentially not expected as a result. In this

138 See Sinabell et al. (2017).
139 See Ibid.
140 See Peneder (2014).

case firms will primarily strive to achieve cost savings through innovations in production processes.

Milk is a good example of this: traditionally produced from GMO-free feed, milk sold at a price of 30.8 cents per kg in March 2017 in Austria (3.7% fat). Milk from cows fed purely on hay on the other hand and produced in accordance with ecological farming criteria cost 48.9 cents per kg. The quality premium as compared with conventional milk was therefore almost 60%. By comparison, the average price for conventional milk in the countries neighbouring Austria to the east was around 2 cents (or 7%) below the price for conventional milk in Austria.[141] This example clearly illustrates the differences in price based on quality features, with only a few people able to identify any differences in taste between these different types of milk.

The correlation described using the example of milk also resurfaces in the results of the recent enterprise survey[142]. A lack of differentiation options for products were frequently rated very significant or significant hindrances in terms of innovation for the businesses surveyed that have introduced no new or significantly modified products over the last two years. By contrast, those businesses that have introduced innovations felt less hindered by a lack of differentiation options.

Austria's agricultural businesses can either acquiesce in their role as a price taker and try to reduce their costs, or they undertake innovation efforts and make investments with uncertain levels of success, in order to develop further based on differentiated products and stand out from the competition.[143] This route is currently only being taken by a minority of businesses, which should be accompanied among other things with the important objective of maintaining the business coupled with the long-term nature of investment decisions, and a comparatively high aversion to risk associated with these.

4.3.5 Summary

The operational structure in the Austrian agricultural industry limits the options available for achieving competitive advantages through economies of scale. This makes it all the important for Austria not to trail behind when it comes to innovation performance. On the contrary: special efforts are required in order to compensate for the structural disadvantages. Very small businesses in particular face some major challenges here. The use of the latest technological developments is expensive and returns are only seen once these are adequately implemented. Increased partnerships, e.g. in the form of machine cooperatives, appear to make a lot of sense in this context, so that small business are also able to benefit from technology-based productivity increases.

An innovation policy for agriculture must take account of regional patterns. The number of business-related tasks is relatively high for instance in the eastern states of Austria and the metropolitan areas of Vienna, Linz, Bregenz and Graz. One reason for this is the accessibility of attractive alternative jobs. In the Central regions of the Alps there are barely any changes in the average operating structure, i.e. low rates of people leaving businesses, partly as a result of a lack of alternative opportunities outside of agriculture. Economies of scale are difficult to achieve in these regions in the absence of growth in the area through high transport costs. Any increase in intensity in animal production is also severely restricted by environmental regulations. The specific production conditions must be taken into account therefore in the development of more environmentally-friendly methods.

141 See Agrarmarkt Austria (2017).
142 See Sinabell et al. (2017).
143 See Peneder (2014).

In mountainous regions the innovations should be expected aimed at improving the working conditions and at saving workers for agricultural tasks combined with innovations in diversification and supplementary tasks to agriculture. By contrast, businesses with growing areas in regions with significant structural change are potentially better off if they rely on new production methods which make economies of scale more likely.

Aside from the regional differences, an innovation policy for the Austrian agricultural industry must take account of its specific features, and in particular the strong links with upstream and downstream industries in the innovation process. Any funding policy that focuses purely on standard indicators (e.g. R&D expenditure, patents, publications) will hardly be productive. The fact that the Austrian population views the importance of R&D in agricultural policy as low compared with the rest of the EU according to a Eurobarometer survey[144] also needs to be considered. Research agendas therefore face the challenge of accounting for concerns among the population as regards certain technologies, while preventing firms from the threat of being at a disadvantage against the international competition. The promotion of research areas that are accepted by society (e.g. more resource-friendly and user-friendly production methods) is a suitable starting point that is also already being pursued. Increased public funding for R&D is advisable, however, in order to close the gap with comparable countries.

Consideration of operational objectives and of the competitive situation of the relevant business is also recommended for the promotion of operational innovation efforts. The strategy already established in Austria of promoting knowledge transfer and exchanges of best practice examples, as well as of improvements in training and the education and IT infrastructure is extremely successful with this. In Austria these tasks are assumed primarily by the agricultural chambers of commerce and agricultural school system, which also offers adult training programmes. New approaches such as the European Innovation Partnership are also pursued in the rural development programme. The fundamental character of the measures will also barely change in future, unlike the continuous changes to the topic-based content.

144 See European Commission (2016b).

5 The culture and practice of RTI evaluation

Evaluations are an indispensable part of the process of introducing and implementing research and technology policy support measures today, both from a legal perspective and in daily practice. In Austria, there are several regulatory bases that are crucial for this: the Research and Technology Promotion Act (FTF-G), the General Guidelines for Granting Support from Federal Funds (ARR 2014), the Research Organisation Act (FOG; Reporting: Sections 6–9), and the RTI guidelines (guidelines on the promotion[1] of research based upon these laws and of commercial-technical research, technology development and innovation).[2] The structure and formal specifications are the same in all guidelines, although there are differences in terms of the motives, targets and indicators of projects eligible for funding.

The Research and Technology Promotion Act (FTF-G Section 15 para. 2) in particular has standardised the evaluation principles as being a minimum requirement for the guidelines. The guidelines stipulate that "a written evaluation plan must be created for all subsidy programmes and measures based upon the [thematic, structural and human resource] RTI guidelines. This plan must include the purpose, objectives, and procedures, as well as deadlines for evaluating the achievement of the funding objectives, and must define appropriate indicators."[3] An appropriate monitoring system must be created to collect the necessary information that provides standardised basic information for the duration of the project.

In addition to the legal and administrative circumstances, an active discussion has also developed over the last few years in Austria over the role, use and options for evaluations and process for dealing with these. Activities surrounding the research and technology policy evaluation platform (fteval) have made important contributions to this trend. The common objective is to boost the quality of the evaluation culture and improve the programme design as well as the evaluation methods of research and technology programmes.

The annual Austrian Research and Technology Report published by the Federal Government also gives an overview of current topics concerning evaluation and presents recent results from evaluations. The following Chapter (5.1) focuses on the issue of the availability and quality of data. It includes a comparison and discussion of the practices for accessing company-related microdata for scientific purposes in Austria and selected European countries. Chapter 5.2 then provides an overview of the institutional evaluation of the funding agencies Austria Wirtschaftsservice GmbH (aws) and Forschungsförderungsgesellschaft mbH (Austrian Research Promotion Agency – FFG), with the results of recent evaluations of Austrian research funding programmes presented in Chapter 5.3.

1 See the federal government's guidelines on offering and implementing funding mechanisms as in paragraphs 10–12 of the Research Organisation Act (FOG), Federal Law Gazette. No. 341/1981.

2 See The guidelines for supporting commercial-technical research and technology development (RTI guidelines 2015), which are: RTI thematic guidelines, RTI structural guidelines, RTI human resources guidelines in accordance with the Research and Technology Promotion Act (FTFG) from the Federal Minister for Transport, Innovation and Technology (ref. BMVIT-609.986/0011-III/I2/2014), and the Federal Minister of Economics and Labour (ref. BMWFW-97.005/0003-C1/9/2014).

3 See RTI theme guidelines, RTI structure guidelines, RTI human resources guidelines, Chapter 3.3.

The descriptions of the evaluations include summaries of the most essential aspects of the underlying subject matter of the study and of the evaluation results. The evaluations presented have been selected according to the following criteria: (1) the evaluation is primarily relevant to federal policy, (2) an approved report of the evaluation is available and (3) the evaluation report is publicly accessible. This basically means that the report has been approved and has been published on the website of the fteval[4] platform.

5.1 The role of microdata for assessing and supporting RTI policy measures in an international comparison

The quality and validity of the evaluations of research and technology policy measures depend crucially on the available data basis. The possibilities for recording and processing individual data sources have fortunately improved considerably in many countries over the last few decades.[5] This also increasingly relates to firm-level data as well as personal data records. The national statistical offices in the individual countries that record detailed information based on statutory regulations serve as an essential data source for this type of information. These administrative data sources are often combined with information from other sources (e.g., additional enterprise surveys) so that all necessary information can be brought together for the evaluation and quantitative assessment of specific economic policy measures. In terms of the applicability of firm-level data for the purposes of evaluating research and technology policy measures in particular, the legal as well as the organisational circumstances vary significantly across different countries. In light of this the present Chapter describes the current legal situation in Austria and subjects this to a comparison at the EU level and to selected countries with a similar level of economic development. Policy implications for any adaptations of the legal and organisational situation in Austria can be derived from the synopsis of the national differences.

5.1.1 Access to firm-level data in Austria

The scientific usability of firm-level data under the law is essentially determined in Austria by two legal standards. Paragraph 46 of the Austrian Data Protection Act 2000 (DSG 2000, Federal Law Gazette I no. 165/1999 in the current applicable version)[6] defines the conditions under which data can be used for scientific purposes and statistical analyses. Subsection 1 stipulates that unless the study is aimed at achieving personal results, the data can be used if it *"1. is publicly available or 2. the [principal] has ascertained it permissibly for other studies or other purposes or 3. it is only indirectly personal for the principal"*, whereby Section 4 (no. 3) states that indirect personal data is only provided *"if the personal reference of the data is such that this principal, service provider or recipient is unable to identify the subject by legally permissible means."* Any such personal reference that is merely indirect is not in general provided in firm-level data. Inferences to individual firms using different corporate features such as the size and/or geographical location cannot be ruled out either, including with compliance with legally permissible means.

Section 46 Subsection 2 no. 1 to 3 govern the legal circumstances required in order to be allowed to use other data for scientific purposes. Specifically this paragraph states the following: *"In the case of data applications for purposes of scientific research and statistical analyses which do not come under Subsection 1, data*

4 See www.fteval.at.
5 See Falk et al. (2015).
6 See https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=bundesnormen&Gesetzesnummer=10001597

may only be used 1. in accordance with the particular statutory regulations or 2. with the consent of the subject or 3. with approval from the data protection authority pursuant to Subsection 3". Based on paragraph 46 Subsection 2 no. 1 therefore the legal assessment as to whether data from official statistics can be used for scientific purposes requires reference to the Austrian Federal Statistics Act (Bundesstatistikgesetz) 2000 (BstatG – Federal Law Gazette I no. 163/1999 in its latest applicable version.)[7] Section 31 (3) of the Austrian Federal Statistics Act stipulates: *"Any use of personal statistical data is also impermissible for scientific purposes."* As already stated above, individual corporate data comes under the legal definition of personal statistical data.

The legal framework provided by the Austrian Data Protection Act 2000 and Federal Statistics Act 2000 results in a situation in Austria based upon which individual firm-level data from official statistics cannot (as a rule) be used for scientific purposes, and therefore equally not for the evaluation of research and technology policy measures.

Nevertheless, a large section of all industrial and RTI-policy measures are evaluated – to some extent this is also even stipulated as mandatory by statute (see Chapter 5.3). In the case of ex-post impact evaluations the researchers must assess the effectiveness of the research and technology policy measures based upon limited available data on account of the legal situation in Austria. Additional data is then collected in most cases, generally based upon specially prepared questionnaires. The essential features of the firm along with the relevant information on the utilisation of the relevant economic policy measure are colleced via these enterprise surveys. This approach makes a lot of sense from a second best point of view, even though it also involves a few problems.

On the one hand the surveys of firms to some extent result in significant additional costs for the evaluators as well as for the enterprises surveyed. Firms have to cover a lot of aspects when answering the questionnaires that only indirectly relate to the utilisation of the specific policy measure. Information on relevant firm-level data (such as balances sheets, income statements and similar items) are crucial for any serious assessment of the effectiveness of the research and technology policy measures. However, these key features are recorded in any case for almost all Austrian firms based on mandatory regulations. These have to be included in the questionnaires as there is no access available to the data collected for the federal statistics. The current Austrian legal situation with respect to the inability to use statistical data for evaluations therefore results in some significant costs which could be saved if existing data could be used, and this could also reduce the bureaucratic burden for Austrian firms.

Unlike data surveys that Statistics Austria carries out as an Austrian federal statistical authority on behalf of the Republic, surveys for evaluation purposes are based on voluntary participation. There are several reasons why this can have a negative impact on the quality of the obtained data.

A "control group" of firms that has not benefited from the specific research or technology policy measure needs to be surveyed for an assessment of the (average) quantitative effects (such as employment and value added effects of the economic policy measure). The control group serves as a basis for assessing how the firms that did benefit from the measure would have developed if they had not implemented the measure.[8] Identifying a suitable control group of firms as part of a survey is often not easy for several reasons. First of all, information about these firms is often missing simply because they do notapply for the support mea-

7 See https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10006095
8 See Angrist and Pischke (2009).

sure. There is also hardly any incentive for firms that have not made use of a research or technology policy measure to participate in this type of survey. The time resources required to answer the questions are generally not in proportion to any potential benefit that these firms would enjoy in taking part in the survey. Furthermore, knowledge is often lacking about the specific measure, meaning that the effort of taking part in the survey becomes even larger. As a result, this can lead to a very low return rate for questionnaires from firms in the control group. A low return rate diminishes the validity of the evaluation results, as the control group may then in some cases not provide a representative comparative benchmark for those firms that have made use of the specific poliy measure.

By contrast, it is relatively easy to identify those firms that have taken part in the specific research or technology policy programme. These must at a minimum submit applications for funding and document the project progress. However, these firms cannot generally be compelled to take part in any survey aimed at evaluating the measures because of the statutory provisions. In practice this means that the return rates from these firms are also generally well below 100%. It can be assumed that those firms that were very satisfied with the measure and wish to continue making use of this have a greater incentive to answer the questionnaire. Firms in which the cost/benefit ratio from participating in a programme is assessed as being negative are typically less prepared to provide information on their experiences with the specific measure. This can ultimately lead to a self-selected– i.e. not representative from a statistical point of view – group of firms that are willing to answer a questionnaire on an economic policy measure. In terms of the scientific analysis, such as the estimation of the effectiveness of the measure, this leads to further difficulties in interpreting the evaluation results.

5.1.2 Access to individual firm-level data in selected comparison countries

The law governing access to microdata from official statistics and other public bodies is managed differently throughout Europe.[9] This ranges from no access, such as in Greece, Poland and Austria, all the way to the ability to gain remote access to microdata (remote access system) as offered by the statistical bodies in some European countries (e.g. the Scandinavian countries, France, Luxembourg and the Netherlands). The statistical office of the EU (Eurostat) as well as the statistical offices in the UK, Germany and Spain permit access for guest scientists via workstations in areas known as safe centres that have been set up at the relevant national statistical offices.

The mode of access depends on the applicable legal situation, in particular the national statistics laws which also define the conditions for scientific data access. Conditions for data access include a link to an authorised institution, such as universities or other research institutes which pursue the task of operating independent scientific research, as well as a written application which includes a description of the project. No access to data is provided for non-scientific or for commercial purposes.

In Europe the law on liberalisation of access to confidential data for scientific purposes is based on EU Regulation no. 557/2013. This Regulation governs the conditions for access to confidential microdata for carrying out statistical analyses for scientific purposes that are sent to Eurostat by the national statistical offices. In terms of innovation research this affects the European Community Innovation Survey (CIS), which was made available to researchers at the Eurostat Safe Centre in Luxembourg. However,

9 See Falk et al. (2015).

Table 5-1: Overview of the access regulations to administrative enterprise data in Austria and the selected comparison countries

	Germany	Denmark	Netherlands	France
With authorised access	Research institutes (independent scientific establishments)	Research institutes (research main purpose of activities), public sector, firms (no private projects)	Research institutes (research main purpose of activities), public sector	Research institutes (research main purpose of activities), public sector
Access for	scientific analyses	scientific analyses	scientific analyses	scientific analyses
Access accreditation	two stage: Accreditation of the institution, approval of the individual projects	two stage: Accreditation of the institution, approval of the individual projects	two stage: Accreditation of the institution, approval of the individual projects	one stage: Approval of the individual projects
Possibility of using data outside of the project	no	no	no	no
Subject to a charge and restricted to duration of the project	yes	yes	yes	yes
Guarantee of statistical confidentiality	technical, contractual and organisational; output controls	technical, contractual and organisational; output controls	technical, contractual and organisational; output controls	technical, contractual and organisational; output controls
Access for foreign Research institutes	no	no	yes	yes
Possibility of linking with external data sources	yes	yes	yes	yes
Data availability	Data from the statistical offices	Data from the statistical office	Data from the statistical office	Data from the statistical office as well as further administrative microdata
Tech. access options	Safe centre	Remote access and safe centre	Remote access and safe centre	Remote access and safe centre
Own separate unit at the statistics office	yes	yes	yes	yes
Amendment to the relevant texts in the Statistics Act over the last 5 years	yes	no	no (possibility has existed since 2004)	yes

the national statistical offices also keep more microdata than that reported to Eurostat. Examples of the access provided to microdata in selected European countries are therefore provided below.

For this purpose, Table 5-1 provides an overview of the essential circumstances for the usability of company-related individual data for scientific purposes in Germany, Denmark, France and the Netherlands. The individual countries are discussed in detail over the next few sections, with details explicitly provided of the historical development in the relevant countries.

Germany

In Germany the Federal Statistics Act stipulates the framework for federal statistics and their organisation. The essential circumstances for access to microdata for scientific purposes are also governed in the Federal Statistics Act. The rules governing the prerequisites for transmitting microdata to scientists were relaxed somewhat in 2016 with an amendment to the law. Since then it has been possible for access to be granted to formal anonymised individual pieces of information (not including names or addresses) within specially secured areas at the statistical offices, known as safe centres.[10] Only individual information that have been "de facto anonymised" can be provided outside of safe

10 See Engelter and Sommer (2016).

centres in Germany. The concept of de facto anonymity was adopted as a legal definition as part of the 2016 amendment, and means that the data can only be uniquely allocated with disproportionately large amounts of time, costs and manpower.

In Germany a large proportion of the microdata from the official statistics is collected, prepared and stored locally in the statistical federal state offices and is available there. The research data centres of the statistical offices of the federal government and the states have set up a central technical data storage facility for scientific purposes. The Federal Statistical Office's research data centre has been in place since 2001, the research data centre of the statistical offices of the federal states has been a joint pilot project since 2002. These projects received start-up financial support from the German Federal Ministry for Education and Research (BMBF).

The "Amtliche Firmendaten für Deutschland (AFiD)" (Official company data for Germany) project was implemented in Germany for the purposes of providing individual enterprise data for scientific purposes. Its aim is to integrate all economic and environmental statistical microdata in future via the official enterprise register. Various research databases and panel data records are created specifically for research purposes as part of the AFiD project. Integration of different enterprise databases also significantly increases the potential for data analysis. Information from different statistical sources can be used together.[11]

Access is restricted to scientific establishments responsible for independent scientific research and is specifically intended for scientific research projects. A separate application form must be submitted for each research project. Usage is subject to a charge and is time-limited. Extensions are possible to include further data, meaning that current survey years or externally collected characteristics (third-party data) can be used for instance.

Denmark

Statistics Denmark provides remote access to microdata.[12] Around 1,000 research projects were carried out in 2012 using this access option. Statistics Denmark has set up a special unit (Research Search Unit) with 17 experts for the purposes of providing micro data for scientific purposes.

Official statistics are produced based on administrative register information as is standard for the Nordic countries (official databases that cover the relevant population), which in turn allows to follow statistical units over time. Most of the administrative registers were set up in the 1980s. This means that the time period covered by the Danish microdata is significantly longer than it is in other countries.

Access to microdata in Denmark is not restricted only to the public sector or to research institutions. Non-governmental organisations, consultancies and private firms can also request access. The credibility and reliability of these organisations are then reviewed by Statistics Denmark. Only authorised organisations can submit project proposals for the usage of microdata. Foreign researchers do not have access to Danish microdata because the necessary contracts are not legally enforceable abroad according to Statistics Denmark. Foreign scientists with a Danish affiliation can, however, obtain access to data from an authorised organisation if the organisation assumes liability.

Statistics Denmark has created a series of specific research databases to reduce the costs for researchers and solve any data problems. These have been processed for external researchers and are either not used or only rarely used by Statistics Denmark in the production of their statistical products. The data from Sta-

11 See http://www.forschungsdatenzentrum.de/datenangebot.asp
12 See https://www.dst.dk/en/TilSalg/Forskningsservice

tistics Denmark can be linked with data from external data sources, e.g. survey data or data from other Danish authorities.

In Denmark the microdata for research purposes cannot be directly provided to researchers. All calculations must be carried out by the scientists on the Statistics Denmark servers by using a remote access system. These servers are disconnected from Statistics Denmark's production networks and only contain the anonymised microdata which are provided for research purposes. Any attempt to identify the individual statistical units or to take data from the server is treated as a serious infringement of the agreement between Statistics Denmark and the researchers. Only aggregated data and results which do not allow to draw inferences about individual statistical units can be taken from the server.[13] These are sent to the researchers via e-mail.

France

The ability to access data from the statistical office for scientific analyses of microdata was also provided in France in 2009. As in other countries the data access in France is also project-specific. Interested parties must apply to the French data protection committee (Comité du Secret Statistique), which reviews the project. The data protection committee is a public body to which representatives of the statistical office (INSEE), the parliament, the data protection authority (CNIL) and other stakeholders belong. The legitimacy of the research project is reviewed as part of the verification process, with clarification of the data that is needed for the project. This review can take between two and six months. If the review is positive, the scientists receive access via the CASD (Centre d'Accès Sécurisé Distant aux Données) remote access system. The researchers must attend an introductory course for this and receive a box with biometric authentication which is required to log onto the secure server and carry out the research project.

Administrative microdata created by other public authorities, such as tax and health data, is now also available in France via this access in addition to the data provided by the statistical office. More than 400 research projects had been carried out in France by 2015 with the involvement of around 1,000 researchers from France and the rest of Europe. Unlike other countries, France also allows researchers who are not affiliated with a French research institute to access these data.

Netherlands

The legal basis for data access for scientific analyses has been in place since 2004 in the Netherlands, and the services offered has been continually expended by the Centraal Bureau voor de Statistiek (CBS). Remote access to data has been possible in the Netherlands for some time, with a wide range of statistical software solutions also on offer.

Access to the microdata which enables indirect identification of the statistical units is restricted to researchers at accredited institutions. Accredited institutions must be research institutes as stated explicitly in the law (e.g. Dutch universities, official organisations and Dutch research institutes). Other organisations, including foreign ones, can be accredited by the national statistics council if the organisation's main purpose is research and the research results are also published publicly. Only researchers from accredited institutions can submit projects and these must each be approved individually.

Access to data can be provided via a safe centre or via remote data access using a secure internet connection. The institute that uses the data is subsequently responsible for data securi-

13 See Statistics Denmark (2018).

ty. The costs of the data access are transparent and depend on the number of different data sources, the data volumes used and the administrative effort.[14] External data can be combined with the statistics data for an additional charge.

5.1.3 Summary

Overall, it can be seen from the good practice countries considered that access to sensitive microdata for research and for scientific evaluations can be provided without compromising on the requirement to comply with statistical secrecy. Compliance with the rules on confidentiality is guaranteed using certain technical, organisational and regulatory measures. In all the countries this includes restricted access with mandatory accreditation of research institutes. In some countries this is a prerequisite for obtaining the authorisation to submit research projects that are approved in a subsequent review process. Some countries required changes to their statistics laws to legalise data access for research purposes. Restrictions in all countries stipulate that the data may only be used by the personally accredited researchers for a limited time period and for the predefined projects. Any non-project specific use is prohibited and is considered a breach of contract. The results of the analyses are subject to statistical confidentiality requirements and output control by the statistical offices; this also applies to remote access to individual enterprise data.

The comparison of the Austrian legal situation with the access practices surrounding individual enterprise data in the selected comparison countries shows that there are still some significant hurdles for accessing microdata for scientific purposes in Austria. From a data protection point of view, it is of course important to ensure that data that is collected based on mandatory obligations is not misused and that individual patents are safeguarded.

The legal situation on data protection when accessing enterprise data does not differ fundamentally in the comparison countries from Austria, but special regulations on the use of individual data for scientific purposes have been created in the other countries examined. The list of countries with similar access to individual company-related information may also be expanded. Finland, Sweden and Estonia can be stated here as further examples of good practice.[15] These countries pay meticulous attention to confidentiality and rely on security measures in order to be able to rule out misuse of data. Confidentiality is generally ensured by an accreditation procedure both at the institutional and subsequently also at the project level. This includes a review of the technical competence of the research institutes and their employees, and of the scientific relevance of the specific research question. Misuse of data is prevented through secure access to the data and output controls. The secure data access is typically achieved in the form of remote access to the servers of the statistical offices or by providing a local system in a safe centre.

The country examples show that data security and the use of enterprise data for scientific purposes do not need to be mutually exclusive. These examples of good practice provide valuable suggestions for Austria in terms of ways to Open Data access to individual data for assessment of the effects of research and technology policy measures. Adjustments to the legal situation would be required in Austria, so that use of this data for research purposes can be made possible in principle, subject to the fulfilment of clear pre-defined conditions. Although the EU General Data Protection Regulation (Regulation 2016/679), which finally came into force as of 25 May 2018, makes adjustments necessary to some substantive laws (including in particular in the area of science), it does not fundamentally change the legal situation with re-

14 See CBS (2018).
15 See Falk et al. (2015).

spect to the ability to use Austrian enterprise data from the official statistics for scientific purposes. As a matter of principle, access for use in science to registration data in public administration was created by the Data Protection Amendment Act 2018 – Science and Research – (WFDSAG 2018), representing an essential step forward in this regard. Nevertheless, its practical implementation threatens to be undermined because of special restrictive norms in certain other laws. Continued inaccessibility to the individual company-related data from official Austria Statistics makes scientific research on research and technology policy measures more difficult. The creation of safe centres seems to be one option that could be implemented quickly. Additional financial resources would be required to set up and operate these centres, allowing Statistics Austria to complete the preparatory work required for data provision and data security and to establish the control mechanisms. However, the costs incurred through this would quickly be recouped, as considerably lower administrative costs would be incurred for additional firm surveys due to the availability of data from official statistics.

With research and technology policy measures , however, the administrative data records cannot replace surveys in their entirety. Valuable additional information can be gained from firms that have made use of the available funding instruments. For the qualitative evaluation results, a survey or other method of obtaining information will remain necessary and useful to obtain starting points for improvements to the supportive measures. In this context it is important that any data obtained through the opening of data access to individual data from the official statistics can also be linked with third-party data. Based on the example of other countries for instance, there could be a possibility of merging data from the official statistics with data from surveys and other sources in the safe centre for specific projects in order to present an overall picture of the economic and innovation policy measures and their economic effects.

Changes to data access and options for linking data could considerably improve the significance of quantitative ex-post impact evaluations of economic policy programmes in general, and of research and technology policy measures in particular. This would contribute towards increasing the efficiency and effectiveness of policy measures for the purposes of evidence-based economic and RTI policy.

5.2 Evaluation of Austria Wirtschaftsservice (aws) and the Austrian Research Promotion Agency (FFG)

The institutional evaluation of the funding agencies Austria Wirtschaftsservice GmbH (aws) and Forschungsförderungsgesellschaft mbH (Austrian Research Promotion Agency – FFG) provides a summary of their impact more than ten years after implementation of the structural reforms to the Austrian funding agencies in the area of research, technology and innovation.[16] The evaluation assesses the development of the funding agencies based on four key themes: (1) the internal structure and organisation of the agencies, (2) the organisational cultures in the agencies, (3) the positioning of the agencies within the Austrian innovation system, (4) the management of the agencies by the owner department responsible. The evaluation has developed three future options for the future relations between the departments responsible and the agencies based on the findings obtained.

5.2.1 An institutional examination of the Austrian Research Promotion Agency (FFG)

The Austrian Research Promotion Agency (FFG) arose in 2004 from the merger of four or-

16 See Bührer et al. (2017).

ganisations in existence at that point (the Industrial Research Promotion Fund – FFF, the Technology Impulse Society – TIG, the Austrian Space Agency – ASA and the Bureau for International Research and Technology Cooperation – BIT), which were all dedicated to the promotion and funding of applied research. The goals in merging the agencies were as follows: (1) reduction in organisational and content-related complexity, (2) solving intrinsic coordination problems through the creation of funding agencies across all departments, (3) increasing political control in relation to the target groups and (4) improving the opportunities for implementation of government targets, i.e. improving efficiency and stepping up the use of resources.

The integration of four forerunner organisations is considered to have been successful overall in the evaluation, even though the forerunner organisations continue to be clearly reflected in the organisational units of the Austrian Research Promotion Agency (FFG) and the work procedures and cultures also differ in these to some extent. The latter point is explained primarily by the different work content and the way that the ministries commission projects. An approach that is heavily focused towards process and providing safeguards can be seen from the point of view of the employees surveyed on the issue of orientation benchmarks, particularly with respect to proper documentation of items and processing these without error as far as possible.

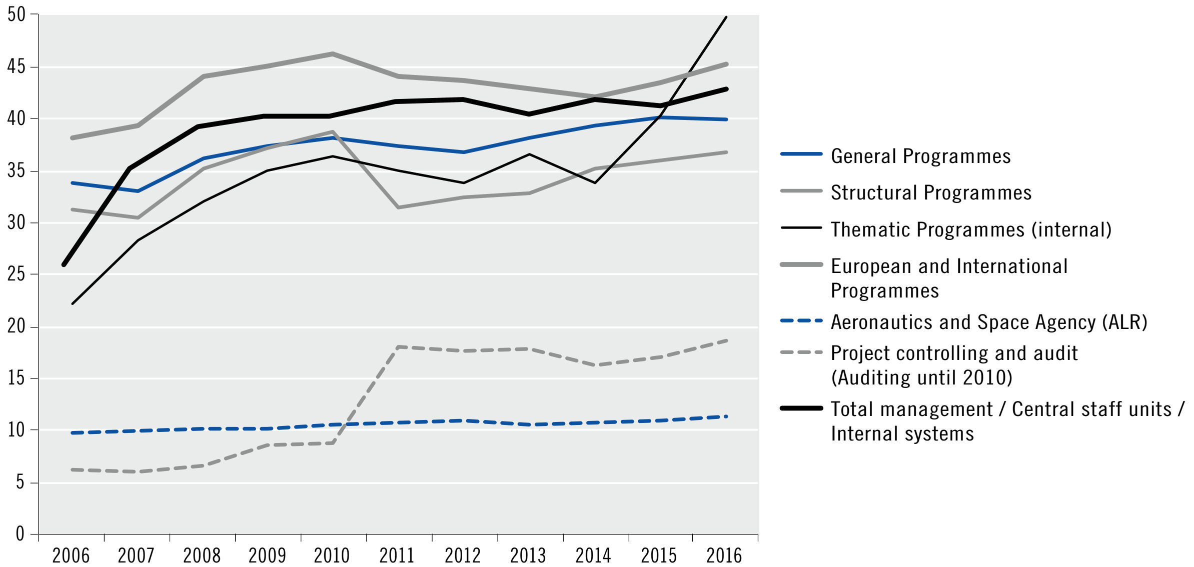
The evaluation therefore characterises the Austrian Research Promotion Agency as an organisation that is heavily focused on process standardisation, with executive management based on a top-down strategy, and pursuing the purpose of presenting itself as a coherent organisation that safeguards dependability and comparability. Harmonisation of formats, the rules of the game and terminology through uniform standards, including for jury processes, are stated as an advantage for all those involved. This is also reflected in the satisfaction shown by customers of the Austrian Research Promotion Agency (FFG). The quality dimensions of "professionalism" and "competence" are evaluated either as very good or good by 93% and 92% of customers respectively. "Focus on the customer" (80% very good or good) and "efficiency" (73%) also receive a positive assessment from a clear majority of those surveyed.

The evaluation detects a challenge for the Austrian Research Promotion Agency in this context in terms of positioning itself appropriately in the area between the competing priorities of ensuring high efficiency and transparency of processes and flexibility, accountability and creativity. According to the evaluation report the pendulum is swinging towards efficient processes and structures here. This means that any room for interpretation or creativity is lacking for the employees. According to the authors this focus on process is primarily attributable to the size of the Austrian Research Promotion Agency as an organisation with just under 300 employees and with an extensive budget that involves a high degree of regulation and requirements in terms of ambitious risk and quality management. At the same time, however, according to the report these structures also express a strategy of preventing errors as a result of the overall circumstances.

Both the headcount at the Austrian Research Promotion Agency as well as the operating costs of the organisational units have risen constantly since 2006 according to internal cost allocations and the operational funds to be awarded (see Fig. 5-1). Headcount rose from 174 (FTEs) to 262 (FTEs) in 2017. This equates to a +50.6% increase. Operating costs rose in the same period from €19 to €32 million (+68%) and operating funds from €368 to €610 million. However, the ratio of administrative costs (full costs) of the funding programmes to the operating funds (smoothed) fell from 3.7% to 3.5%.

In light of this, the evaluation unquestionably assesses the operational implementation of programmes by the Austrian Research Promotion Agency to be outstanding, and the de-

Fig. 5-1: Austrian Research Promotion Agency (FFG): Development of full-time equivalents by area, 2006–2016



Source: Bührer et al. (2017).

velopment of the processing costs also shows that it fulfils its tasks very effectively and efficiently. The size of the Austrian Research Promotion Agency is not only seen by the evaluation as an advantage nationally for the purposes of administering topic-based priorities effectively throughout Austria; it is also described as essential in terms of international positioning.

Aside from the internal challenge at the Austrian Research Promotion Agency (FFG) of enabling simplification and flexibility while also guaranteeing high transparency and efficiency of processes at the same time, the complex funding portfolio is also identified as a further challenge. This is despite standardisation of offer submission by the Austrian Research Promotion Agency (FFG) and the creation of an instrument toolbox which tries to present the Agency's funding and financing instruments in a structured and clear format.

The commissioning system of the ministries to the Austrian Research Promotion Agency is seen as a central challenge which is outside of the Agency's area of influence. This is characterised by a large number of different commissioning methods and control mechanisms and is seen as a major obstacle in terms of the Agency's further development towards higher efficiency and above all effectiveness. The evaluation therefore recommends simplification of the commissioning processes, a reduction in the diverse variety of programmes and optimisation of the interfaces with the departments responsible.

5.2.2 An institutional examination of the Austria Wirtschaftsservice (aws)

Austria Wirtschaftsservice (aws) was founded in 2002 through the merger of the Finance Guarantee Society FGG, the Innovation Agency and the BÜRGES financing bank. Since being founded, Austria Wirtschaftsservice (aws) has also assumed responsibility for the transactions of the ERP Fund (funds which the Republic of Austria receives under the Marshall Plan following the Second World War) and for executive management of the National Foundation (endowed from funds of the Austrian National Bank, the ERP Fund and the federal government).

The evaluation states that the Agency's starting conditions were not perfect. The period in which Austria Wirtschaftsservice was founded was characterised by financial difficulties for the FGG prior to founding, as well as major expectations related to savings potentials (20%). Structural reform objectives on the other hand were not the priority. The very high level of heterogeneity of the forerunner organisations, multiple changes to the executive management team and expansion of the funding business by 2009 resulted in the expected savings potentials being seen as unrealistic. According to the evaluation report, large scale and intensive efforts to develop a common guiding principle and implement efficient structures and processes have only been undertaken in the last five to eight years. These have also been successful, as reflected in the high levels of satisfaction recorded from employees and in particular customers.

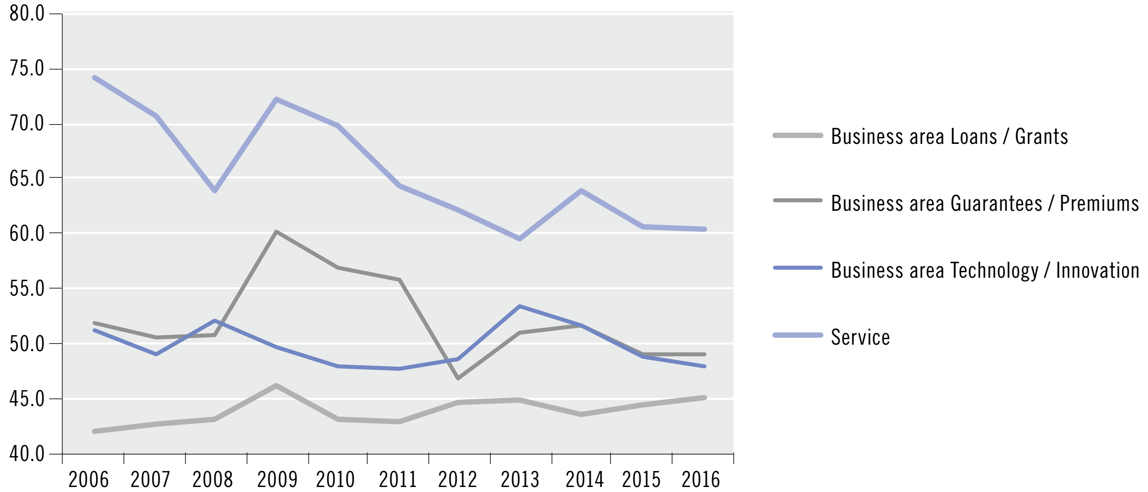
Despite a wide variety in the services, which also include the processing of competitions in addition to the core business of loans, guarantees and grants, equity instruments and consultation, Austria Wirtschaftsservice has still been able to position itself clearly in its role as an enterprise and industry-promoting organisation according to the evaluation. At the same time it still sees potential for expanding awareness of the “aws brand”, primarily based on the fact that loans and guarantees are generally administered via principal banks and there is often no direct contact between customers and Austria Wirtschaftsservice (aws). Whether the measures already implemented aimed at increasing awareness and corporate identity have been effective should be monitored over coming years according to the evaluation.

The measures to develop the internal organisation implemented over recent years are also rated as positive by the evaluation. Implementation of numerous modern management instruments has resulted in optimised and more efficient processes. The tendency towards avoiding errors resulting from the focus on process also represents a constant challenge for Austria Wirtschaftsservice (aws). Processes aimed at creating a guiding principle, team building initiatives and the introduction of management retreats have contributed towards employees identifying significantly with the Agency's guiding principle, meaning that the focus on customers and service remains a high priority.

With respect to staff development, the evaluation shows that headcount fell slightly following the merger as departing staff were not replaced in all cases. The number of employees in the business units rose again with increasing project volumes and reached a high in 2009 (see Fig. 5-2). The savings implemented by the government as a result of the financial crisis also affecting the funding business, with some staff made redundant. As can be seen from Fig. 5-2, significant numbers of employees were lost in the service staff area. The service departments merged from the forerunner organisations have been structured along professional lines based on intensive staff development and the required processes have essentially been able to support standardisation.

Overall, Austria Wirtschaftsservice is certified by the evaluation as having a high level of knowledge and skills in awarding funds as well as in the banking business, and it has all of the tools required for these diverse activities. Reducing organisational and content-related complexity, solving the coordination problems resulting from this and ensuring political governance remain crucial challenges for Austria Wirtschaftsservice. The complexity of the tasks means that the commissioning situation is also a varied one. Implementing ERP loans means that Austria Wirtschaftsservice is required to develop an annual programme that is then decided by the federal government. There are long-term agreements in place for guarantees, aid advice to the federal government and the

Fig. 5-2: Austria Wirtschaftsservice (aws): Active employees in full-time equivalents as at the reference date 31 Dec., incl. temporary staff, 2006–2016



Source: Bührer et al. (2017).

payment office for the European structural funds. However, many of the projects commissioned are short-term ones limited to one year, involving planning uncertainty both for the Agency as well as for customers. This makes it considerably more difficult to instil any strategic momentum into the target groups.

5.2.3 Positioning and coordination of the agencies

With respect to the positioning of the agencies, the evaluation finds that both agencies have been able to position themselves clearly in the national innovation policy environment. They operate to a large extent as a one-stop shop for application-oriented R&D (Austrian Research Promotion Agency (FFG)) and investment-related corporate funding (Austria Wirtschaftsservice (aws)). Both agencies support innovative projects from these different perspectives, as also defined in their relevant statutory bases.

Structural reform of the funding system has allowed greater horizontal coordination between the agencies in the Austrian funding system, and the evaluation finds that various benefits have been achieved as a result of the merger of the forerunner organisations.

The evaluation does see optimisation potential primarily based on the fact that principals have different requirements in terms of documentation and reporting, and the owners' different governance structures impede the possibilities for harmonisation of organisational structures.

In addition to this, the incentive structure for the agencies should be modified to the extent that both agencies currently operate a funding budget maximisation since innovations in the funding portfolio have so far been possible almost exclusively as a result of persistence with existing programmes. This has also resulted in overlaps at the margins of the different business models intrinsic to both agencies based on notions of competition, or their internal perspective of rounding out their own portfolios, even though these business models are adequate in reality. This is currently reinforced by the fact that additional budgets are available precisely in these marginal areas.

Nevertheless, the overlap between both agencies is described as being a relatively small one. It is found in the areas of enterprise creation, patents, VC and crossovers to market. According to the evaluation, the demarcation between both agencies could be sharpened by making the criteria for commissioning the individual agencies more explicit. In the case of those topics which require a bridge between the enterprise perspective/R&D/market crossover, the owners/principals need to ensure that the agencies also work on these topics together and that complementary skills and expertise are therefore combined from the point of view of the evaluation.

5.2.4 Management and governance of the agencies

The ongoing high level of complexity in the governance system is highlighted as a central finding in the present evaluation. According to the evaluation this is due on the one hand to the fact that control over the agencies is still provided via numerous performance agreements, which consume a lot of time and resources for all concerned. On the other hand there is no concept of control coordinated consistently between the owners, and the ministerial departments have no clear owner strategy to guide their actions. Not least therefore, this results in diverging self-perceptions and third-party perceptions with respect to the distribution of responsibilities between the ministerial departments and agencies. However, these divergent allocations of roles are ultimately in keeping with the fact that the delegation of tasks to the agencies is incomplete. Management of the agencies is assumed by the different ministries with their relevant specialist departments. These use different control mechanisms and channels (such as instructions to the relevant executive management teams, commissioning of programmes, rights of verification and control, etc.), which are generally not coordinated and in some cases even contradict each other according to the evaluation.

While the agencies have become more autonomous in largely unchanged circumstances as a result of the accumulation of strategic intelligence, there has not been any adequate recalibration of the system (including as a consequence of the "System Evaluation"[17]) or any comprehensive analogous co-evolution within the ministerial departments. The latter point relates primarily to the lack of development of any new concept of management and governance and corresponding adjustments, or of the capabilities in light of the increased professionalisation of the agencies' implementation processes.

In addition to simplification of the complex commissioning systems, the evaluation recommends greater policy-strategic leadership with clear definitions of targets, content, roles and interfaces between the owners/principals and agencies against this background. Furthermore the agencies should be given more operational freedom through complete delegation of the processes for implementing funding measures, in order to be able to address their customers more effectively with streamlined products and processes, and to optimise the impact of the measures offered by them.

5.2.5 Summary

The evaluation argues in favour of allowing the agencies to design funding portfolios dynamically, responsibly and with a willingness to assume risks, with these portfolios addressing and implementing policy-related priorities under the responsibility of the ministries commissioning the projects. At the same time the corresponding circumstances must reinforce the governance options for the departments responsible (not least in order to confront the problem of an otherwise lack of indirect democratic con-

17 See Aiginger et al. (2009).

trol and legitimisation and to retain the agencies as instruments for implementing the policy decision-making process) and to place the governance system on a basis of inspiring confidence and achieving results.

In summary, the evaluation advises the owners to boost the agencies' financial and operational autonomy in particular in line with the guiding principle of "performance through autonomy". Transitioning from micromanagement towards a results-oriented management "from a distance" which, based on a global budget, may stipulate the desired impact of the agency based on defined targets and impact indicators, but which lets the agency predominantly allocate the budget to instruments, is the preferred option for the future according to the evaluation. The key benefit of this future option would be in the greater degree of flexibility in the agency to implement more clearly communicable products, acceleration of processes to address target groups more effectively, and short feedback loops and flexible combination of instruments to ensure greater leverage of the funds deployed. It should be noted in this context that this model is already very widespread and is consistently implemented in the Scandinavian countries in particular.

By contrast, any continuation with the status quo would perpetuate the manifest governance problems, even though all the parties involved would have come up with practical routines to deal with these. Another future scenario could involve a diluted version of the global management outlined above as a type of "further development of the status quo". This further development is also focused on reinforcing the strategic management of the agencies by the ministerial departments and boosting the agencies at the same time through greater independence at the operational level, which should above all include greater degrees of freedom in programme development than previously. In contrast with the global management outlined above, however, the agency has less power to decide on the design for its portfolio and its implementation.

Based on the evaluation of the funding societies, a discussion could in any case be initiated on the topics of ownership, management abilities and funding in the RTI system. The departments responsible for the funding societies, the Federal Ministry for Digital and Economic Affairs (BMDW) and Federal Ministry for Transport, Innovation and Technology (BMVIT) are in a process of continuous coordination. Reassessment of the governance structures in the RTI system as well as realignment of the concept of management and governance are also topics in the federal government's current programme.

5.3 Selected further evaluations

Recent evaluations of Austrian research funding programmes are presented briefly below: the combined programme evaluation of the Christian Doppler Laboratories and Josef Ressel Centres (on behalf of the Federal Ministry for Digital and Economic Affairs), the evaluation of the BRIDGE programme for the 2009–2016 period (on behalf of the Federal Ministry for Transport, Innovation and Technology), the evaluation of the Austrian security research programme KIRAS 2017 (on behalf of the Federal Ministry for Transport, Innovation and Technology) and the evaluation of innovation-promoting public procurement (on behalf of the Federal Ministry for Transport, Innovation and Technology and the Federal Ministry of Digital and Economic Affairs).

5.3.1 Combined programme evaluation of the Christian Doppler Laboratories and Josef Ressel Centres

Objective of the evaluation

The programme evaluation of the Christian Doppler Laboratories (CD laboratories) and Josef Ressel Centres (JR Centres)[18] had two fundamental objectives: one was to review the ongoing funded projects (i.e. of the CD laboratories and JR Centres), and the other involved an examination of the funding programme as a whole with respect to the systemic impact levels of Output (key indicator level), Outcome (operational target level) and Impact (industrial and social policy target level). The evaluation relied on the results of the benefit, programme and system evaluation of Christian Doppler Society (CDG) from 2011[19], with the current examination focusing in particular on the new instrument of the JR Centres introduced in 2012.

Programme objectives and key information

The CDG has been organised as a non-profit association since 1995 with representatives from firms, scientists and the public sector. Its key objectives involve support for applied basic research at universities, universities of applied sciences and research institutes, support for knowledge and technology transfer between scientific partners and firms as well as the development of human resources. The aim here is to make a contribution towards Austria as a place for research and business by improving innovative potential and competitiveness.

This is implemented by funding the establishment of CD laboratories at universities, as well as JR Centres at universities of applied sciences since 2012. These are 50% funded by the public sector, with these funds provided by the Federal Ministry for Digital and Economic Affairs (BMDW) and the National Foundation for Research, Technology and Development. The private funds are provided by enterprise partners of the relevant research units which are members of the CDG at the same time, with a higher funding ratio for SMEs. The annual budget for CD Laboratories is between €110,000 and €700,000, and for JR Centres it is between €80,000 and €400,000. A total of 30% of the resources must be dedicated to independent basic research, irrespective of the interests of the firms involved. Both the CD Laboratories and the JR Centres are integrated into the structures of the relevant institution and are not separate legal entities. The maximum duration is seven years for CD Laboratories and five years for JR Centres. The research groups include between 3 and 15 researchers and are led by highly qualified scientists. The research priorities area in the area of technical sciences and natural sciences.

At the time of the evaluation, there were 72 CD Laboratories at 16 universities and non-university research institutes, as well as 9 new JR Centres at 8 universities of applied sciences with a total of 830 and 100 active employees respectively. The present evaluation covers the 45 CD Laboratories that had expired since the last evaluation in 2011 as well as the 6 JR Centres still active as of July 2016.

Results of the evaluation

The evaluation highlights in particular the high level in the achievement of objectives related to the systemic impact objectives. The CD Laboratories and JR Centres for instance enabled collaborative projects with industry with a higher focus on basic research than would have been the case with R&D carried out purely internally within a firm. In the case of the CD Laboratories there was also an increase determined in scientific publications and dissemination activities in relation to the funds used as compared with the last evaluation in 2011. While the JR Centres generally receive a positive rating, no far-reaching statements can be made about the impact or the necessary changes to the program design according to the evaluation as a result of the short duration to date.

18 See Alt et al. (2016).
19 See Alt et al. (2012).

The survey carried out as part of the evaluation shows that the CD Laboratories have proven themselves in particular as a result of their structure, their longer-term focus and their clear objectives. Partners in science and industry appear to be highly satisfied with the instrument. The long-term nature of the partnerships was highlighted, and this enables strategic access to scientific knowledge and expertise to firms in particular, combined with the ability to establish new skills. This supports a sustained build-up of human capital. The administrative effort was largely rated as satisfactory. The CDG was also found to feature a lot of flexibility over time with respect to the adaptations required to the funding instruments, which contributed towards maintaining the programme's appeal by consistently adjusting to new sets of circumstances.

The evaluation identifies more proactive development of new topic areas over and above the existing priorities in the areas of "mathematics, IT and electronics" as a particular area for action. Compared with the evaluation, it was also determined that a higher number of CD Laboratories could no longer be continued as a result of the increase in enterprise partners, overwhelmingly based on economic considerations. The evaluation recommends paying more attention to partners' economic situations in the interim evaluations of the individual laboratories. In summary the evaluation determines that no conclusive assessment of the JR Centres can be provided yet with respect to the impact as well as potential actions areas as a result of the comparatively low number of cases and short duration of the funding schemes to date. The development of the JR Centres will need to be evaluated over the next few years, particularly against the backdrop of the structural development in the universities of applied sciences sector.

5.3.2 Evaluation of the BRIDGE programme for the 2009–2016 period

Objective of the evaluation

The objective of the interim evaluation completed in 2018 of the BRIDGE programme[20] was to reflect on the existing programme progress based on the 2013/2015 programme documentation (in relation to data focused on the period between 2009 and 2016) as well as the development of corresponding conclusions and recommendation for further development of the programme.

Programme objectives and key information

BRIDGE is an initiative financed by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and by the Austrian National Foundation for Research, Technology and Development aimed at closing the funding gap within the range of oriented basic research/industrial research, with the former also clearly focused on the sub-area from the perspective of industrial exploitation. It has provided support for basic research-related projects since 2004 that already reveal a realistic potential for exploitation.

There have been changes to the BRIDGE funding portfolio since the programme was started. The Translational Research Programme (TRP) funded by the Federal Ministry for Transport, Innovation and Technology was suspended in 2012 as this no longer fell within this Ministry's political remit, as a basic research-related project taken over by the Austrian Science Fund (FWF). The BRIDGE 2 programme line was also terminated in 2010 on account of an overlap with the general programmes operated by the Austrian Research Promotion Agency (FFG). With BRIDGE 1 (almost unchanged since the programme was introduced) and BRIDGE Frühphase (early stage), the BRIDGE pro-

20 See Kaufmann et al. (2018).

gramme now includes two funding instruments that differ primarily through the degree of application relevance to research. While the funding is provided on an open-topic basis, participation of potential partners for exploitation is mandatory. In both funding lines it is only the scientific partners that receive funding, with the exploitation partners required to provide their own personal contributions to differing extents. Unlike BRIDGE 1 the personal contributions can also be provided as contributions in-kind within BRIDGE early stage.

As part of the 2009–2016 period considered in the evaluation, a total of €135.9 million was distributed in funding, with €91.2 million of this via BRIDGE 1. The average annual funding amount of €20.5 million has fallen to €17 million compared with the period before 2009. A total of 465 projects were approved in the period examined with total project costs amounting to €168 million.

Results of the evaluation

Despite some individual overlaps with other funding instruments, BRIDGE is contributing towards an acceleration of scientific and industrial relations in Austria, and helping to close a gap in the programme landscape by enabling smaller projects/consortia and the focus on exploitation and knowledge transfer. One of the indicators for the high level of acceptance for BRIDGE among the target group can be seen in the high rates of subscription in the funding lines. The bandwagon effects are also considered to be low by the evaluators. According to this only between 4-7% of the projects funded would have been implemented in a similar form without the funding from BRIDGE. In terms of the structure of the funding recipients, it can be stated that the proportion of SMEs that are exploitation partners in BRIDGE projects has fallen in favour of the large enterprises. Another finding is that comparatively risky projects are obviously being funded via BRIDGE. Half of the exploitation partners stated in this context that the new knowledge desired could not be achieved. At the same time, 45% of all research institutes confirmed that partnerships could be continued for up to four years after the collaboration in BRIDGE had come to an end.

In a direct comparison between funded and non-funded project applications, a higher scientific publication tendency than patenting tendency can be determined among funded applicants based on an analysis of the data from Impact Monitoring by the Austrian Research Promotion Agency along with bibliometric studies and patent statistics. Efforts aimed at achieving high scientific standards that are comparable internationally can be found with the programme, as is evident from the survey of funding recipients. The peer review process is seen as objective, with potential for improvement seen solely with respect to the quality of the approval in the sense of feedback that is more learning-based.

The difficulty of defining the limits between the two programme lines BRIDGE 1 and BRIDGE early stage was highlighted as an action area in the evaluation. The evaluators recommend merging the two programme lines, arguing that this will eliminate the demarcation by the application relevance of the projects and will achieve efficiency gains in processing and will reduce the subscription rates in BRIDGE early stage.

5.3.3 Evaluation of the Austrian security research programme KIRAS. 2017 Report

Objective of the evaluation

Progress with the Austrian Security Research Programme KIRAS is analysed and reported in annual cycles as part of the accompanying evaluation in the 2014–2020 programme phase. The evaluation consists on the one hand of a consistent core, which includes for instance a survey of stakeholder participation, an analysis of the programme performance, and an evaluation of the effects on the national economy, and on the other hand consists of an examination of the priorities which change each year. The evaluation is supplemented by security monitoring aimed at analysing security awareness and the population's sense of security.

The report from 2017[21] was primarily aimed at evaluating achievement of the six defined KIRAS programme targets using the funds provided. The quantitative indicators on impact measurement set out in the programme document and the target values sought formed the basis for this.

Programme objectives and key information

Implemented in 2005 as a funding programme for national security research, KIRAS uses two supplementary funding instruments today: the "Collaborative R&D projects" instruments, which funds industrial research projects and experimental development, as well as the "R&D Services" instrument, which supports relevant studies and study-related projects. Responsibility for the programme itself lies with the Federal Ministry of Transport, Innovation and Technology (BMVIT), with the Austrian Research Promotion Agency (FFG) in charge of running the programme and its overall management. The funding programme is scheduled to continue until 31 December 2020.

KIRAS pursues six strategic objectives: to improve the subjective perception & objective level of security of Austrian citizens; to support the generation of knowledge needed for security policy; to promote security-related technology leaps; to support the growth of the Austrian security industry; to achieve excellence in security research; and to integrate relevant societal questions in every project.

In the ongoing phase of the funding programme, the topic-based focus is on protection of critical infrastructures and enshrining KIRAS into European research funding in 2017. Specific assessment criteria have been or are being created and published for all proposals. In light of this, all applications submitted are reviewed and assessed based on consideration of the social dimensions. Funded projects should for instance contribute inter alia towards safeguarding qualified jobs over the long term.

Applications have been made for funding amounting to €212.1 million since the project was launched in 2005. Projects amounting currently to €110.8 million have been approved, with €77 million of funding already provided for these (total funding ratio of 70%). The average costs requested per project have so far amounted to approx. €526,000. The project funding generated cumulative effects of €152.7 million of gross value added and 2,835 secure jobs (full-time equivalents) between 2006 and the 2017 round of approvals.

Results of the evaluation

With respect to the target of "increasing security and security awareness", the evaluation identifies an increase in the proportion of KIRAS projects that relate to a specific threat. The population's perception of danger has also increased, as have the measures aimed at raising awareness through KIRAS projects in response to this. The target was therefore classified as having been overachieved.

The second programme target of "generating the knowledge required for security policy" was also overachieved by the projects in terms of individual target values. These target values relate among other things to inclusion of stakeholders in the projects, with 229 actively participating in the 127 "Collaborative R&D projects" funded so far. Here, the evaluation points out that those targets that are more important from a project perspective also tend to be achieved.

The two targets of "achieving knowledge, procedural and technology leaps" and of "grow-

21 See Engelhardt et al. (2018).

ing the Austrian security industry" were also achieved according to the evaluation report. Accordingly, 89% of firms and 81% of scientific establishments stated that they had developed new research areas within the scope of KIRAS projects. KIRAS accordingly also boosts innovation in products, services and the organisation area, which according to the evaluation is beneficial in terms of the ratio of the funding amount to value add, and contributes towards growth of the security industry. The evaluators also assert that a significant part of the projects would not have taken place without KIRAS research funding.

With respect to the target of "establishing and expanding excellence in the area of security research", almost all of those surveyed as part of the evaluation stated that new skills and expertise were acquired as a result of the funded project. The goal of "consideration of social issues in all aspects of security research" was also largely achieved as a cross-cutting objective. According to the evaluation the results of the KIRAS projects are communicated to society in many cases, including through articles in daily newspapers, awareness events or using informational material. For the purposes of the topic-based priorities for 2017, the evaluation also shows that KIRAS represents an important step towards preparation for participation in EU projects. This applies both to the direct technical aspects as well as to the framework conditions and formation of consortia.

5.3.4 Evaluation of public procurement promoting innovation (PPPI)

Objective of the evaluation

The interim evaluation completed in 2018[22] of the PPPI initiative was aimed at reviewing the existing implementation of the PPPI guiding principle and the measures set out within this. This related primarily to the services of the PPPI service centre, the design of the PPPI service network, the PPPI monitoring system and the involvement of the key stakeholders. The intention was also to determine the extent to which the institutional framework and governance structure facilitated efficient implementation of the initiative. Recommendations and proposals for continuation of the initiative were supposed to be derived from the findings.

Programme objectives and key information

The PPPI initiative links in with the Austrian RTI strategy from 2011, based upon which the PPPI guiding principle was developed and adopted in 2012. The overriding aim of the PPPI guiding principle is to increase the share of public procurement that is used for innovations. Further targets of the PPPI guiding principle include boosting demand-side innovation policy, perception of the public sector as an "intelligent" customer, and creating incentive structures and reference markets. The Federal Ministry for Digital and Economic Affairs (BMDW) and Federal Ministry for Transport, Innovation and Technology (BMVIT) are jointly responsible for implementing the PPPI guiding principle.

Results of the evaluation

Austria is a progressive country in international comparisons of public procurement promoting innovation with its PPPI guiding principle and implementation of the measures applied within this. The guiding concept and its implementation focus in particular on raising awareness, qualification and corresponding support. Implementation of the defined measures and activities is already at a very advanced stage. Although no systemic use of PPPI can be identified yet among public clients, the preparations for this have been thriving as a result of the steps that have already been implemented.

22 See Ruhland et al. (2018).

Key signs of the comprehensive political significance of PPPI are provided on the one hand through the two presentations to the Austrian Council of Ministers on the development and implementation of the guiding concept and on the other through the comprehensive anchoring of PPPI in relevant strategy documents, including the 2017–2022 government programme. The established governance mechanisms, incentive systems and resources provided to implement the beneficial measures or actual PPPI projects are not, however, keeping up with this currently.

Although there is political backing for the measures, this support is not being provided to the extent anticipated or required, as is expressed through the lack of possibilities for coordination and management approaches from departmental PPPI coordinators and PPPI plans. However, this is also connected with the considerable effort required for strategic coordination and for creation of the principles (including legal ones).

Establishment of the PPPI service office has resulted in a one-stop shop that has achieved a positive impact in terms of the preparations for more systematic use of PPPI through raising awareness, providing information and knowledge, qualification and networking. The service office's work by way of a project competition has also meant that pilot projects have been supported and efforts have been initiated to implement further projects.

The PPPI monitoring activities implemented are comprehensive and highly differentiated. The monitoring approach proposed in the guiding concept has, however, been understood as the maximum variant and some of its points could not be implemented according to the evaluation. Irrespective of this, relatively high levels of attention were dedicated to the activities subsumed under the concepts of monitoring and benchmarking. Although the approach followed with respect to a complete survey of the relevant volumes revealed its limits, it was successful empirically given the relatively high participation by respondents. Promising alternative ways of recording data via procurement platforms are currently being reviewed with the aim of achieving a complete survey.

The breadth of penetration of the measures under the PPPI guiding concept is still constrained when measured against aspirations. Implementation at the operational level (among purchasers) has not yet succeeded to the desired extent. Even through the ministerial departments in charge, i.e. the Federal Ministry for Digital and Economic Affairs (BMDW) and Federal Ministry for Transport, Innovation and Technology (BMVIT), are pushing the topic forward, efforts to actually enshrine and implement PPPI in the strategy plans of all ministries lack any broader political will. As shown in the evaluation, there are currently no mandatory elements in the procurement processes of most public organisations, such as (internal) targets, designated/earmarked budgets, strategic PPPI plans, etc.

The recommendations from the evaluation address those areas in which there is a potential for improvement and subsume these under two scenarios. The first scenario contains suggestions for improving the status quo and covers the short to medium term. The second scenario covering the medium to long term builds on the improvements in scenario 1, and sees the idea of the guiding concept broadly realised (establishing new governance structures, differentiation between the operational possibilities and stipulation of more robust support structures).

6 List of Figures and Tables

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7 Literature

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8 Annex I

8.1 Country codes

Country/region	Codes
Albania	AL
Argentina	AR
Austria	AT
Australia	AU
Belgium	BE
Bulgaria	BG
Brazil	BR
Canada	CA
Switzerland	CH
Chile	CL
China	CN
Cyprus	CY
Czechia	CZ
Germany	DE
Denmark	DK

Country/region	Codes
Estonia	EE
Greece	EL
Spain	ES
Finland	FI
France	FR
Hong Kong	HK
Croatia	HR
Hungary	HU
Ireland	IE
India	IN
Israel	IL
Iceland	IS
Italy	IT
Japan	JP

Country/region	Codes
South Korea	KR
Liechtenstein	LI
Lithuania	LT
Luxembourg	LU
Latvia	LV
Montenegro	ME
Macedonia	MK
Malta	MT
Mexico	MX
Nigeria	NG
Netherlands	NL
Norway	NO
New Zealand	NZ
Poland	PL

Country/region	Codes
Portugal	PT
Romania	RO
Serbia	RS
Russia	RU
Sweden	SE
Singapore	SG
Slovenia	SI
Slovakia	SK
Turkey	TR
Taiwan	TW
Ukraine	UA
United Kingdom	UK
United States of America	US
South Africa	ZA

8.2 Explanations of different types of transnational RTI partnerships

Public-Public Partnerships

- JPI – Joint Programming Initiatives: Bundling of resources and capacities of the research funding of multiple Member States on certain research priorities (programmes funded by Member States, financial support through Horizon 2020 for CSA coordination and support measure, joint proposals may be funded by Horizon 2020 or take place via ERA NET activities).
- Article 185 initiatives (previously Article 169 of the Treaty on the Functioning of the European Union): contractually regulated cooperation between the EU and platform of the Member States aimed at coordinating national R&D programmes for more efficient use of resources (each of the initiatives in accordance with Article 185 acts as a long-term funding programme in which the Commission is also involved in addition to the Member States, with funding by the Member States and the Framework Programme for R&D of the EU) → joint proposals of the initiative → projects aimed at partners from science and industry, Eurostars Initiative exclusively for SMEs (EUROSTARS projects).
- ERA-NET activities (FP 7: ERA-NET, ERA-NETplus; Horizon 2020: ERA-Cofund): Coordination instrument for national research funding programmes for bundling and further developing existing priority areas, formulating common priority areas, clustering as well as developing transnational funding programmes and joint calls in 'virtual common pots' → the objective is cross-border research and technology cooperation; sponsorship is provided by the EC and the Member States.
- EJP – European Joint Programme Cofund: Co-financing instrument to promote transnationally coordinated R&D and innovation programmes, funded by the EU Commission (from Horizon 2020) and the Member States based on annual work programmes for a period of five years.

Public-Private Partnerships:

- EIT – European Institute of Innovation and Technology: Funding instruments for the Knowledge and Innovation Communities (KIC) → cooperative institutes that work autonomously in a consortium of institutes from the knowledge triangle (scientific research – scientific teaching – corporate research and innovation) with differing ranges of activities (training and education, innovation projects as well as support for market launches of innovative products and new ventures); funded as a cross-sectional field within the scope of Horizon 2020.
- EIP – European Innovation Partnerships: a networking tool and not a funding tool → Platform for innovation that brings together European partners and public and private stakeholders to cover topics, no EU funding; funding for joint projects via the structural funds, Horizon 2020, national funding programmes.
- JTI – Joint Technology Initiatives: Public-private partnerships for funding transnational technology initiatives; development of initiatives through transnational industrial associations; develop own strategic agendas, work programmes and proposals, select project, funded by industry and EU (with the exception of JTI ECSEL, → funding here also by MS). Each of these initiatives in accordance with Article 187 TFEU has its own separate legal personality.
- Contractual Public-Private Partnerships cPPPs: Interlinking between public and private stakeholders in the aim of implementing funding priority areas and proposals in Horizon 2020, 50/50 public/private funding, proposal and funding via the Horizon 2020 work programme → partners from universities, industry and SMEs.

Other multilateral initiatives:

- FET – Flagships: Future and Emerging Technologies: long-term funding programme for up to ten years with up to €100 million of individual funding per year and flagship initiative → enshrined in Horizon 2020 Pillar 1 Excellence of Science with separate work programme; consortia include partners from industry and research.
- ETP – European Technology Platforms: Initiatives for building networks in industry with the aim of bundling topics and matters from the stakeholder side in the overall value added chain in one research area (industry, scientists and researchers, SMEs, end consumers) in order to influence the setting of priorities at the European level → funding by industrial partners, their structures vary greatly.
- COSME – Competitiveness of SMEs: Consultation instrument, (programme owner and sponsor EC, €2.3 billion), designed exclusively for intermediaries (banks, national governments, research on the topic) → aimed at improving competitiveness of SMEs.
- COST – European Cooperation in Science and Technology: Funding and networking instrument for researchers → funds (from the funds in the EU R&D Framework Programme) travel expenses etc. for conferences, short-term research exchange initiatives, publications.
- EUREKA – Initiative for application-oriented R&D in Europe: Funding by Member States for firms participating in EUREKA clusters, top-up funding in Austria for EUREKA participation (sponsored by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Federal Ministry for Digital and Economic Affairs (BMDW)).

Other EU programmes not related directly to R&D:
EIF – European Investment Fund: The objective is to provide funding for SMEs using tools for own funding (venture capital, support for growth and mezzanine capital), loans and microfinancing. The owners are the EIB Group (European Investment Bank and European Investment Fund) and the EC.

- EFSI – European Fund for Strategic Investments: joint initiative between the EIB Group and the EC aimed at stimulating private investments in strategic areas (strategic infrastructure, including digital networks, transportation and energy; education, research, development and innovation, development of renewable energy and resource efficiency, funding and promotion of SMEs and mid-cap firms). The plan is to use funds of around €21 billion to leverage investments of around €315 billion over the next three years (from 2016).
- ESIF – European Structural and Investment Funds: include the Cohesion Fund, the European Social Fund (ESF), the European Agricultural Fund for Rural Development (EAFRD), the European Maritime and Fisheries Fund (EMFF) and the European Regional Development Fund (ERDF) with their own priorities and objectives in each case. In the relevant period between 2014–2020 the ERDF is focused on funding and promoting regional stimulus through research and innovation with a budget of €793 million. The overall ESIF budget includes €454 billion for the 2014–2020 period.

8.3 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	Federal Ministry for Civil Service and Sport (BMÖDS) – GovLab Austria	Federal Ministry of Transport, Innovation and Technology (BMVIT) – Massive Open Online Courses "Smart Cities" Austrian Research Promotion Agency (FFG), Federal Ministry for Transport, Innovation and Technology (BMVIT) – Regional Talents	Federal Ministry for Civil Service and Sport (BMÖDS) – GovLab Austria Federal Ministry for Transport, Innovation and Technology (BMVIT) – open consultations as part of the efforts to develop the energy research strategy			LBG – Open Innovation in Science Research and Competence Center (OIS)
Action area 2	Formation of heterogeneous Open Innovation networks and partnerships across disciplines, branches of industry and organisations	FAZAT Steyr – Nature of Innovation AustriaTech Urban mobility laboratories Federal Ministry for Transport, Innovation and Technology (BMVIT) – test environments for automated driving Austrian Research Promotion Agency (FFG), Federal Ministry for Transport, Innovation and Technology (BMVIT) – Pilot factories Industry 4.0	Austrian Research Promotion Agency (FFG), Austrian Science Fund (FWF) – Open Ideation Days Austrian Research Promotion Agency (FFG) – I-realize tenders	PPPI, Federal Ministry for Digital and Economic Affairs (BMDW), Federal Ministry for Transport, Innovation and Technology (BMVIT) – Matchmaking platform & crowdsourcing challenges Federal Ministry for Civil Service and Sport (BMÖDS) – GovLab Austria ASFINAG – Innovation focus on service stations	Federal Ministry for Civil Service and Sport (BMÖDS) – GovLab Austria Federal Ministry of Transport, Innovation and Technology (BMVIT) & KLIEN – Future of energy 2050 dialogue process Federal Ministry of Transport, Innovation and Technology (BMVIT) – Innovation platform Active and Assisted Living (AAL) Austria	Austrian Patent Office – Open Data Initiative Austrian Research Promotion Agency (FFG) – info network	LBG – Ideas Lab
Action area 3	Formation of heterogeneous Open Innovation networks and partnerships across disciplines, branches of industry and organisations	Federal Ministry for Civil Service and Sport (BMÖDS) – GovLab Austria Austrian Federal Railways (ÖBB) – Open Innovation Lab & Service Design Center Austrian Research Promotion Agency (FFG) , Federal Ministry for Transport, Innovation and Technology (BMVIT) – innovation workshops and innovation laboratories Austrian Research Promotion Agency (FFG) – Education LABs	Austrian Research Promotion Agency (FFG) – Education LABs	Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA), Austrian Economic Chambers (WKÖ) – Open Austria Silicon Valley City of Vienna – implementation of the "Innovative Vienna 2020" strategy		Federal Ministry of Transport, Innovation and Technology (BMVIT) – 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 cocreation 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
	Austrian Research Promotion Agency (FFG), Federal Ministry for Transport, Innovation and Technology (BMVIT) – Promotion of OI as part of the COMET centres		Salzburg – Competence Centre for Open Innovation (KOI)	Austrian Patent Office – Training and events Federal Ministry of Education, Science and Research (BMBWF) & Federal Ministry for Transport, Innovation and Technology (BMVIT) – Dissemination of methodological knowledge of OI in workshops	Austrian Patent Office – Open Data Initiative Austrian Science Fund (FWF) – Open Access Policy 2020	Austrian Patent Office – Raising awareness of exploitation strategies	Federal Ministry of Education, Science and Research (BMBWF) & Federal Ministry of Transport, Innovation and Technology (BMVIT) – Information & communication work via the official Open Innovation website (www.openinnovation.gv.at) BMBWF & BMVIT – Dissemination of methodological knowledge of OI in workshops
	Federal Ministry for Transport, Innovation and Technology (BMVIT) – Active and Assisted Living (AAL) test regions		Austrian Research Promotion Agency (FFG) – Focus on Open Innovation in the COIN networks Austrian Cooperative Research (ACR) – Co-creation workshops		Federal Ministry of Transport, Innovation and Technology (BMVIT) – “e-genius” open content platform Federal Ministry for Transport, Innovation and Technology (BMVIT) – Exchange of open RTI data pioneers		Federal Ministry of Transport, Innovation and Technology (BMVIT) – Information & communication work within the scope of the Open4Innovation platform
Austrian Research Promotion Agency (FFG) – Ideas Lab 4.0 CDG – Partnership in Research	Austrian Exchange Service (OeAD), Federal Ministry of Education, Science and Research (BMBWF) – Citizen Science Austrian Research Promotion Agency (FFG) – Impact Innovation	Austria Wirtschaftsservice (aws) (ncp-ip) – Submission of a working group on compensation mechanisms in Open Innovation	Salzburg – Competence Centre for Open Innovation (KOI) Austrian Patent Office – SME research service offering Austrian Research Promotion Agency (FFG) – Impact Innovation		Austrian Patent Office – Patent Scan Austrian Science Fund (FWF) – Open Access Policy 2020 Universities, Federal Ministry of Education, Science and Research (BMBWF) – Implementation of the OANA recommendations on Open Access Federal Ministry for Transport, Innovation and Technology (BMVIT) – Provision of research results of funded projects (Open4Innovation – platform)		

8.4 Public financing of R&D in the business enterprise sector

	Business enterprise sector		Change	Direct financing		Change	Indirect financing		Change
	2006	2015	2006–2015	2009	2015	2006–2015	2009	2015	2006–2015
as a percentage of GDP									
AT	0.170	0.270	0.100	0.094	0.130	0.036	0.089	0.140	0.051
AT 14% FP	0.170	0.329	0.159	0.094	0.130	0.036	0.089	0.199	0.110
AU	0.120	0.200	0.080	0.030	0.030	0.000	0.077	0.170	0.093
BE	0.120	0.390	0.270	0.075	0.110	0.035	0.144	0.280	0.136
BR	0.040	0.110	0.070	.	0.080	N/A	0.044	0.030	N/A
CA	0.220	0.170	-0.050	0.024	0.040	0.016	0.215	0.130	-0.085
CH	0.030	0.030	0.000	0.036	0.030	-0.006	0.000	0.000	0.000
CL	0.003	0.020	0.017	0.004	0.010	0.006	0.000	0.010	0.010
CN	0.100	0.130	0.030	0.054	0.070	0.016	.	0.060	N/A
CZ	0.140	0.140	0.000	0.135	0.080	-0.055	0.029	0.060	0.031
DE	0.080	0.070	-0.010	0.084	0.070	-0.014	0.000	0.000	0.000
DK	0.090	0.130	0.040	0.041	0.050	0.009	0.117	0.080	-0.037
EE	0.040	0.060	0.020	0.070	0.060	-0.010	0.000	0.000	0.000
EL	0.020	0.080	0.060	0.008	0.030	0.022	0.000	0.050	0.050
ES	0.120	0.120	0.000	0.116	0.060	-0.056	0.030	0.060	0.030
FI	0.090	0.070	-0.020	0.070	0.070	0.000	0.000	0.000	0.000
FR	0.240	0.390	0.150	0.151	0.110	-0.041	0.230	0.280	0.050
HU	0.180	0.350	0.170	0.045	0.200	0.155	0.089	0.150	0.061
IE	0.080	0.360	0.280	0.051	0.070	0.019	0.143	0.290	0.147
IL	0.159	0.110	-0.049	0.159	0.110	-0.049	0.000	0.000	0.000
IS	0.160	0.170	0.010	0.078	0.110	0.032	0.000	0.060	0.060
IT	0.040	0.080	0.040	0.038	0.040	0.002	0.000	0.040	0.040
JP	0.140	0.150	0.010	0.025	0.030	0.005	0.057	0.120	0.063
KR	0.300	0.350	0.050	0.149	0.170	0.021	0.181	0.180	-0.001
LT	0.010	0.030	0.020	.	0.010	N/A	.	0.020	N/A
LU	0.041	0.040	-0.001	0.041	0.040	-0.001	0.000	0.000	0.000
LV	0.010	0.004	-0.006	.	0.002	N/A	.	0.002	N/A
MX	0.060	0.060	0.000	0.011	0.060	0.049	0.000	0.000	0.000
NL	0.100	0.170	0.070	0.032	0.020	-0.012	0.119	0.150	0.031
NO	0.110	0.190	0.080	0.087	0.090	0.003	0.048	0.100	0.052
NZ	0.090	0.080	-0.010	0.044	0.070	0.026	0.000	0.010	0.010
PL	0.024	0.050	0.026	0.024	0.050	0.026	0.000	0.000	-0.000
PT	0.080	0.150	0.070	0.025	0.050	0.025	0.115	0.100	-0.015
RU	0.540	0.540	0.000	0.445	0.390	-0.055	0.000	0.150	0.150
SE	0.110	0.130	0.020	0.150	0.130	-0.020	0.000	0.000	0.000
SI	0.110	0.190	0.080	0.141	0.070	-0.071	0.138	0.120	-0.018
SK	0.030	0.023	-0.007	0.014	0.020	0.006	0.000	0.003	0.003
TR	0.040	0.070	0.030	0.051	0.040	-0.011	0.045	0.030	-0.015
UK	0.120	0.230	0.110	0.088	0.100	0.012	0.074	0.130	0.056
US	0.230	0.250	0.020	0.180	0.180	-0.000	0.050	0.070	0.020
ZA	0.110	0.050	-0.060	0.113	0.020	-0.093	0.013	0.030	0.017

Note: Total value for LU 2015=2011.

Source: OECD (2017). R&D Tax Incentive Indicators, July 2017. Calculations: Austrian Institute of Economic Research (WIFO).

9 Annex II

Research funding and research contracts of the federal government according to the federal research database

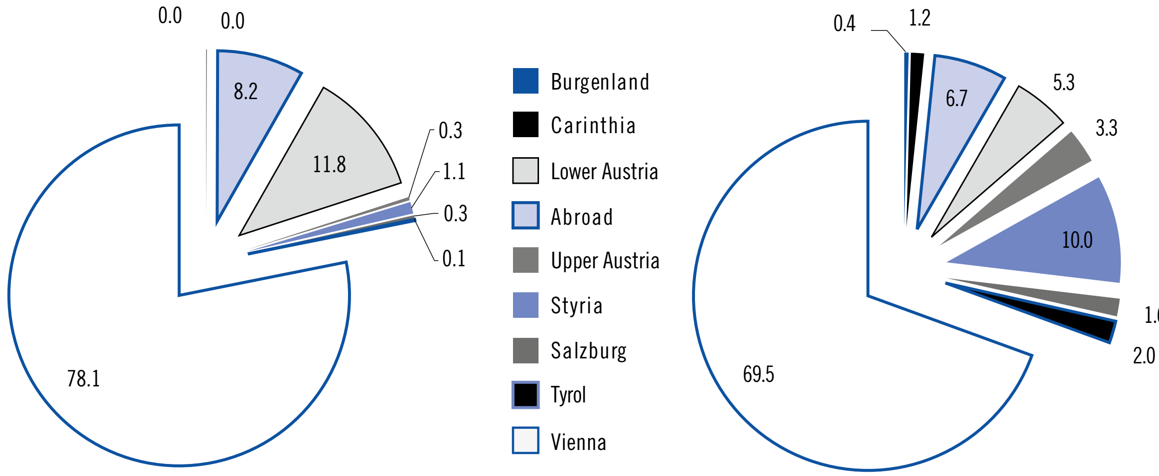
Figures 9-1 to 9-4 provide an overview of R&D funding and contracts recorded in the federal research data base B_f.dat by the Austrian ministries in 2017. The database for recording research funding and contracts (B_f.dat) for the federal government has been in place since 1975, and was set up as a "documentation of facts by the federal government" in the then Federal Ministry of Science and Research. 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 the Federal Law Gazette I No. 131/2015. The last more far-reaching adaptation took place in 2008 with the migration to a database to which all ministerial departments have access and in which they all enter their research-related funding and contracts independently. 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.[1] The B_f.dat database is not used for recording payments made. Instead, it is a documentation database which also records some contextual information on the R&D projects. With regard to the relevant reporting year, the database makes a distinction between ongoing and completed R&D projects, their overall funding volume and actual funds paid in the reporting year, thereby providing a current picture of the number of projects and of project financing.

The data in the B-f.dat reveals that the total funding for the 455 R&D projects currently ongoing or completed in the reporting year amounts to around €439.97 million in 2017, with €403.24 million (92%) of this already paid out in this year. Approximately 85% of the funds for 2017 are paid out as global funding to research institutions[2]. Funding amounting to €67.64 million remains once this global funding for institutions is excluded from the partial amounts paid. Compared to 2016 this means an increase of €4.06 million. It should be noted that the amount of funding for each reporting year generally relates to partial amounts for an ongoing or a completed project which may be subject to annual fluctuations depending on the respective progress of the project.

When a distinction is made according to the main location of the applicants, then Vienna continues to be the federal Austrian state with by far the largest share in both R&D funds paid out (78.1%) as well as ongoing and completed projects (69.5%). Around 8.2% of amounts go abroad, predominantly in the form of member contributions. Two projects were attributed to the state of Burgenland in 2017 with a total of €20,615 paid out in R&D funds, while Vorarlberg (as in 2016) had no ongoing or completed projects documented.[3]

1 Link to the database: www.bmbwf.gv.at/bfdat-public
2 The data takes into account funding for institutions at amounts of more than €500,000 in each case.
3 No project was allocated to the regional government of Vorarlberg in 2017.

Fig. 9-1: Share of R&D projects and partial amounts in 2017 by contractor's main location (in %)



Note: including "major" global financing for research institutions and the Austrian Science Fund (FWF). Burgenland had two ongoing or completed projects in 2017 (0.005% of the partial amounts).

Source: Federal Ministry of Education, Science and Research (BMBWF), Federal research database B_f.dat. Date: 11 April 2018.

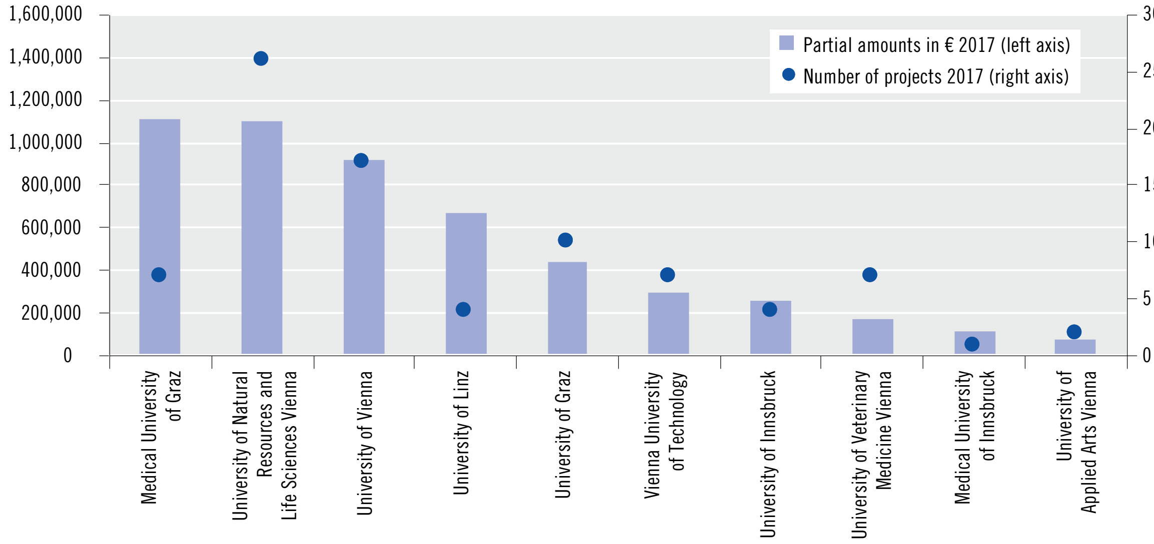
The number of ongoing or completed projects with universities as contractors continues to decline, with 97 projects currently in progress (2016: 108), as does the volume of funds disbursed, at € 5.12 million (2016: €5.46 million). This means the number of projects at universities corresponds with 21.3% of the total ongoing and completed projects and 1.2% of the paid funds. The Medical University of Graz has the highest sum of partial amounts (€423,868.77), but is significantly behind the University of Natural Resources and Life Sciences and the University of Vienna in terms of the number of projects. The partial amounts and the number of projects per university generally differ between the two reporting years, so the same universities cannot always gain projects that are equivalent in size or quantity.

The shares broken down by field of science have remained relatively constant over the years. As in the previous year the natural sciences feature the greatest share of funds paid out (19.8%; 2016: 19.7%), while the social sciences predominate in terms of the number of ongoing and completed R&D projects (35.1%; 2015: 33.8%).

As in 2016, the Federal Ministry of Science, Research and Economy (BMWFW) will continue to account for the largest share of current and paid projects and financing contributions in 2017.[4] The Federal Ministry of Science, Research and Economy (BMWFW) accounts for 42.2% of the projects (excluding global financing), followed by the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) with 14.7% and the Federal Ministry of Labour, Social Affairs and Consumer Protection (BMASK) with 10.8%. The greatest portion of the total financing volume of these projects (76.5%) was also attributed to the Federal Ministry of Science, Research and Economy (BMWFW) as client. The reason the

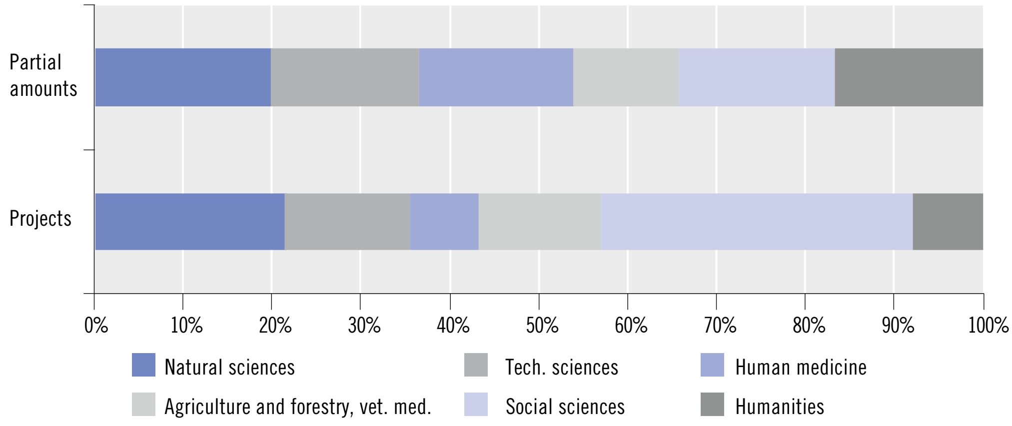
4 Some projects may be counted twice as a result of combined projects between ministries.

Fig. 9-2: Partial amounts and projects by selected universities, 2017



Source: Federal Ministry of Education, Science and Research (BMBWF), Federal research database B_f.dat. Date: 11 April 2018.

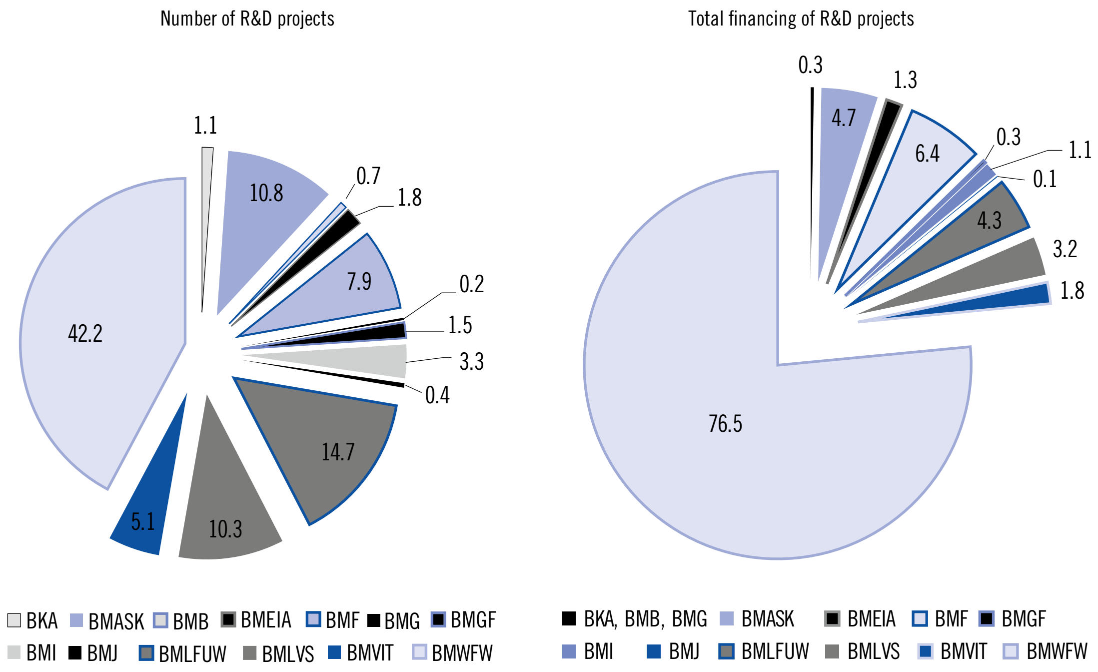
Fig. 9-3: Partial amounts and projects by fields of science (in %), 2017



Note: including "major" global financing for research institutions and the Austrian Science Fund (FWF).

Source: Federal Ministry of Education, Science and Research (BMBWF), Federal research database B_f.dat. Date: 11 April 2018.

Fig. 9-4: R&D projects by number and total financing amounts by ministerial department (in %), 2017



Note: excl. "major" global financing with funding amounts higher than €500,000.

Source: Federal Ministry of Education, Science and Research (BMBWF), Federal research database B_f.dat. Date: 11 April 2018.

Federal Ministry for Transport, Innovation and Technology (BMVIT) had a comparatively small percentage (1.8%) was that most of the R&D funds were outsourced to the Austrian Research Promotion Agency (FFG) and the Austria Wirtschaftsservice (aws).

The annual documentation of the research funding and research contracts by the federal government shows the projects in the reporting year which have been newly awarded or are ongoing or completed, with the titles, contractors, funding contributions, scientific classifications, contract and completion dates classified according to the awarding party, and this can be found on the Federal Ministry of Education, Science and Research's website.[5]

5 Link to the publications: http://www.bmbwf.gv.at/bfdat-jb

10 Statistics

1. Financing of gross domestic expenditure on R&D (Tables 1 and 2)[1]

According to an estimate by Statistics Austria, around € 12.3 billion are expected to be spent in Austria in 2018 on research and experimental development (R&D). Austria's research intensity, the indicator that represents gross domestic expenditure for R&D as a percentage of nominal gross domestic product (GDP), will increase to 3.19%. The research intensity will thus be slightly above the levels of 2017 (3.16%) and 2016 (3.15%) and significantly higher than in 2015 (3.05%). From 2017 to 2018, the research expenditure is expected to increase by 5.6%, i.e. faster than nominal GDP (+4.9%). The R&D intensity has been above the 3% level targeted by the EU by 2020 since 2014, but below the Austrian target value of 3.76%. In ten-year intervals, the research intensity in Austria has risen sharply: the figure was still at 2.57% in 2008 and only 1.73% in 1998. At around €6.11 billion (+6.8% compared to 2017), domestic firms will finance the majority of R&D in Austria. Around €1.95 billion is expected to come from abroad for research, mainly from multinational firms conducting research in Austria. The government will finance research with €4.2 billion in 2018. This is 4.3% more than in 2017, slightly below the forecast increase in nominal gross domestic product of 4.9%. Almost €3.56 billion (+4.1% compared to 2017) is to be borne by the federal government (including research tax premiums and R&D funds from the National Foundation for Research, Technology and Development), and around €526 million by the regional governments. Other public institutions – such as municipalities, chambers or social security institutions – will contribute around €117 million. R&D funding from the private non-profit sector will amount to around €71 million.

Of the total €12.3 billion in R&D expenditure in 2018, around half (49.5%) will be financed by Austrian business enterprises, 34.1% by the government and 15.8% will come from abroad. The share of the private non-profit sector will be around 0.6%.

In an EU comparison for 2016 (the most recent year with EU comparative data), Austria ranks second behind Sweden (3.25%) and ahead of Germany (2.94%), Denmark (2.87%) and Finland (2.75%). The only other countries that are also above the EU average of 2.03% are Belgium (2.49%) and France (2.25%).

Further international comparative data are available for 2015: Switzerland achieved the highest research intensity in Europe this year at 3.37 %. South Korea (4.23%), Japan (3.29%) and the US (2.79%) also achieved a high research in-

1 Each year, Statistics Austria creates a "Total estimate of the gross domestic expenditure for R&D" 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 total estimate, any necessary retroactive revisions or updates are made, reflecting the latest data. They present, using the definitions of the Frascati Manual which are globally valid (OECD, EU) and thus guarantee international comparability, the financing of the expenditures for research and experimental development that was carried out in Austria. According to these definitions and guidelines, foreign financing of R&D done in Austria is included, although Austrian payments for R&D performed abroad are excluded (domestic concept).

tensity in 2015. China's research intensity was at 2.07% also slightly above that of the EU (2.04% in 2015).

2. Federal R&D expenditure in 2018

2.1. The federal expenditure shown in Table 1 for R&D carried out in Austria in 2018 is composed as described below. According to the methodology of the R&D global estimate, the core item is the total amount of R&D financed by the federal government in Austria on the basis of the draft of the federal budget appropriation 2018 (March 2018). The estimate also includes, according to the information currently available, the funds that should be paid out in 2018 by the National Foundation for Research, Technology, and Development, as well as the estimates of the 2018 payout for research tax premiums (Source: Federal Ministry of Finance in each case).

2.2. In addition to its expenditures for R&D in Austria, in 2018 the federal government will pay **contributions to international organisations** aimed at research and the promotion of research amounting to €104.7 million (based on the budget appropriation draft 2018; March 2018) but which will not be included in Austria's gross domestic expenditure on R&D in accordance with the domestic concept.

2.3. In the tables "Federal expenditure on research and research promotion", the total research-related expenditure of the federal government, which include the research-related shares of the contribution payments to international organisations (see Pt. 2.2 above), were evaluated on the basis of the draft of the federal budget appropriation 2018 (as of March 2018). These correspond to the "GBARD"-Konzept[2] used by the OECD and the EU, which refers primarily to the budgets of the central and federal states, in contrast to the domestic concept, which includes research-relevant contributions to international organisations and forms the basis for the classification of R&D budget data according to socio-economic objectives for reporting to the EU and OECD.

In 2018 the following socio-economic objectives receive the largest portions of federal expenditure on research and research promotion:

- Promotion of general knowledge advancement: 31.1%
- Promotion of trade, commerce, and industry: 24.6%
- Promotion of the health care system: 21.2%
- Promotion of social and socio-economic development: 4.7%
- Promotion of research covering the earth, the seas, the atmosphere and space: 4.7%
- Promotion of energy production, storage and distribution 3.9%

3. R&D expenditure of the regional governments

The research financing by the Austrian government as collated in Table 1 is listed from the state 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.

4. Comprehensive R&D survey 2015

In addition to the observations in Section 1.2.1, Tables 12 to 17 provide an overview of the amount of funding and personnel devoted to research and experimental development (R&D) that was recorded by Statistics Austria among all institutions in all economic sectors that promote R&D, in the course of the comprehensive 2015 survey.

2 GBARD: Government Budget Allocations for Research and Development.

5. An international comparison of 2015 R&D expenditure

The overview in Table 18 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 2017-2).

6 Austria's participation in the European Framework Programmes

Tables 19 through 22 provide an overview of Austria's participation in the European Framework Programmes for research and development.

7. Research funding by the Austrian Science Fund (FWF)

Tables 23 and 24 provide detailed information about the funding of projects in Austrian Science Fund (FWF) projects.

8. Funding by the Austrian Research Promotion Agency (FFG)

Tables 25 to 27 provide detailed information on funding approvals by the Austrian Research Promotion Agency (FFG).

9. The Austria Wirtschaftsservice (aws) technology programmes

Tables 28 through 30 show an overview of disbursed funding under the auspices of the Austria Wirtschaftsservice (aws) technology programmes.

10. Christian Doppler Research Agency

Tables 31 to 34 depict the status and historical development of the CD laboratories and the "Josef Ressel Centres (JR-Centres)" support programme for universities of applied sciences that was set up in 2013.

List of Tables in the Statistical Annex

Table 1: R&D global estimate for 2018: Gross domestic expenditure on R&D Financing of research and experimental development carried out in Austria in 2004–2018

Financing	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1. Gross domestic expenditure on R&D (in € millions)	**5,249.55**	**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**	**11,133.23**	**11,679.31**	**12,336.88**
of which financed by:															
Federal government [1])	1,462.02	1,764.86	1,772.06	1,916.96	2,356.78	2,297.46	2,586.43	2,614.29	2,984.27	2,852.68	3,086.03	3,036.19	3,353.01	3,418.41	3,559.29
Regional governments [2])	207.88	330.17	219.98	263.18	354.35	273.37	405.17	298.71	416.31	307.45	461.59	344.97	445.78	498.78	525.76
Business enterprise sector [3])	2,475.55	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	5,385.03	5,719.15	6,110.68
Abroad [4])	1,016.61	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	1,782.17	1,865.93	1,953.63
Other [5])	87.49	96.32	106.20	113.04	115.83	132.97	137.86	140.77	147.99	155.19	162.33	158.08	167.24	177.04	187.52
2. Nominal GDP [6](in € billions)	242.35	254.08	267.82	283.98	293.76	288.04	295.90	310.13	318.65	323.91	333.06	344.49	353.30	369.22	387.29
3. Gross domestic expenditure on R&D as a % of GDP	***2.17***	***2.37***	***2.36***	***2.42***	***2.57***	***2.60***	***2.73***	***2.67***	***2.91***	***2.95***	***3.09***	***3.05***	***3.15***	***3.16***	***3.19***

As at: 19 April 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) 2004, 2006, 2007, 2009, 2011, 2013, 2015: Survey results (federal government including the Austrian Science Fund (FWF), Austrian Research Promotion Agency (FFG)).
2005, 2008, 2010, 2012: Annex T of the Federal Finances Acts (in each case Part b, Outlays); 2014: Federal Finances Act 2016, Detailed overview of research-related appropriation of federal funds (Part b, Outlays).
2016-2018: Based on the draft of the Budget appropriation 2018 (March 2018).
2005: including €84.4 million National Foundation for Research, Technology and Development and €121.3 million research tax premiums.
2008: including €91.0 million National Foundation for Research, Technology and Development and €340.6 million research tax premiums.
2010: including €74.6 million National Foundation for Research, Technology and Development and €328.8 million research tax premiums.
2012: including €51.3 million National Foundation for Research, Technology and Development and €574.1 million research tax premiums.
2014: including €38.7 million National Foundation for Research, Technology and Development and €493.2 million research tax premiums.
2016: including €51.7 million National Foundation for Research, Technology and Development and €527.7 million research tax premiums.
2017: including €48.2 million National Foundation for Research, Technology and Development and €585.6 million research tax premiums.
2018: including €140.7 million National Foundation for Research, Technology and Development and an expected €610.0 million research tax premiums (Source: Federal Ministry of Finance (BMF), based on the currently available information).

2) 2004, 2006, 2007, 2009, 2011, 2013, 2015: survey results. 2005, 2008, 2010, 2012, 2014, 2016-2018: Based on the R&D expenditure reported by the state government offices.

3) 2004, 2006, 2007, 2009, 2011, 2013, 2015: survey results. 2005, 2008, 2010, 2012, 2014, 2016-2018: Estimates made by Statistics Austria.

4) 2004, 2006, 2007, 2009, 2011, 2013, 2015: survey results. 2005, 2008, 2010, 2012, 2014, 2016-2018: Estimates made by Statistics Austria.

5) Financing by local governments (excluding Vienna), chambers, social insurance institutions and other public financing and from the private non-profit sector.
2004, 2006, 2007, 2009, 2011, 2013, 2015: survey results. 2005, 2008, 2010, 2012, 2014, 2016-2018: Estimates made by Statistics Austria.

6) 2004–2017: Statistics Austria, as of March 2018. 2018: Austrian Institute of Economic Research (WIFO), economic forecast March 2018.

Table 2: R&D global estimate for 2018: Gross domestic expenditure on R&D financing of research and experimental development carried out in Austria in 2004–2018 as a % of GDP

Financing	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gross domestic expenditure on R&D as a % of GDP	***2.17***	***2.37***	***2.36***	***2.42***	***2.57***	***2.60***	***2.73***	***2.67***	***2.91***	***2.95***	***3.09***	***3.05***	***3.15***	***3.16***	***3.19***
of which financed by:															
Federal government [1])	0.60	0.69	0.66	0.68	0.80	0.80	0.87	0.84	0.94	0.88	0.93	0.88	0.95	0.93	0.92
Regional governments [2])	0.09	0.13	0.08	0.09	0.12	0.09	0.14	0.10	0.13	0.09	0.14	0.10	0.13	0.14	0.14
Business enterprise sector [3])	1.02	1.08	1.14	1.18	1.18	1.22	1.23	1.23	1.33	1.44	1.47	1.52	1.52	1.55	1.58
Abroad [4])	0.42	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
Other [5])	0.04	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
2. Nominal GDP [6](in € billions)	**242.35**	**254.08**	**267.82**	**283.98**	**293.76**	**288.04**	**295.90**	**310.13**	**318.65**	**323.91**	**333.06**	**344.49**	**353.30**	**369.22**	**387.29**

As at: 19 April 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

Footnotes see Table 1.

Table 3: Federal expenditure on research and research promotion, 2015 – 2018

Ministerial department[1]	Outlays				Financing budgeted			
	2015[2]		2016[3]		2017[3]		2018[3]	
	in € millions	in %	in € millions	in %	in € millions	in %	in € millions	in %
Federal Chancellery (BKA)[4]	35.686	*1.3*	40.289	*1.4*	40.981	*1.4*	44.255	*1.5*
Federal Ministry for Family and Youth (BMFJ)	0.886	*0.0*	1.095	*0.0*	1.620	*0.1*	.	.
Federal Ministry of Civil Service and Sports (BMÖDS)	.	.	.	.	.	.	-	-
Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA)	1.718	*0.1*	2.152	*0.1*	2.198	*0.1*	2.765	*0.1*
Federal Ministry of Labour, Social Affairs and Consumer Protection (BMASK)	6.484	*0.2*	5.747	*0.2*	6.511	*0.2*	.	.
Federal Ministry for Health (BMG)	5.669	*0.2*	.	.	.	.	.	.
Federal Ministry of Health and Women's Affairs	.	.	5.764	*0.2*	6.982	*0.2*	.	.
Federal Ministry of Labour, Social Affairs, Health and Consumer Protection (BMASGK)	.	.	.	.	.	.	12.860	*0.4*
Federal Ministry for Education and Women's Affairs (BMBF)	38.098	*1.4*	.	.	.	.	.	.
Federal Ministry of Education (BMB)	.	.	39.927	*1.4*	36.224	*1.3*	.	.
Federal Ministry of Science, Research and Economy (BMWFW)	2,107.858	*76.9*	2,213.521	*77.0*	2,208.008	*77.5*	.	.
Federal Ministry of Education, Science and Research	.	.	.	.	.	.	2,197.742	*75.5*
Federal Ministry for Digital and Economic Affairs (BMDW)	.	.	.	.	.	.	101.120	*3.5*
Federal Ministry of Finance (BMF)	30.490	*1.1*	30.683	*1.1*	31.843	*1.1*	32.307	*1.1*
Federal Ministry of the Interior (BMI)	1.135	*0.0*	1.234	*0.0*	1.309	*0.0*	1.447	*0.0*
Federal Ministry of Defence and Sports (BMLVS)	1.972	*0.1*	2.352	*0.1*	3.800	*0.1*	.	.
Federal Ministry of Defence (BML)	.	.	.	.	.	.	4.684	*0.2*
Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW)	44.637	*1.6*	44.373	*1.5*	43.942	*1.5*	.	.
Federal Ministry for Sustainability and Tourism (BMNT)	.	.	.	.	.	.	38.948	*1.3*
Federal Ministry of Justice (BMJ)	0.017	*0.0*	0.082	*0.0*	0.040	*0.0*	.	.
Federal Ministry of Constitutional Affairs, Reforms, Deregulation and Justice (BMVRDJ)	.	.	.	.	.	.	0.019	*0.0*
Federal Ministry for Transport, Innovation and Technology (BMVIT)	470.194	*17.1*	488.487	*17.0*	470.862	*16.5*	477.134	*16.4*
Total	**2744.844**	***100.0***	**2,875.706**	***100.0***	**2854.320**	***100.0***	**2,913.281**	***100.0***

As at: March 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) In accordance with the applicable version of the Act Governing Federal Ministries of 1986 (2015: Federal Law Gazette I No. 11/2014; 2016, 2017: Federal Law Gazette I No. 49/2016); 2018: Federal Law Gazette I No. 164/2017).

2) Federal Finances Act 2017, Detailed overview of research-related appropriation of federal funds.

3) Based on the draft of the Budget appropriation 2018 (March 2018).

4) Including the highest executive bodies.

Table 4: Detailed overview of research-related appropriation of federal funds, 2016 – 2018

Federal spending on research from 2016 to 2018 by ministry

The following tables for the years 2016 to 2018 are broken down according to

- Contributions from federal funds to international organisations whose goals include research and the promotion of research (Part a)
- Other federal spending on research and research promotion (Part b, federal research budget)

This list has been drawn up primarily in consideration of research effectiveness, as based on the research concept defined by the Frascati manual of the OECD. This concept is also used by Statistics Austria as a benchmark in carrying out surveys of research and experimental development (R&D).

Detailübersicht Forschungswirksame Mittelverwendungen des Bundes	Finanzierungsvoranschlag 2018		Finanzierungsvoranschlag 2017		Erfolg 2016	
	Insgesamt	Forschung	Insgesamt	Forschung	Insgesamt	Forschung
	Mio. €					
Teil a [1])	116,652	104,696	113,867	101,098	118,415	102,062
Teil b [2])	6.410,094	2.808,585	6.508,002	2.753,222	6.923,272	2.773,644
Insgesamt	**6.526,746**	**2.913,281**	**6.621,869**	**2.854,320**	**7.041,687**	**2.875,706**

Stand: März 2018 **Quelle: Bundesministerium für Finanzen**

[1]) Beitragszahlungen an internationale Organisationen, die Forschung und Forschungsförderung (mit) als Ziel haben. -
[2]) Inlandsausgaben des Bundes für Forschung und Forschungsförderung (Bundesbudget Forschung).

BUNDESVORANSCHLAG 2018

Detailübersicht Forschungswirksame Mittelverwendungen des Bundes

(Beträge in Millionen Euro)

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a) Beitragszahlungen an internationale Organisationen - Finanzierungsvoranschlag

VA-Stelle	Konto	Ugl	Bezeichnung	Anm	Finanzierungsvoranschlag 2018			Finanzierungsvoranschlag 2017			Erfolg 2016		
					Insgesamt	hievon %	hievon Forschung	Insgesamt	hievon %	hievon Forschung	Insgesamt	hievon %	hievon Forschung
			Bundeskanzleramt										
			UG10										
10010100	7800	100	Mitgliedsbeiträge an Institutionen im Ausland		0,113	100	0,113	0,194	100	0,194	0,178	100	0,178
10010100	7800	101	Mitgliedsbeitrag für OECD			20		3,675	20	0,735	3,726	20	0,745
10010100	7800	102	OECD-Energieagentur (Mitgliedsbeitrag)			20		0,220	20	0,044	0,222	20	0,044
10010100	7800	103	OECD-Beiträge zu Sonderprojekten			20		0,010	20	0,002		20	
10010100	7800	110	Mitgliedsbeitrag AV-Infostelle		0,032	5	0,002	0,030	5	0,002	0,030	5	0,002
10010200	7800	100	Mitgliedsbeiträge an Institutionen im Ausland		0,006	30	0,002	0,006	30	0,002	0,006	30	0,002
			Summe UG10		**0,151**		**0,117**	**4,135**		**0,979**	**4,162**		**0,971**
			Summe Bundeskanzleramt		**0,151**		**0,117**	**4,135**		**0,979**	**4,162**		**0,971**
			BM für Europa, Integration und Äußeres										
			UG12										
12020200	7800	101	Mitgliedsbeitrag für OECD	*	3,115	20	0,623						
12020200	7800	102	OECD-Energieagentur (Mitgliedsbeitrag)	*	0,225	20	0,045						
12020200	7840	000	Laufende Transfers an Drittländer	*	3,144	35	1,100	3,190	35	1,117	3,419	35	1,197
12020200	7840	002	Organisation der VN für industr.Entwicklung(UNIDO)		0,605	46	0,278	0,695	46	0,320	0,793	46	0,365
12020200	7840	003	Org. VN Erziehung,Wissensch.u.Kultur(UNESCO)		2,131	30	0,639	2,270	30	0,681	1,965	30	0,590
12020200	7840	056	Drogenkontrollprogramm der VN (UNDCP)		0,400	20	0,080	0,400	20	0,080		20	
			Summe UG12		**9,620**		**2,765**	**6,555**		**2,198**	**6,177**		**2,152**
			Summe BM für Europa, Integration und Äußeres		**9,620**		**2,765**	**6,555**		**2,198**	**6,177**		**2,152**
			BM für Finanzen										
			UG15										
15010100	7800	000	Laufende Transferzahlungen an das Ausland		0,151	100	0,151				0,100	100	0,100
			Summe UG15		**0,151**		**0,151**				**0,100**		**0,100**
			Summe BM für Finanzen		**0,151**		**0,151**				**0,100**		**0,100**
			BM für Bildung, Wissenschaft und Forschung										
			UG30										
30010300	7800	104	OECD-Schulbauprogramm		0,031	100	0,031	0,031	100	0,031	0,023	100	0,023
30010400	7800	000	Laufende Transferzahlungen an das Ausland	*	0,037	100	0,037	0,090	100	0,090	0,004	100	0,004
			Summe UG30		**0,068**		**0,068**	**0,121**		**0,121**	**0,027**		**0,027**
			UG31										
31030100	7800	000	Laufende Transferzahlungen an das Ausland		0,750	100	0,750	0,500	100	0,500	0,488	100	0,488
31030100	7800	066	Forschungsvorhaben in internationaler Kooperation		0,802	100	0,802	1,152	100	1,152	0,289	100	0,289
31030100	7800	200	Beiträge an internationale Organisationen		1,570	50	0,785	1,730	50	0,865	1,300	50	0,650
31030204	7800	062	ESO		6,520	100	6,520	6,350	100	6,350	5,965	100	5,965
31030204	7800	063	Europ. Zentrum für mittelfristige Wettervorhersage		1,300	100	1,300	1,260	100	1,260	1,197	100	1,197
31030204	7800	064	Molekularbiologie - Europäische Zusammenarbeit		2,900	100	2,900	3,077	100	3,077	2,903	100	2,903

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31030204	7800	065	World Meteorological Organisation	0,400	50	0,200	0,520	50	0,260	0,488	50	0,244
31030204	7800	200	Beiträge an internationale Organisationen	0,840	50	0,420	0,825	50	0,413	0,803	50	0,402
31030204	7800	242	Beitrag für die CERN	23,700	100	23,700	23,700	100	23,700	21,118	100	21,118
			Summe UG31	**38,782**		**37,377**	**39,114**		**37,577**	**34,551**		**33,256**
			Summe BM für Bildung, Wissenschaft und Forschung	**38,850**		**37,445**	**39,235**		**37,698**	**34,578**		**33,283**
			BM für Digitalisierung und Wirtschaftsstandort									
			UG40									
40020100	7800	100	Mitgliedsbeiträge an Institutionen im Ausland	0,900	11	0,099	1,000	11	0,110	0,974	11	0,107
			Summe UG40	**0,900**		**0,099**	**1,000**		**0,110**	**0,974**		**0,107**
			Summe BM für Digitalisierung und Wirtschaftsstandort	**0,900**		**0,099**	**1,000**		**0,110**	**0,974**		**0,107**
			BM für Verkehr, Innovation und Technologie									
			UG34									
34010100	7800	200	Beiträge an internationale Organisationen	0,050	100	0,050	0,060	100	0,060	0,046	100	0,046
34010100	7800	600	ESA-Pflichtprogramme	17,900	100	17,900	17,900	100	17,900	17,891	100	17,891
34010100	7800	601	EUMETSAT	9,580	100	9,580	9,600	100	9,600	7,465	100	7,465
34010100	7800	602	OECD-Energieagentur	0,010	100	0,010	0,070	100	0,070			
34010100	7800	603	ESA-Wahlprogramme	34,364	100	34,364	30,364	100	30,364	33,633	100	33,633
34010100	7830	000	Laufende Transfers an Drittländer	0,220	100	0,220	0,130	100	0,130	0,221	100	0,221
			Summe UG34	**62,124**		**62,124**	**58,124**		**58,124**	**59,256**		**59,256**
			UG41									
41010100	7800	200	Beiträge an internationale Organisationen	0,180	6	0,011	0,180	6	0,011	0,108	6	0,006
41020100	7800	200	Beiträge an internationale Organisationen	0,020	100	0,020	0,021	100	0,021		100	
41020402	7800	200	Beiträge an internationale Organisationen	0,064	15	0,010	0,050	15	0,008	0,046	15	0,007
41020500	7800	200	Beiträge an internationale Organisationen	0,030	15	0,005	0,020	15	0,003	0,035	15	0,005
41020500	7830	000	Laufende Transfers an Drittländer	0,482	15	0,072	0,482	15	0,072	0,459	15	0,069
41020601	7800	200	Beiträge an internationale Organisationen	0,050	50	0,025	0,050	50	0,025	0,035	50	0,018
41020700	7800	200	Beiträge an internationale Organisationen	0,585	20	0,117	0,570	20	0,114	0,557	20	0,111
			Summe UG41	**1,411**		**0,260**	**1,373**		**0,254**	**1,240**		**0,216**
			Summe BM für Verkehr, Innovation und Technologie	**63,535**		**62,384**	**59,497**		**58,378**	**60,496**		**59,472**
			BM für Nachhaltigkeit und Tourismus									
			UG42									
42010100	7800	100	Mitgliedsbeiträge an Institutionen im Ausland	0,020	50	0,010	0,020	50	0,010	0,006	50	0,003
42020202	7800	080	FAO-Beiträge	3,400	50	1,700	3,400	50	1,700	6,897	50	3,449
42020202	7800	081	FAO Welternährungsprogramm, Beiträge		50			50		5,000	50	2,500
42020202	7800	083	Int. Vertrag für pflanzengenetische Ressourcen	0,025	100	0,025	0,025	100	0,025	0,025	100	0,025
			Summe UG42	**3,445**		**1,735**	**3,445**		**1,735**	**11,928**		**5,977**
			Summe BM für Nachhaltigkeit und Tourismus	**3,445**		**1,735**	**3,445**		**1,735**	**11,928**		**5,977**
			Teil a -Summe	**116,652**		**104,696**	**113,867**		**101,098**	**118,415**		**102,062**

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b) Bundesbudget Forschung - Finanzierungsvoranschlag
(ausgen. die bereits im Abschnitt a) ausgewiesen sind)

VA-Stelle	Konto	Ugl	Bezeichnung	Anm	Finanzierungsvoranschlag 2018			Finanzierungsvoranschlag 2017			Erfolg 2016		
					Insgesamt	hievon %	hievon Forschung	Insgesamt	hievon %	hievon Forschung	Insgesamt	hievon %	hievon Forschung
			Parlamentsdirektion										
			UG02										
02010500	7330	086	Nationalfonds für Opfer des Nationalsozialismus	*	3,726	2	0,075	3,723	5	0,186	3,500	3	0,105
			Summe UG02		**3,726**		**0,075**	**3,723**		**0,186**	**3,500**		**0,105**
			Summe Parlamentsdirektion		**3,726**		**0,075**	**3,723**		**0,186**	**3,500**		**0,105**
			Bundeskanzleramt										
			UG10										
10010100	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,002	28	0,001	0,522	50	0,261	0,792	28	0,222
10010100	7270	000	Werkleistungen durch Dritte		0,672	4	0,027	2,711	4	0,108	1,782	4	0,071
10010200			Zentralstelle	*				2,114	100	2,114			
10010200	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,001	50	0,001	0,001	50	0,001	0,001	50	0,001
10010200	7270	000	Werkleistungen durch Dritte		9,386	4	0,375	7,380	4	0,295	2,430	4	0,097
10010401	7340	001	Pauschalabgeltung gem. § 32 Abs.5 BStatG		50,891	1	0,509	50,891	1	0,509	50,557	1	0,506
10010402			Österr. Staatsarchiv		14,865	3	0,446	14,897	1	0,149	13,929	3	0,418
			Summe UG10		**75,817**		**1,359**	**78,516**		**3,437**	**69,491**		**1,315**
			UG25										
25010500	7270	006	Werkleistungen durch Dritte (zw)		0,732	61	0,447	1,073	48	0,515	0,755	40	0,302
25010500	7420	113	Familie und Beruf Management GesmbH.		2,140	33	0,706	2,140	33	0,706	2,140	34	0,728
25010500	7664	007	Forschungsförderung gem. § 39i FLAG 1967 (zw)					0,100	100	0,100			
25020100	7270	000	Werkleistungen durch Dritte		0,947	1	0,009	1,100	11	0,121	1,002	3	0,030
25020200	7270	000	Werkleistungen durch Dritte		1,787	2	0,036	1,782	10	0,178	1,732	2	0,035
			Summe UG25		**5,606**		**1,198**	**6,195**		**1,620**	**5,629**		**1,095**
			UG32										
32010300			Denkmalschutz		38,343	18	6,902	38,343	18	6,902	33,195	18	5,975
32030100			Bundesmuseen		128,162	27	34,604	128,162	23	29,477	118,233	27	31,923
			Summe UG32		**166,505**		**41,506**	**166,505**		**36,379**	**151,428**		**37,898**
			Summe Bundeskanzleramt		**247,928**		**44,063**	**251,216**		**41,436**	**226,548**		**40,308**
			BM für Inneres										
			UG11										
11010200	7270	900	Werkleistungen durch Dritte	*	0,012	100	0,012	0,012	100	0,012	0,013	100	0,013
11020600			Bundeskriminalamt	*	14,182	8	1,135	15,836	8	1,267	12,888	8	1,031
11020800	7270	900	Werkleistungen durch Dritte	*				0,030	100	0,030	0,030	100	0,030
11030100	7672	009	Projekte des AMIF (Kofinanzierung)								0,078	100	0,078
11040100	7270	900	Werkleistungen durch Dritte	*							0,073	100	0,073
11040200	7281	311	ISF-P Sonstige Werkleistungen (EU/zw)	*							0,009	100	0,009
			Summe UG11		**14,194**		**1,147**	**15,878**		**1,309**	**13,091**		**1,234**
			UG18										
18010100	7660	900	Zuschüsse f. lfd. Aufwand an private Institutionen	*	0,017	100	0,017						
18010100	7672	009	Projekte des AMIF (Kofinanzierung)	*	0,283	100	0,283						
			Summe UG18		**0,300**		**0,300**						
			Summe BM für Inneres		**14,494**		**1,447**	**15,878**		**1,309**	**13,091**		**1,234**
			BM für Verfassung, Reformen, Deregulierung und Justiz										
			UG13										
13010100	7271	900	Werkleistungen (durch Dritte)	*	0,038	50	0,019	0,045	50	0,023	0,095	50	0,048
13030101	7271	900	Werkleistungen (durch Dritte)	*				0,033	50	0,017	0,068	50	0,034
			Summe UG13		**0,038**		**0,019**	**0,078**		**0,040**	**0,163**		**0,082**
			Summe BM für Verfassung, Reformen, Deregulierung und Justiz		**0,038**		**0,019**	**0,078**		**0,040**	**0,163**		**0,082**

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			BM für Landesverteidigung										
			UG14										
14010100	7270	000	Werkleistungen durch Dritte								0,049	58	0,028
14010100	7270	900	Werkleistungen durch Dritte								1,252	100	1,252
14010202			Heeresgeschichtliches Museum								7,033	15	1,055
14020100	4691	000	Versuche und Erprobungen auf kriegstechn. Gebiet								0,166	10	0,017
14040100			Heeresgeschichtliches Museum	*	3,479	15	0,522	2,926	20	0,585			
14050100	7270	000	Werkleistungen durch Dritte	*	0,258	58	0,150	0,700	58	0,406			
14050100	7270	900	Werkleistungen durch Dritte	*	1,000	100	1,000	2,800	100	2,800			
14050100	7411	028	FFG - Verteidigungsforschung		3,000	100	3,000						
14050202	4691	000	Versuche und Erprobungen auf kriegstechn. Gebiet		0,120	10	0,012	0,090	10	0,009			
			Summe UG14		**7,857**		**4,684**	**6,516**		**3,800**	**8,500**		**2,352**
			Summe BM für Landesverteidigung		**7,857**		**4,684**	**6,516**		**3,800**	**8,500**		**2,352**
			BM für Finanzen										
			UG15										
15010100	6430	001	Arbeiten des WIIW		0,829	50	0,415	0,790	50	0,395	0,789	50	0,395
15010100	6430	002	Arbeiten des WSR		1,371	50	0,686	1,371	50	0,686	1,371	50	0,686
15010100	6430	003	Arbeiten des Wifo		4,167	52	2,167	4,085	50	2,043	4,000	50	2,000
15010100	7270	000	Werkleistungen durch Dritte	*	1,444	18	0,260	1,415	100	1,415			
15010100	7661	002	Institut für Finanzwissenschaft und Steuerrecht										
15010100	7662	002	Institut für höhere Studien und wiss. Forschung		3,600	56	2,016	3,574	50	1,787	3,547	53	1,880
15010100	7663	005	Forum Alpbach										
15010100	7666	020	Europ.Zentrum f. Wohlfahrtspolit. u. Sozialforsch.								0,030	100	0,030
15010100	7669	020	Sonstige Förderungsbeiträge	*	0,300	100	0,300	0,093	100	0,093	0,325	35	0,114
			Forschungswirksamer Lohnnebenkostenanteil		26,312	100	26,312	25,424	100	25,424	25,478	100	25,478
			Summe UG15		**38,023**		**32,156**	**36,752**		**31,843**	**35,540**		**30,583**
			Summe BM für Finanzen		**38,023**		**32,156**	**36,752**		**31,843**	**35,540**		**30,583**
			BM für Arbeit, Soziales, Gesundheit und Konsumentenschutz										
			UG20										
20010101	7340	302	Überweisung an das AMS gem. § 41 (2) (zw)	*	471,610	1	4,716	469,612	1	3,992	439,610	1	3,448
20010201	7270	006	Werkleistungen durch Dritte (zw)	*	335,145		0,503	374,498		0,749	418,116		0,331
20010201	7668	901	Nicht einzeln anzuführende Subventionen (zw)	*							119,278		0,200
			Summe UG20		**806,755**		**5,219**	**844,110**		**4,741**	**977,004**		**3,979**
			UG21										
21010100	7270	000	Werkleistungen durch Dritte		5,927	3	0,178	3,282	3	0,098	2,782	5	0,139
21010300	7270	000	Werkleistungen durch Dritte		0,894	16	0,143	0,876	16	0,140	0,744	16	0,119
21010300	7660	900	Zuschüsse f. lfd. Aufwand an private Institutionen		3,094	2	0,062	3,596	2	0,072	2,452	2	0,049
21010400	7262	001	Beitrag Europ. Zentrum Wohlfahrtspol.u.Sozialfor.		0,587	50	0,294	0,587	50	0,294	0,587	50	0,294
21010400	7270	000	Werkleistungen durch Dritte		2,153	4	0,086	2,300	4	0,092	1,327	7	0,093
21010400	7270	304	Werkleistungen EU-SILC		1,128	100	1,128	1,074	100	1,074	1,074	100	1,074
			Summe UG21		**13,783**		**1,891**	**11,715**		**1,770**	**8,966**		**1,768**
			UG24										
24010100			Zentralstelle					1,232	100	1,232			
24010200	7420	012	Transferzahlungen, Ernährungsagentur (Ges.m.b.H)		49,878	11	5,487	49,878	11	5,487	49,878	11	5,487
24030100	7270	000	Werkleistungen durch Dritte		4,004	4	0,160	3,975	4	0,159	1,154	12	0,138
24030200	7270	000	Werkleistungen durch Dritte		5,165	2	0,103	5,204	2	0,104	4,649	3	0,139
			Summe UG24		**59,047**		**5,750**	**60,289**		**6,982**	**55,681**		**5,764**
			Summe BM für Arbeit, Soziales, Gesundheit und Konsumentenschutz		**879,585**		**12,860**	**916,114**		**13,493**	**1.041,651**		**11,511**
			BM für Bildung, Wissenschaft und										

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			Forschung										
			UG30										
30010400			Qualitätsentwicklung und -steuerung	*	41,277	8	3,302	45,936	8	3,675	33,168	8	2,653
30010400	7340	000	Transferzahlungen an sonst. Träger öffentl.Rechtes		0,247	100	0,247	0,001	100	0,001	5,296	100	5,296
30010400	7340	003	Basisabgeltung (BIFIE)		11,600	80	9,280	12,000	80	9,600	13,000	80	10,400
30010500			Lehrer/innenbildung		226,192	10	22,619	221,204	10	22,120	212,014	10	21,201
30020700			Zweckgebundene Gebarung Bundesschulen	*	7,967	3	0,239	23,558	3	0,707	11,677	3	0,350
			Summe UG30		**287,283**		**35,687**	**302,699**		**36,103**	**275,155**		**39,900**
			UG31										
31010100			Zentralstelle und Serviceeinrichtungen		56,761	20	11,352	56,969	20	11,394	53,902	20	10,780
31020100			Universitäten		3.244,194	49	1.589,655	3.239,461	48	1.554,941	3.206,372	49	1.571,122
31020100	7270	000	Werkleistungen durch Dritte		0,330	49	0,162	0,330	48	0,158	0,150	49	0,074
31020100	7353	440	Klinischer Mehraufwand (Klinikbauten)		62,149	50	31,075	62,149	50	31,075	32,617	50	16,309
31020200			Fachhochschulen		305,443	14	42,762	294,633	15	44,195	284,110	14	39,775
31020300	7270	900	Werkleistungen durch Dritte		2,432	22	0,535	2,468	22	0,543	2,431	22	0,535
31030100			Projekte und Programme	*	14,198	100	14,198	12,866	100	12,866	11,905	100	11,905
31030100	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,001	100	0,001	0,001	100	0,001		100	
31030100	7270	034	Ersatzmethoden zum Tierversuch		0,370	100	0,370	0,370	100	0,370	0,142	100	0,142
31030100	7270	900	Werkleistungen durch Dritte		7,393	100	7,393	7,665	100	7,665	6,481	100	6,481
31030100	7662	311	Institut für höhere Studien und wiss. Forschung		0,400	100	0,400	0,400	100	0,400	0,300	100	0,300
31030100	7665	007	Stiftung Dokumentationsarchiv		0,405	100	0,405	0,405	100	0,405	0,280	100	0,280
31030100	7679	120	Lfd. Transfers an sonstige juristische Personen		25,191	100	25,191	26,019	100	26,019	18,075	100	18,075
31030201			Zentralanstalt für Meteorologie und Geodynamik		24,167	37	8,942	25,670	37	9,498	23,837	37	8,820
31030202			Geologische Bundesanstalt		11,637	47	5,469	11,481	47	5,396	10,945	47	5,144
31030204			Forschungsinstitutionen	*	9,454	100	9,454	8,158	100	8,158	7,672	100	7,672
31030204	7270	031	Med Austron		1,600	100	1,600	1,600	100	1,600	0,282	100	0,282
31030204	7332	352	FWF Programme		181,000	100	181,000	163,900	100	163,900	178,789	100	178,789
31030204	7332	452	FWF Geschäftsstelle		12,000	100	12,000	11,100	100	11,100	10,700	100	10,700
31030204	7340	004	ISTA		51,300	100	51,300	53,500	100	53,500	51,619	100	51,619
31030204	7340	006	ÖAW Globalbudget		113,362	100	113,362	103,065	100	103,065	102,180	100	102,180
31030204	7340	010	ÖAW Beauftragungen und Programme		8,828	100	8,828	9,125	100	9,125	6,889	100	6,889
31030204	7348	900	Universitäten - Sonstige Tranferzahlungen		1,135	49	0,556	1,075	48	0,516	1,041	49	0,510
31030204	7661	022	Ludwig-Boltzmann-Gesellschaft		7,600	100	7,600	7,600	100	7,600	8,090	100	8,090
31030204	7679	007	Verein der Freunde der Salzburger Stiftung		1,000	100	1,000	1,000	100	1,000	1,000	100	1,000
31030204	7679	008	Inst. für die Wissenschaften vom Menschen			100		0,750	100	0,750	0,750	100	0,750
			Summe UG31		**4.142,350**		**2.124,610**	**4.101,760**		**2.065,240**	**4.020,559**		**2.058,223**
			Summe BM für Bildung, Wissenschaft und Forschung		**4.429,633**		**2.160,297**	**4.404,459**		**2.101,343**	**4.295,714**		**2.098,123**
			BM für Digitalisierung und Wirtschaftsstandort										
			UG33										
33010100			Kooperation Wissenschaft-Wirtschaft		37,000	100	37,000	40,000	100	40,000	50,102	100	50,102
33010200			Innovation, Technologietransfer		44,496	100	44,496	44,591	100	44,591	51,839	100	51,839
33010300			Gründung innovativer Unternehmen		19,525	100	19,525	20,100	100	20,100	19,584	100	19,584
			Summe UG33		**101,021**		**101,021**	**104,691**		**104,691**	**121,525**		**121,525**
			UG40										
40020100	7270	000	Werkleistungen durch Dritte					6,338	3	0,190	2,213	5	0,111
40020100	7660	900	Zuschüsse f. lfd. Aufwand an private Institutionen								1,653	6	0,099
40030100			Eich- und Vermessungswesen	*				83,586		0,200	83,528		0,200
			Summe UG40					**89,924**		**0,390**	**87,394**		**0,410**
			Summe BM für Digitalisierung		**101,021**		**101,021**	**194,615**		**105,081**	**208,919**		**121,935**

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			und Wirtschaftsstandort										
			BM für Verkehr, Innovation und Technologie										
			UG34										
34010200	7340	100	Rat f. Forschung und Technologieentwicklung		1,800	100	1,800	1,800	100	1,800	1,800	100	1,800
34010200	7413	001	Austrian Institute of Technology AIT-Förderungen		0,010	100	0,010		100		0,034	100	0,034
34010200	7413	002	Austrian Institute of Technology AIT		55,100	90	49,590	50,658	90	45,592	50,792	90	45,713
34010200	7413	003	Nuclear Engineering Seibersdorf NES		10,430	30	3,129	10,550	30	3,165	3,800	30	1,140
34010200	7413	004	Silicon Austria		12,500	100	12,500						
34010200	7414	001	Austria Tech - Förderungen			100			100			100	
34010200	7414	002	Austria Tech		1,400	100	1,400	1,400	100	1,400	1,142	100	1,142
34010200	7660	075	F&T-Förderung		0,300	100	0,300	0,300	100	0,300	0,252	100	0,252
34010200	7661	030	Österreichische Computergesellschaft		0,040	100	0,040	0,075	100	0,075	0,069	100	0,069
34010200	7662	341	Joanneum Research Forsch.ges.m.b.H(Techn.schwerp)		2,350	100	2,350	2,350	100	2,350	2,461	100	2,461
34010200	7663	104	Gesellschaft für Mikroelektronik			100		0,030	100	0,030		100	
34010200	7666	005	Österreichisches Institut für Nachhaltigkeit		0,030	100	0,030	0,045	100	0,045	0,050	100	0,050
34010200	7667	006	Sonstige gemeinnützige Einrichtungen		1,610	100	1,610	2,490	100	2,490	1,809	100	1,809
34010200	7668	040	Salzburg Research		0,410	100	0,410	0,300	100	0,300	0,402	100	0,402
34010200	7668	050	Profactor		0,500	100	0,500	0,500	100	0,500	0,455	100	0,455
34010200	7690	002	Preisverleihungen		0,010	100	0,010	0,010	100	0,010	0,004	100	0,004
34010300	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,160	100	0,160	0,006	100	0,006	0,160	100	0,160
34010300	7270	000	Werkleistungen durch Dritte		5,500	100	5,500	5,000	100	5,000	5,757	100	5,757
34010300	7280	030	FTI-Projekte, Beauftragungen an Dritte		1,700	100	1,700	2,265	100	2,265	1,452	100	1,452
34010300	7330	352	Translational research (F&E)		0,095	100	0,095	0,950	100	0,950	0,940	100	0,940
34010300	7330	652	Fonds wissensch./Programmabw.		0,005	100	0,005	0,250	100	0,250	0,504	100	0,504
34010300	7411	001	FFG - Basisprogramme		95,000	100	95,000	126,052	100	126,052	100,000	100	100,000
34010300	7411	002	FFG - FTI-Programme, Förderungen		147,905	100	147,905	126,798	100	126,798	181,612	100	181,612
34010300	7411	003	FFG - FTI-Programme (F&E-Dienstleist.,Sonst.WV)		10,000	100	10,000	15,000	100	15,000	11,748	100	11,748
34010300	7411	004	FFG - Administrative Kosten		16,700	100	16,700	14,500	100	14,500	13,902	100	13,902
34010300	7412	001	Austria Wirtschaftsservice GmbH AWS - Förderungen		13,373	100	13,373	10,950	100	10,950	4,764	100	4,764
34010300	7412	002	Austria Wirtschaftsservice GmbH AWS			100			100			100	
34010300	7412	003	Austria Wirtschaftsservice GmbH AWS - Admin.Kost.		0,250	100	0,250	0,150	100	0,150	0,225	100	0,225
34010300	7432	030	FTI-Projekte, Förderungen		0,350	100	0,350	0,200	100	0,200	0,347	100	0,347
34010300	7480	002	Technologieschwerpunkte (Unternehmungen)			100			100			100	
34010300	7680	030	FTI-Projekte, Förderungen an phys. Pers.			100			100		0,008	100	0,008
			Summe UG34		**377,528**		**364,717**	**372,629**		**360,178**	**384,489**		**376,750**
			UG41										
41010200	7330	080	Transferzahlungen an Klima- und Energiefonds	*	47,000	95	44,650	47,000	100	47,000	51,500	95	48,925
41020100	7270	000	Werkleistungen durch Dritte		1,726	50	0,863	1,726	50	0,863	1,312	40	0,525
41020100	7270	800	Elektromobilität		0,400	60	0,240	0,200	60	0,120	0,012	80	0,010
41020100	7270	801	E-Mobilität für alle: Urbane Elektromobilität		0,001	20		0,001	20				
41020100	7411	002	FFG - FTI-Programme, Förderungen		1,000	100	1,000	2,000	100	2,000	1,500	100	1,500
41020100	7411	003	FFG - FTI-Programme (F&E-Dienstleist.,Sonst.WV)		0,010	100	0,010	0,200	100	0,200			
41020100	7411	004	FFG - Administrative Kosten		0,010	100	0,010	0,100	100	0,100			
41020100	7480	501	Progr.Kombinierter Güterverk.Straße-Schiene-Schiff		3,300	50	1,650	3,300	50	1,650	1,597	50	0,799
41020100	7660	000	Zuschüsse f. lfd. Aufwand an private		1,030	95	0,979	0,049	95	0,047	0,005	95	0,005

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			Institutionen										
41020100	7668	055	Technisches Museum Wien		0,601	80	0,481	0,301	80	0,241	0,110	80	0,088
41020300	7270	000	Werkleistungen durch Dritte								0,255	80	0,204
41020300	7411	002	FFG - FTI-Programme, Förderungen		0,001	50	0,001	0,001	50	0,001			
41020300	7411	004	FFG - Administrative Kosten		0,001	50	0,001	0,001	50	0,001	0,061	50	0,031
41020300	7489	001	Breitbandinitiative (admin. Aufwand)		0,001	50	0,001	0,001	50	0,001			
41020300	7489	002	Breitband - Förderungen		0,001	50	0,001	0,001	50	0,001			
41020402	7270	000	Werkleistungen durch Dritte		1,159	5	0,058	0,613	5	0,031	0,336	5	0,017
41020402	7270	006	Werkleistungen durch Dritte (zw)		1,750	5	0,088	1,003	5	0,050	3,212	5	0,161
			Summe UG41		**57,991**		**50,033**	**56,497**		**52,306**	**59,900**		**52,265**
			Summe BM für Verkehr, Innovation und Technologie		**435,519**		**414,750**	**429,126**		**412,484**	**444,389**		**429,015**
			BM für Nachhaltigkeit und Tourismus										
			UG42										
42010100			Zentralstelle	*	0,200	100	0,200	0,200	100	0,200	0,241	100	0,241
42010200	7411	000	Lfd Transfers an verbundene Unternehmungen	*	37,303	33	12,310	37,303	33	12,310	37,302	33	12,310
42020300			Forschung und Sonstige Maßnahmen	*	2,000	100	2,000	1,797	100	1,797	1,632	100	1,632
42020401			Landwirtschaftliche Schulen	*	43,731	21	9,184	46,366	21	9,737	45,092	21	9,469
42020402			Landwirtschaftliche Hochschule		5,100	3	0,153	4,757	3	0,143	4,623	3	0,139
42020403			Landwirtschaftliche Bundesanstalten		3,152	60	1,891	3,188	66	2,104	3,186	60	1,912
42020405			HBLA u. Forschungsanst. f. Landw. Ernähr., Lebensm.- u. Biotechn. Tirol		4,633	1	0,046	4,419	1	0,044	4,462	1	0,045
42020501			HBLA für Wein- und Obstbau Klosterneuburg		10,700	30	3,210	11,093	37	4,104	11,017	30	3,305
42020502			Bundesamt für Weinbau		4,950	3	0,149	5,030	3	0,151	5,086	3	0,153
42030101	7270	000	Werkleistungen durch Dritte		0,268	20	0,054	0,268	20	0,054	0,343	20	0,069
42030104			Forschung und Sonstige Maßnahmen Forst	*	0,400	100	0,400	1,124	100	1,124	0,800	100	0,800
42030204	7270	000	Werkleistungen durch Dritte	*	0,010	100	0,010	1,040	8	0,083	0,455	8	0,036
42030205			Bundesamt für Wasserwirtschaft		6,900	25	1,725	5,330	25	1,333	4,831	25	1,208
			Summe UG42		**119,347**		**31,332**	**121,915**		**33,184**	**119,070**		**31,319**
			UG43										
43010200	7700	500	Investitionszuschüsse		44,621	1	0,446	46,868	1	0,469	61,749	1	0,617
43010300			Klima- und Energiefonds		37,400	12	4,488	37,720	12	4,526	37,820	12	4,538
43010500			Nachhaltiger Natur- und Umweltschutz	*	35,806	1	0,358	27,826	12	3,339	45,494	1	0,455
43010500	7270	080	Forschungsaufwendungen		0,140	100	0,140	0,240	100	0,240	0,238	100	0,238
43010500	7420	021	Transferzahlungen an die UBA Ges.m.b.H		14,956	3	0,449	14,956	3	0,449	14,956	3	0,449
43020200	7700	500	Investitionszuschüsse	*							19,600		0,080
43020300	7700	251	Investitionsförderungen (zw)	*							346,330		0,700
			Summe UG43		**132,923**		**5,881**	**127,610**		**9,023**	**526,187**		**7,077**
			Summe BM für Nachhaltigkeit und Tourismus		**252,270**		**37,213**	**249,525**		**42,207**	**645,257**		**38,396**
			Teil b -Summe		**6.410,094**		**2.808,585**	**6.508,002**		**2.753,222**	**6.923,272**		**2.773,644**
			Gesamtsumme Teil a + b		**6.526,746**		**2.913,281**	**6.621,869**		**2.854,320**	**7.041,687**		**2.875,706**

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BUNDESVORANSCHLAG 2018

Detailübersicht Forschungswirksame Mittelverwendungen des Bundes

Anmerkungen

Allgemeine Anmerkungen

*) F& E Koeffizienten geschätzt

Die Detailübersicht Foschungswirksame Mittelverwendung des Bundes:

a) Beitragszahlungen aus Bundesmitteln an internationale Organisationen, die Forschung und Forschungsförderung (mit) als Ziel haben,

b) Bundesbudget-Forschung - Finanzierungsvorschlag (ausgen. die bereits im Abschnitt a) ausgewiesen sind)

Für die Aufstellung dieser Ausgaben ist in erster Linie der Gesichtspunkt der Forschungswirksamkeit maßgebend, der inhaltlich über den Aufgabenbereich 99 "Grundlagen-, angewandte Forschung und experimentelle Entwicklung" hinausgeht und auf dem Forschungsbegriff des Fascati-Handbuches der OECD beruht, wie er im Rahmen der forschungsstatistischen Erhebungen der STATISTIK AUSTRIA zur Anwendung gelangt.

Forschungswirksame Anteile bei den Bundesausgaben finden sich daher nicht nur bei den Ausgaben des Aufgabenbereiches 99 "Grundlagen-, angewandte Forschung und experimentelle Entwicklung" sondern auch in zahlreichen anderen Aufgabenbereichen.

Finanzierungsvoranschlag

VA-Stelle	Konto	Ugl	Anmerkung
			Parlamentsdirektion
02010500	7330	086	Die gemeldete Forschungsquote beträgt 3,1 % anstatt 3 % (System läßt keine Prozentsätze zu).
			Bundeskanzleramt
10010200			Teilbetrag der Voranschlagsstelle.
			BM für Inneres
11010200	7270	900	*) Teilbetrag der Voranschlagsstelle.
11020600			* Teilbetrag
11020800	7270	900	*) Teilbetrag der Voranschlagsstelle.
11040100	7270	900	*) Teilbetrag der Voranschlagsstelle.
11040200	7281	311	Im Erfolg 2016 ist es ein Teilbetrag der VA-Stelle.
18010100	7660	900	*) Aufgrund einer Budgetstrukturänderung wurde die Voranschlagsstelle 11030100 ab 2018 in die Voranschlagsstelle 18010100 überführt.
			*) Teilbetrag der Voranschlagsstelle.
18010100	7672	009	*) Teilbetrag der Voranschlagsstelle.
			BM für Europa, Integration und Äußeres
12020200	7840	000	Beiträge an die IAEO (Internationale Atomenergieorganisation) zur Förderung der internationalen Bemühungen um nukleare Sicherheit und Nichtverbreitung von Kernwaffen sowie zum Atomstopp.
12020200	7800	101	*) BMG-Novelle
12020200	7800	102	*) BMG-Novelle
			BM für Verfassung, Reformen, Deregulierung und Justiz
13010100	7271	900	*) Studie zum "Umgang mit Misshandlungsvorwürfen gegen Exekutivbedienstete" (Auftragnehmer:ALES) Auftragsvolumen 2018: 50.158 Euro + Studie des Instituts für Konfliktforschung zum Thema "Schutz der sexuellen Integrität" davon 2018: 38.250 Euro
13030101	7271	900	*) Studie De-Radikalisierung im Gefängnis (inkl. der ursprünglich für 2017 vorgesehenen zweiten Rate).
			BM für Landesverteidigung
14040100			*) Teilbetrag (eigene Fistl);
14050100	7270	900	*) Teilbetrag der Voranschlagsstelle.
14050100	7270	000	*) Teilbetrag der Voranschlagsstelle.
			BM für Finanzen
15010100	7669	020	*) Teilbetrag der Voranschlagsstelle.
15010100	7270	000	*) Teilbetrag der Voranschlagsstelle.
			BM für Arbeit, Soziales, Gesundheit und Konsumentenschutz
20010101	7340	302	*) Forschungsanteil liegt bei 0,85 % (System rundet auf 1%)
20010201	7270	006	*) Forschungsanteil liegt bei 0,15 % (System rundet auf 0).
20010201	7668	901	der Prozentsatz betr. 0,17 %
			BM für Bildung, Wissenschaft und Forschung
30010400	7800	000	*) Teilbetrag der VA-Stelle.
30010400			Teilbetrag der Voranschlagsstelle
30020700			Teilbetrag der Voranschlagsstelle
31030100			*) Der Restbetrag ergibt sich rechnerisch bei dieser VA-Stelle.
31030204			*) Der Restbetrag ergibt sich rechnerisch bei dieser VA-Stelle.
			BM für Digitalisierung und Wirtschaftsstandort
40030100			*) Fixbetrag
			BM für Verkehr, Innovation und Technologie
41010200	7330	080	* KLIEN: ab 2016 werden bei dieser Post nur mehr F&E-Projekte finanziert; daher die Erhöhung von 39 auf 95 %.

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			BM für Nachhaltigkeit und Tourismus
42010100			*) PSP-Element 42P101010001, 42P101010002 und 42P101020002.
42010200	7411	000	Finanzstellen 90306 (AGES) und 90309 (BFW).
42020300			PSP-Element 42P101010001 und 42P10102002
42020401			*) Finanzstellen 22010 (Francisco-Josephinum), 22013 (Raumberg-Gumpenstein), 22016 (Gartenbau).
42030104			*) PSP-Element 42P101020002
42030204	7270	000	*) PSP-Element 42P10102003
43010500			*) Teilbetrag der VA-Stelle.
43020200	7700	500	*) Forschungsanteil ist unter 1% (0,3 %).
43020300	7700	251	*) Forschungsanteil ist unter 1% (0,2 %).

Ergebnisvoranschlag

VA-Stelle	Konto	Ugl	Anmerkung
			Keine Anmerkungen erfasst.

Table 5: Federal expenditure on research and research promotion by socio-economic objective, 2002–2018

Breakdown of Annex T of the Auxiliary Document and the Detailed overview of research-related appropriation of federal funds (Parts a and b) for the Federal Finances Acts

Reporting years		Total federal expenditure for R&D	of which												
			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
2002[1]	in € 1,000	1,466,695	94,112	85,313	243,301	26,243	42,459	16,604	315,345	97,860	45,204	11,153	21	12,579	476,501
	in %	*100.0*	*6.4*	*5.8*	*16.6*	*1.8*	*2.9*	*1.1*	*21.5*	*6.7*	*3.1*	*0.8*	*0.0*	*0.9*	*32.4*
2003[2]	in € 1,000	1,452,124	96,812	86,018	241,728	25,960	39,550	15,787	316,273	92,762	49,487	10,665	4	12,966	464,112
	in %	*100.0*	*6.7*	*5.9*	*16.6*	*1.8*	*2.7*	*1.1*	*21.8*	*6.4*	*3.4*	*0.7*	*0.0*	*0.9*	*32.0*
2004[3]	in € 1,000	1,537,890	84,670	61,182	308,316	25,716	41,489	10,846	362,961	73,670	41,336	13,260	163	15,724	498,557
	in %	*100.0*	*5.5*	*4.0*	*20.0*	*1.7*	*2.7*	*0.7*	*23.6*	*4.8*	*2.7*	*0.9*	*0.0*	*1.0*	*32.4*
2005[4]	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[5]	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[6]	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[7]	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[8]	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[9]	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[10]	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[11]	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[12]	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[13]	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[14]	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[15]	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[15]	in € 1,000	2,854,320	131,238	61,870	718,688	117,953	46,299	78,213	602,973	134,084	52,506	28,465	4,673	-	877,358
	in %	*100.0*	*4.6*	*2.2*	*25.2*	*4.1*	*1.6*	*2.7*	*21.1*	*4.7*	*1.8*	*1.0*	*0.2*	-	*30.8*
2018[15]	in € 1,000	2,913,281	136,418	60,767	715,383	114,696	62,444	78,956	618,734	136,410	50,159	28,963	5,573	-	904,778
	in %	*100.0*	*4.7*	*2.1*	*24.6*	*3.9*	*2.1*	*2.7*	*21.2*	*4.7*	*1.7*	*1.0*	*0.2*	-	*31.1*

As at: March 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) Annex T of the Auxiliary Document for the Federal Finances Act 2004, outlays. – 2) Annex T of the Auxiliary Document for the Federal Finances Act 2005, outlays. – 3) Annex T of the Auxiliary Document for the Federal Finances Act 2006, outlays. Revised data. – 4) Annex T of the Auxiliary Document for the Federal Finances Act 2007, outlays. – 5) Annex T of the Auxiliary Document for the Federal Finances Act 2008, outlays. Revised data. – 6) Annex T of the Auxiliary Document for the Federal Finances Act 2009, outlays. – 7) Annex T of the Auxiliary Document for the Federal Finances Act 2010, outlays. – 8) Annex T of the Auxiliary Document for the Federal Finances Act 2011, outlays. – 9) Annex T of the Auxiliary Document for the Federal Finances Act 2012, outlays. – 10) Annex T of the Auxiliary Document for the Federal Finances Act 2013 (financing proposal), outlays. Revised data. – 11) Annex T of the Auxiliary Document for the Federal Finances Act 2014 (financing proposal), outlays. – 12) Annex T of the Auxiliary Document for the Federal Finances Act 2015 (financing proposal), outlays. Revised data. – 13) Federal Finances Act 2016, Detailed overview of research-related appropriation of federal funds, outlays. – 14) Federal Finances Act 2017, Detailed overview of research-related appropriation of federal funds, outlays. Revised data. – 15) Based on the draft of the Budget appropriation 2018 (March 2018).

Table 6: Federal expenditure on research and research promotion by socio-economic objective and ministerial department, 2016[1]

Ministerial department		Total federal expenditure for R&D	of which											
			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	40,289	6,002	-	-	44	2	-	-	7,511	-	391	-	-	26,339
	in %	*100.0*	*14.9*	-	-	*0.1*	*0.0*	-	-	*18.6*	-	*1.0*	-	-	*65.4*
BMI	in € 1,000	1,234	-	-	-	-	-	-	-	1,234	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMB	in € 1,000	39,927	-	-	-	-	-	39,927	-	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	*100.0*	-	-	-	-	-	-	-
BMWFW	in € 1,000	2,213,521	96,821	28,280	481,602	26,550	21,996	41,497	553,033	103,481	28,604	25,792	1,313	-	804,552
	in %	*100.0*	*4.4*	*1.3*	*21.8*	*1.2*	*1.0*	*1.9*	*24.9*	*4.7*	*1.3*	*1.2*	*0.1*	-	*36.2*
BMASK	in € 1,000	5,747	-	-	-	-	-	-	-	5,747	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMGF	in € 1,000	5,764	-	-	-	-	-	-	5,764	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	*100.0*	-	-	-	-	-	-
BMEIA	in € 1,000	2,152	-	-	-	1,197	-	-	-	955	-	-	-	-	-
	in %	*100.0*	-	-	-	*55.6*	-	-	-	*44.4*	-	-	-	-	-
BMJ	in € 1,000	82	-	-	-	-	-	-	-	82	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMLVS	in € 1,000	2,352	-	-	-	-	-	-	-	-	-	-	1,297	-	1,055
	in %	*100.0*	-	-	-	-	-	-	-	-	-	-	*55.1*	-	*44.9*
BMF	in € 1,000	30,683	1,050	1,395	4,795	349	325	1,018	6,682	6,660	410	372	-	-	7,627
	in %	*100.0*	*3.4*	*4.5*	*15.6*	*1.1*	*1.1*	*3.3*	*21.8*	*21.7*	*1.3*	*1.2*	-	-	*25.0*
BMLFUW	in € 1,000	44,373	488	30,226	237	-	-	139	-	5,949	7,077	-	-	-	257
	in %	*100.0*	*1.1*	*68.2*	*0.5*	-	-	*0.3*	-	*13.4*	*15.9*	-	-	-	*0.6*
BMFJ	in € 1,000	1,095	-	-	-	-	-	-	-	1,095	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMVIT	in € 1,000	488,487	26,879	927	260,630	94,763	24,331	29	26,928	2,995	13,495	1,880	-	-	35,630
	in %	*100.0*	*5.5*	*0.2*	*53.3*	*19.4*	*5.0*	*0.0*	*5.5*	*0.6*	*2.8*	*0.4*	-	-	*7.3*
Total	**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***

As at: March 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) Based on the budget appropriation draft 2018 (March 2018). – 2) Including the highest executive bodies.

Table 7: Federal expenditure on research and research promotion by socio-economic objective and ministerial department, 2017[1]

Ministerial department		Total federal expenditure for R&D	of which											
			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 € 1,000	40,981	5,542	-	-	44	2	-	-	8,602	-	665	-	-	26,126
	in %	*100.0*	*13.5*	-	-	*0.1*	*0.0*	-	-	*21.0*	-	*1.6*	-	-	*63.8*
BMI	in € 1,000	1,309	-	-	-	-	-	-	-	1,309	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMB	in € 1,000	36,224	-	-	-	-	-	36,224	-	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	*100.0*	-	-	-	-	-	-	-
BMWFW	in € 1,000	2,208,008	96,841	27,989	464,474	26,639	21,769	40,819	563,624	102,438	28,184	25,552	1,458	-	808,221
	in %	*100.0*	*4.4*	*1.3*	*21.0*	*1.2*	*1.0*	*1.8*	*25.5*	*4.6*	*1.3*	*1.2*	*0.1*	-	*36.6*
BMASK	in € 1,000	6,511	-	-	-	-	-	-	-	6,511	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMGF	in € 1,000	6,982	-	-	-	-	-	-	6,982	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	*100.0*	-	-	-	-	-	-
BMEIA	in € 1,000	2,198	-	-	-	1,117	-	-	-	1,081	-	-	-	-	-
	in %	*100.0*	-	-	-	*50.8*	-	-	-	*49.2*	-	-	-	-	-
BMJ	in € 1,000	40	-	-	-	-	-	-	-	40	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMLVS	in € 1,000	3,800	-	-	-	-	-	-	-	-	-	-	3,215	-	585
	in %	*100.0*	-	-	-	-	-	-	-	-	-	-	*84.6*	-	*15.4*
BMF	in € 1,000	31,843	1,075	1,016	4,884	355	331	1,003	6,772	7,907	402	379	-	-	7,719
	in %	*100.0*	*3.4*	*3.2*	*15.3*	*1.1*	*1.0*	*3.1*	*21.3*	*24.9*	*1.3*	*1.2*	-	-	*24.2*
BMLFUW	in € 1,000	43,942	538	32,011	243	-	-	143	-	1,700	9,023	-	-	-	284
	in %	*100.0*	*1.2*	*72.9*	*0.6*	-	-	*0.3*	-	*3.9*	*20.5*	-	-	-	*0.6*
BMFJ	in € 1,000	1,620	-	-	-	-	-	-	-	1,620	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMVIT	in € 1,000	470,862	27,242	854	249,087	89,798	24,197	24	25,595	2,876	14,897	1,869	-	-	34,423
	in %	*100.0*	*5.8*	*0.2*	*52.9*	*19.1*	*5.1*	*0.0*	*5.4*	*0.6*	*3.2*	*0.4*	-	-	*7.3*
Total	**in € 1,000**	**2,854,320**	**131,238**	**61,870**	**718,688**	**117,953**	**46,299**	**78,213**	**602,973**	**134,084**	**52,506**	**28,465**	**4,673**	**-**	**877,358**
	in %	***100.0***	***4.6***	***2.2***	***25.2***	***4.1***	***1.6***	***2.7***	***21.1***	***4.7***	***1.8***	***1.0***	***0.2***	**-**	***30.8***

As at: March 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) Based on the budget appropriation draft 2018 (March 2018). – 2) Including the highest executive bodies.

Table 8: Federal expenditure on research and research promotion by socio-economic objective and ministerial department, 2018[1]

Ministerial deptartment		Total federal expenditure for R&D	of which												
			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 communica-tions	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	44,255	6,506	-	-	-	2	-	-	8,799	-	404	-	-	28,544
	in %	*100.0*	*14.7*	-	-	-	*0.0*	-	-	*19.9*	-	*0.9*	-	-	*64.5*
BMÖDS	in € 1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	in %	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMEIA	in € 1,000	2,765	-	-	-	1,145	-	-	-	1,620	-	-	-	-	-
	in %	*100.0*	-	-	-	*41.4*	-	-	-	*58.6*	-	-	-	-	-
BMASGK	in € 1,000	12,860	-	-	-	-	-	-	5,750	7,110	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	*44.7*	*55.3*	-	-	-	-	-
BMBWF	in € 1,000	2,197,742	99,644	28,614	365,985	27,052	22,255	77,767	580,601	105,318	28,954	26,167	1,411	-	833,974
	in %	*100.0*	*4.5*	*1.3*	*16.7*	*1.2*	*1.0*	*3.5*	*26.4*	*4.8*	*1.3*	*1.2*	*0.1*	-	*38.0*
BMDW	in € 1,000	101,120	-	-	101,120	-	-	-	-	-	-	-	-	-	-
	in %	*100.0*	-	-	*100.0*	-	-	-	-	-	-	-	-	-	-
BMF	in € 1,000	32,307	1,080	1,421	4,877	355	331	1,034	6,799	7,471	418	378	-	-	8,143
	in %	*100.0*	*3.3*	*4.4*	*15.1*	*1.1*	*1.0*	*3.2*	*21.0*	*23.1*	*1.3*	*1.2*	-	-	*25.3*
BMI	in € 1,000	1,447	-	-	-	-	-	-	-	1,447	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMLV	in € 1,000	4,684	-	-	-	-	-	-	-	-	-	-	4,162	-	522
	in %	*100.0*	-	-	-	-	-	-	-	-	-	-	*88.9*	-	*11.1*
BMNT	in € 1,000	38,948	697	29,920	230	-	-	153	-	1,700	5,881	-	-	-	367
	in %	*100.0*	*1.8*	*76.8*	*0.6*	-	-	*0.4*	-	*4.4*	*15.1*	-	-	-	*0.9*
BMVRDJ	in € 1,000	19	-	-	-	-	-	-	-	19	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMVIT	in € 1,000	477,134	28,491	812	243,171	86,144	39,856	2	25,584	2,926	14,906	2,014	-	-	33,228
	in %	*100.0*	*6.0*	*0.2*	*50.8*	*18.1*	*8.4*	*0.0*	*5.4*	*0.6*	*3.1*	*0.4*	-	-	*7.0*
Total	**in € 1,000**	**2,913,281**	**136,418**	**60,767**	**715,383**	**114,696**	**62,444**	**78,956**	**618,734**	**136,410**	**50,159**	**28,963**	**5,573**	**-**	**904,778**
	in %	***100.0***	***4.7***	***2.1***	***24.6***	***3.9***	***2.1***	***2.7***	***21.2***	***4.7***	***1.7***	***1.0***	***0.2***	**-**	***31.1***

As at: March 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) Based on the budget appropriation draft 2018 (March 2018). – 2) Including the highest executive bodies.

Table 9: General research-related university expenditure by the federal government ("General University Funds"), 2000–2018[1]

Years	General university funds	
	Total	R&D
	in million €	
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	3,325.605	1,609.839
2018	3,330.311	1,644.530

As at: March 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) 2000-2015: 1) Based on Annex T of the Auxiliary Document and the Detailed overview of research-related appropriation of federal funds for the Federal Finances Act. 2016-2018: Based on the draft of the Budget appropriation 2018 (March 2018).

Table 10: **Research promotion schemes and contracts awarded by the federal government in 2017, broken down by sector/ area of performance and awarding ministerial department**
Analysis of the federal research database [1] without "major" global financing [2]

Ministerial department	Partial amounts 2017	of which awarded to																				
		Higher education sector						Government sector					Private non-profit sector			Business enterprise sector						
		Universities (including teaching hospitals)	Art universities	Austrian Academy of Sciences	Universities of applied sciences	Other higher education sector [3]	Total	Federal institutions (outside of the higher education sector)	Private non-profit facilities mostly run on public financing	Ludwig Boltzmann Society	Other public sector [4]	Total	Private non-profit sector	Individual researchers	Total	Institutes' sub-sector ("Kooperativer Bereich") incl.competence centres (excluding AIT)	Austrian Institute of Technology GmbH – AIT	Company R&D sub-sector ("firmeneigener Bereich")	Total	Austrian Science Fund (FWF)	Austrian Forschungsförderungsgesellschaft mbH	Abroad
	in €	in %																				
BKA	156,437	38.4	-	-	-	-	38.4	-	22.4	-	-	22.4	-	-	-	-	-	39.2	39.2	-	-	-
BMASK	3,186,802	8.0	-	-	0.3	-	8.3	39.1	19.9	-	-	59.0	0.1	0.7	0.8	-	-	11.8	11.8	-	-	20.1
BMB	17,100	43.8	-	-	35.1	-	78.9	-	-	-	-	-	21.1	-	21.1	-	-	-	-	-	-	-
BMEIA	907,038	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	100.0	-	-	-
BMFJ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMF	4,309,951	0.3	-	-	-	-	0.3	30.2	18.2	-	-	48.4	0.0	2.4	2.4	-	-	7.1	7.1	-	39.5	2.3
BMG	7,920	100.0	-	-	-	-	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMGF	170,595	23.4	-	-	-	-	23.4	-	34.9	-	-	34.9	41.7	-	41.7	-	-	-	-	-	-	-
BMI	757,135	19.0	-	-	8.2	-	27.2	-	45.5	-	-	45.5	13.8	-	13.8	-	-	11.2	11.2	-	-	2.3
BMJ	54,500		-	-	-	-	-	-	100.0	-	-	100.0	-	-	-	-	-	-	-	-	-	-
BMLFUW	2,926,091	65.6	-	-	0.6	-	66.2	19.1	3.4	-	-	22.5	2.4	-	2.4	3.4	-	0.7	4.1	-	4.8	-
BMLVS	2,182,602	11.1	-	0.3	9.5	-	20.9	2.3	-	-	-	2.3	3.6	1.6	5.2	28.3	20.3	18.2	66.8	-	-	4.8
BMVIT	1,206,980	-	-	-	-	-	-	-	55.0	-	-	55.0	5.1	-	5.1	14.2	-	25.7	39.9	-	-	-
BMWFW	51,755,929	5.7	0.2	0.2	0.1	0.1	6.3	7.2	12.8	-	-	20.0	3.9	0.1	4.0	0.2	0.1	1.1	1.4	-	0.6	67.7
Total	**67,639,080**	**8.3**	**0.1**	**0.2**	**0.5**	**0.1**	**9,2**	**10.2**	**13.8**	**-**	**-**	**24.0**	**3.5**	**0.3**	**3.8**	**1.5**	**0.7**	**4.5**	**6.7**	**0.0**	**3.2**	**53.1**

As at: April 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1 Data as per: 29.03.2018.

2) i.e. excl. institutional financing with funding amounts higher than €500,000.

3) Private universities, pedagogical universities, testing agencies at technical federal colleges and other facilities categorised within the higher education sector.

4) State, local and chamber institutions as well as facilities of social insurance carriers.

Table 11: Research promotion schemes and contracts awarded by the federal government in 2017, broken down by socio-economic objective and awarding ministerial department

Analysis of the federal research database [1] without "major" global financing [2]

Ministerial department		Partial amounts 2017	of which											
			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	Funding of social and socio-economic development	Promotion of environmental protection	Funding of urban and physical planning	Promotion of national defence	Promotion of general knowledge advancement
BKA	in €	156,437	-	-	-	-	-	-	-	140,483	-	15,954	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*89.8*	-	*10.2*	-	-
BMASK	in €	3,186,802	-	-	21,864	-	-	-	-	3,162,438	-	-	-	2,500
	in %	*100.0*	-	-	*0.6*	-	-	-	-	*99.3*	-	-	-	*0.1*
BMB	in €	17,100	-	-	-	-	-	7,500	-	9,600	-	-	-	-
	in %	*100.0*	-	-	-	-	-	*43.9*	-	*56.1*	-	-	-	-
BMEIA	in €	907,038	-	-	-	-	-	-	-	907,038	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-
BMFJ	in €	-	-	-	-	-	-	-	-	-	-	-	-	-
	in %	-	-	-	-	-	-	-	-	-	-	-	-	-
BMF	in €	4,309,951	-	-	-	-	-	-	20,000	2,413,771	-	-	-	1,876,180
	in %	*100.0*	-	-	-	-	-	-	*0.5*	*56.0*	-	-	-	*43.5*
BMG	in €	7,920	-	7,920	-	-	-	-	-	-	-	-	-	-
	in %	*100.0*	-	*100.0*	-	-	-	-	-	-	-	-	-	-
BMGF	in €	170,595	-	-	-	-	-	-	-	170,595	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-
BMI	in €	757,135	-	-	-	-	30,063	-	62,000	641,443	-	-	-	23,629
	in %	*100.0*	-	-	-	-	*4.0*	-	*8.2*	*84.7*	-	-	-	*3.1*
BMJ	in €	54,500	-	-	-	-	-	-	-	44,500	-	-	-	10,000
	in %	*100.0*	-	-	-	-	-	-	-	*81.7*	-	-	-	*18.3*
BMLFUW	in €	2,926,091	260,710	1,698,825	103,634	65,643	-	-	256,157	136,535	300,173	-	-	104,414
	in %	*100.0*	*8.9*	*58.0*	*3.5*	*2.2*	-	-	*8.8*	*4.7*	*10.3*	-	-	*3.6*
BMLVS	in €	2,182,602	5,000	-	463,564	-	-	-	155,000	76,750	-	54,725	481,932	945,631
	in %	*100.0*	*0.2*	-	*21.2*	-	-	-	*7.1*	*3.5*	-	*2.5*	*22.1*	*43.4*
BMVIT	in €	1,206,980	-	-	652,012	49,000	107,841	-	-	92,061	-	-	-	306,066
	in %	*100.0*	-	-	*54.0*	*4.1*	*8.9*	-	-	*7.6*	-	-	-	*25.4*
BMWFW	in €	51,755,929	8,385,033	1,001	32,000	-	-	50,000	6,042,795	3,190,415	75,680	-	-	33,979,005
	in %	*100.0*	*16.2*	*0.0*	*0.1*	-	-	*0.1*	*11.7*	*6.2*	*0.1*	-	-	*65.6*
Total	**in €**	**67,639,080**	**8,650,743**	**1,707,746**	**1,273,074**	**114,643**	**137,904**	**57,500**	**6,535,952**	**10,985,629**	**375,853**	**70,679**	**481,932**	**37,247,425**
	in %	***100.0***	***12.8***	***2.5***	***1.9***	***0.2***	***0.2***	***0.1***	***9.7***	***16.2***	***0.6***	***0.1***	***0.7***	***55.0***

As at: April 2018

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1 Data as per: 29.03.2018.

2) i.e. excl. institutional financing with funding amounts higher than €500,000.

Table 12: Expenditure on research and experimental development (R&D), broken down by sector of performance and source of funds, 2006–2015

Sectors	2006		2007		2009		2011		2013		2015	
	in €1,000	in %	in €1,000	in %	in €1,000	in %	in €1,000	in %	in €1,000	in %	in €1,000	in %
Sectors of performance												
Total	**6,318,587**	**100.0**	**6,867,815**	**100.0**	**7,479,745**	**100.0**	**8,276,335**	**100.0**	**9,571,282**	**100.0**	**10,499,146**	**100.0**
Higher education sector [1]	1,523,160	24.1	1,637,277	23.8	1,951,845	26.1	2,117,553	25.6	2,327,754	24.3	2,468,207	23.5
Government sector[2]	330,232	5.2	367,300	5.3	399,093	5.3	425,222	5.1	424,885	4.4	481,113	4.6
Private non-profit sector[3]	16,519	0.3	17,377	0.3	35,905	0.5	40,719	0.5	40,223	0.4	51,338	0.5
Business enterprise sector	4,448,676	70.4	4,845,861	70.6	5,092,902	68.1	5,692,841	68.8	6,778,420	70.9	7,498,488	71.4
of which:												
Institutes' sub-sector ("kooperativer Bereich")[4]	428,492	6.8	468,219	6.8	482,719	6.5	625,650	7.6	763,758	8.0	825,002	7.9
Company R&D sub-sector ("firmeneigener Bereich")	4,020,184	63.6	4,377,642	63.7	4,610,183	61.6	5,067,191	61.2	6,014,662	62.9	6,673,486	63.5
Sources of funds												
Total	**6,318,587**	**100.0**	**6,867,815**	**100.0**	**7,479,745**	**100.0**	**8,276,335**	**100.0**	**9,571,282**	**100.0**	**10,499,146**	**100.0**
Public sector	2,071,310	32.8	2,260,857	32.9	2,661,623	35.6	3,014,526	36.4	3,269,850	34.2	3,484,951	33.2
Business enterprise sector	3,056,999	48.4	3,344,400	48.7	3,520,016	47.0	3,820,904	46.2	4,665,748	48.7	5,222,223	49.7
Private non-profit sector	26,928	0.4	32,316	0.5	42,179	0.6	39,236	0.5	45,473	0.5	54,286	0.5
Abroad	1,163,350	18.4	1,230,242	17.9	1,255,927	16.8	1,401,669	16.9	1,590,211	16.6	1,737,686	16.6
of which EU	103,862	1.6	101,094	1.5	111,470	1.5	150,259	1.8	180,660	1.9	198,351	1.9

Source: Statistics Austria. Survey of research and experimental development in 2015.

1) Universities including hospitals, art universities, the Austrian Academy of Sciences, testing institutes at technical federal colleges, universities of applied sciences, private universities and the University for Continuing Education Krems. Including pedagogical universities (since 2007). As of 2009 also includes other institutions attributable to the university sector. – 2) Federal institutions (not including those combined in the higher education sector), state, local government and chamber institutions, R&D institutions of the social insurance carriers, public sector-financed and/or controlled private non-profit institutions as well as R&D institutions of the Ludwig Boltzmann-Society; including regional hospitals. The regional hospitals were not surveyed by questionnaire, but instead Statistics Austria prepared an estimate of their R&D expenditures based on the reports of the offices of the provincial governments. – 3) Private non-profit institutions whose status is predominantly private or under civil law, sectarian or other non-public. – 4) Including The Austrian Institute of Technology GmbH and centres of excellence. – Rounding differences.

Table 13: Employees in research and experimental development (R&D), headcounts and full-time equivalents, by sector of performance/ survey area and occupation, 2015

Sectors, areas	Survey units performing R&D	Total	of which		
			Researchers	Technicians and equivalent	Other supporting staff
			Headcounts		
Total	**5,181**	**126,171**	**78,051**	**36,336**	**11,784**
1. Higher education sector	**1,265**	**47,562**	**36,699**	**6,815**	**4,048**
of which:					
1.1 Universities (without hospitals)[1]	1,031	34,352	26,168	4,985	3,199
1.2 University hospitals	87	5,865	4,294	979	592
1.3 Art universities	63	1,743	1,539	119	85
1.4 Academy of Sciences	31	1,672	1,440	225	7
1.5 Universities of applied sciences	24	2,333	1,850	383	100
1.6 Private universities	11	769	651	63	55
1.7 Pedagogical universities	15	334	317	15	2
1.8 Other higher education sector [2]	3	494	440	46	8
2. Government sector[3]	**250**	**6,632**	**3,747**	**1,270**	**1,615**
of which:					
2.1 Without regional hospitals	250	6,632	3,747	1,270	1,615
2.2 Regional hospitals	.	.	.	.	.
3. Private non-profit sector[4]	**55**	**969**	**621**	**253**	**95**
4. Business enterprise sector	**3,611**	**71,008**	**36,984**	**27,998**	**6,026**
of which:					
4.1 Institutes' sub-sector ("kooperativer Bereich")[5)]	61	8,490	5,077	2,296	1,117
4.2 Company R&D sub-sector ("firmeneigener Bereich")	3,550	62,518	31,907	25,702	4,909
			Full-time equivalents		
Total	**5,181**	**71,395.9**	**43,562.4**	**22,387.0**	**5,446.5**
1. Higher education sector	**1,265**	**17,682.1**	**13,657.7**	**2,537.3**	**1,487.1**
of which:					
1.1 Universities (without hospitals)[1]	1,031	13,252.6	10,116.7	1,883.7	1,252.1
1.2 University hospitals	87	1,654.6	1,111.1	383.3	160.3
1.3 Art universities	63	318.2	269.3	26.1	22.8
1.4 Academy of Sciences	31	932.6	823.1	105.0	4.4
1.5 Universities of applied sciences	24	869.8	736.7	109.5	23.6
1.6 Private universities	11	275.2	239.2	19.0	17.0
1.7 Pedagogical universities	15	74.4	72.5	1.8	0.1
1.8 Other higher education sector [2]	3	304.7	289.1	8.9	6.7
2. Government sector[3]	**250**	**2,673.5**	**1,682.1**	**395.8**	**595.6**
of which:					
2.1 Without regional hospitals	250	2,673.5	1,682,1	395.8	595.6
2.2 Regional hospitals	.	.	.	.	.
3. Private non-profit sector[4]	**55**	**506.6**	**350.3**	**116.9**	**39.4**
4. Business enterprise sector	**3,611**	**50,533.7**	**27,872.3**	**19,337.0**	**3,324.4**
of which:					
4.1 Institutes' sub-sector ("kooperativer Bereich")[5)]	61	5,336.0	3,548.4	1,110.0	677.6
4.2 Company R&D sub-sector ("firmeneigener Bereich")	3,550	45,197.7	24,323.9	18,227.0	2,646.8

Source: Statistics Austria. Survey of research and experimental development in 2015. Compiled on: 21 July 2017.

1) Including the University for Continuing Education Krems. – 2) Testing institutes at technical federal colleges as well as other programmes that can be attributed to the higher education sector (reported together to keep data confidential). – 3) Federal institutions (not including those combined in the higher education sector), state, local government and chamber institutions, R&D institutions of the social insurance carriers, public sector-financed and/or controlled private non-profit institutions as well as R&D institutions of the Ludwig Boltzmann-Society; without regional hospitals. The regional hospitals were not surveyed by questionnaire, but instead Statistics Austria prepared an estimate of the R&D expenditures based on the reports of the offices of the provincial governments. For this reason there is no data about employees in R&D. –- 4) Private non-profit institutions whose status is predominantly private or under civil law, sectarian, or other non-public. - 5) Including The Austrian Institute of Technology GmbH and competence centres. - Rounding differences

Table 14: Employees in research and experimental development (R&D) (in full-time equivalents) in all of the areas surveyed [1] broken down by state[2] and occupation, 2015

Regional governments	Survey units performing R&D	Full-time equivalents in R&D			
		Total	of which		
			Researchers	Technicians and equivalent	Other supporting staff
Austria	**5,181**	**71,395.9**	**43,562.4**	**22,387.0**	**5,446.5**
Burgenland	101	735.8	396.5	260.4	79.0
Carinthia	229	3,455.0	2,263.5	1,052.1	139.4
Lower Austria	580	6,289.9	3,269.6	2,602.3	417.9
Upper Austria	897	12,729.3	6,944.1	4,521.5	1,263.7
Salzburg	284	3,116.2	1,951.9	975.9	188.4
Styria	951	14,286.3	8,284.1	4,774.4	1,227.8
Tyrol	420	5,724.0	3,596.9	1,661.7	465.3
Vorarlberg	165	2,320.1	1,314.7	920.5	84.9
Vienna	1,554	22,739.2	15,541.1	5,618.2	1,580.0

Source: Statistics Austria. Survey of research and experimental development in 2015. Compiled on: 21 July 2017.

1) The regional hospitals were not surveyed by questionnaire, but instead Statistics Austria prepared an estimate of the R&D expenditures based on the reports of the offices of the provincial governments. For this reason there is no data about employees in R&D. – 2) The standard evaluation was performed based on the location of the institution or enterprise conducting R&D. – Rounding differences.

Table 15: Financing of expenditure for research and experimental development (R&D) by sector of performance/ survey area and promotion area, 2015

R&D performed in the sectors, areas	Survey units performing R&D	Total	Promotion areas								
			Business enterprise sector	Public sector					Private non-profit sector	Abroad incl. international organisations (without EU)	EU
				Total	Federal government[1]	Regional governments[2]	Local governments[2]	Other [1]			
		in €1,000									
Total[3]	**5,181**	**10,499,146**	**5,222,223**	**3,484,951**	**2,593,341**	**344,973**	**6,749**	**539,888**	**54,286**	**1,539,335**	**198,351**
1. Higher education sector	**1,265**	**2,468,207**	**130,595**	**2,165,070**	**1,794,956**	**65,518**	**1,993**	**302,603**	**34,556**	**45,410**	**92,576**
of which:											
1.1 Universities (without hospitals)[4]	1,031	1,847,703	89,945	1,652,266	1,375,396	32,431	1,287	243,152	12,280	28,973	64,239
1.2 University hospitals	87	270,424	13,550	239,102	212,628	3,517	13	22,944	2,213	9,538	6,021
1.3 Art universities	63	40,695	648	39,141	35,455	475	48	3,163	144	62	700
1.4 Academy of Sciences	31	135,330	4,706	118,768	103,281	614	-	14,873	901	2,390	8,565
1.5 Universities of applied sciences	24	90,642	13,097	66,878	35,996	18,982	627	11,273	4,738	1,437	4,492
1.6 Private universities	11	35,636	8,353	10,100	2	5,040	15	5,043	14,109	1,617	1,457
1.7 Pedagogical universities	15	8,746	296	8,013	7,768	175	3	67	42	23	372
1.8 Other higher education sector[5]	3	39,031	-	30,802	24,430	4,284	-	2,088	129	1,370	6,730
2. Government sector[6,3]	**250**	**481,113**	**29,059**	**418,916**	**163,183**	**228,947**	**3,522**	**23,264**	**4,209**	**7,100**	**21,829**
of which:											
2.1 Without regional hospitals	250	312,207	29,059	250,010	163,183	60,041	3,522	23,264	4,209	7,100	21,829
2.2 Regional hospitals	.	168,906	.	168,906	.	168,906	.	.	.	.	.
3. Private non-profit sector[7]	**55**	**51,338**	**10,197**	**2,933**	**523**	**426**	**30**	**1,954**	**12,473**	**20,537**	**5,198**
4. Business enterprise sector	**3,611**	**7,498,488**	**5,052,372**	**898,032**	**634,679**	**50,082**	**1,204**	**212,067**	**3,048**	**1,466,288**	**78,748**
of which:											
4.1 Institutes' sub-sector ("kooperativer Bereich")[8]	61	825,002	134,864	210,431	130,481	27,225	454	52,271	594	445,246	33,867
4.2 Company R&D sub-sector ("firmeneigener Bereich")	3,550	6,673,486	4,917,508	687,601	504,198	22,857	750	159,796	2,454	1,021,042	44,881

Source: Statistics Austria. Survey of research and experimental development in 2015. Compiled on: 7 August 2017.

1) The funds from the Austrian Research Promotion Fund and the R&D financing by the higher education sector are included under "Other". – 2) Regional governments including Vienna. Local governments without Vienna. –- 3) Number of survey units not including regional hospitals. 4) Including University for Continuing Education Krems. – 5) Testing institutes at technical federal colleges as well as other programmes that can be attributed to the higher education sector. – 6) Federal institutions (not including those combined in the higher education sector), state, local government and chamber institutions, R&D institutions of the social insurance carriers, public sector-financed and/or controlled private non-profit institutions as well as R&D institutions of the Ludwig Boltzmann Society; including regional hospitals. The regional hospitals were not surveyed by questionnaire, but instead Statistics Austria prepared an estimate of their R&D expenditures based on the reports of the offices of the provincial governments. – 7) Private non-profit institutions whose status is predominantly private or under civil law, sectarian or other non-public. – 8) Including The Austrian Institute of Technology GmbH and centres of excellence.

Table 16: Financing of expenditure on research and experimental development (R&D) in all survey areas[1], by state[2] and promotion area in 2015

Regional governments	Survey units performing R&D3)	Total	Promotion areas								
			Business enterprise sector	Public sector					Private non-profit sector	Abroad incl. international organisations (without EU)	EU
				Total	Federal govern-ment[4]	Regional govern-ments[5]	Local gov-ernments[5]	Other [4]			
		in €1,000									
Austria	**5,181**	**10,499,146**	**5,222,223**	**3,484,951**	**2,593,341**	**344,973**	**6,749**	**539,888**	**54,286**	**1,539,335**	**198,351**
Burgenland	101	80,685	56,303	16,173	7,730	5,913	-	2,530	-	7,324	885
Carinthia	229	632,019	268,248	124,812	87,282	20,149	304	17,077	463	230,646	7,850
Lower Austria	580	792,726	519,050	191,216	106,520	58,891	498	25,307	9,505	54,598	18,357
Upper Austria	897	1,789,135	1,323,589	321,159	218,080	33,770	1,501	67,808	2,013	130,216	12,158
Salzburg	284	384,846	234,345	135,902	103,027	12,883	783	19,209	2,813	6,483	5,303
Styria	951	2,067,335	794,432	666,011	492,844	58,838	1,456	112,873	2,294	568,794	35,804
Tyrol	420	975,090	477,183	370,863	289,272	36,207	331	45,053	5,023	109,598	12,423
Vorarlberg	165	295,903	242,477	45,322	22,984	14,850	522	6,966	81	7,240	783
Vienna	1,554	3,481,407	1,306,596	1,613,493	1,265,602	103,472	1,354	243,065	32,094	424,436	104,788

Source: Statistics Austria. Survey of research and experimental development in 2015. Compiled on: 7 August 2017.

1) Including R&D expenditure estimate for regional hospitals. – 2) The standard evaluation was performed by the headquarters of the R&D-operating institution or firm. – 3) Number of survey units not including regional hospitals. – 4) The funds from the Austrian Research Promotion Fund and the R&D financing by the higher education sector are included under "Other". 5) States including Vienna. Local governments without Vienna.

Table 17: Gross regional product (GRP), gross domestic expenditure on R&D and regional research intensity for 2015

Regions, regional governments (NUTS 1, NUTS 2)	Gross regional product ("regional GDP")[1]	Gross domestic expenditure on R&D [2]	
	in € millions	in € millions	as a % of GRP
Austria	**339,896**	**10,499.15**	**3.09**
Eastern Austria	**147,908**	**4,180.93**	**2.83**
Burgenland	7,962	79.73	1.00
Lower Austria	53,408	935.40	1.75
Vienna	86,538	3,165.80	3.66
Southern Austria	**61,936**	**2,820.38**	**4.55**
Carinthia	18,610	585.29	3.15
Styria	43,326	2,235.09	5.16
Western Austria	**129,957**	**3,497.82**	**2.69**
Upper Austria	58,138	1,846.32	3.18
Salzburg	24,943	384.67	1.54
Tyrol	30,761	965.28	3.14
Vorarlberg	16,115	301.55	1.87
Extra-Regio [3]	95	.	.

Source: Statistics Austria. Survey of research and experimental development in 2015. Compiled on: 7 August 2017.

1) As at: 22 Dec. 2016. Concept ESA 2010, national accounts revision date: July 2016. – 2) Regional allocation by R&D location / the R&D locations of the survey units. – 3) The "Extra-Regio" includes parts of the economic area which cannot be allocated directly to a region (embassies abroad). – Rounding differences.

Table 18: An international comparison of research and experimental development (R&D) in 2015

Country	Gross domestic expenditure on R&D as a % of GDP	Financing of gross domestic expenditure of 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	2.47	22.5	58.6	77,520[b]	69.9	20.3	9.2	0.5
Denmark [p]	2.96	29.4	59.4	59,532	63.9	33.4	2.3	0.4
Germany	2.92	27.9[d]	65.6	640,516	68.7	17.3	14.1[d]	.
Finland	2.90	28.9	54.8	50,367	66.7	24.4	8.2	0.8
France	2.27	34.8	54.0	428,643	63.7	22.0	12.8	1.5
Greece	0.97	53.1	31.4	49,658	33.0	37.8	28.1	1.1
Ireland	1.20	25.9	48.4	35,170	71.3	24.4	4.3	.
Italy	1.34[c]	38.0	50.0	259,167	58.2	25.5[e]	13.1	3.2
Luxembourg	1.27	47.7	47.1	5,227	51.6	18.6	29.8[d]	.
Netherlands	2.00	33.1	48.6	129,060	56.0	32.1	11.9[d]	.
Austria [7]	**3.05**	**33.2**	**49.7**	**71,396**	**71.4**	**23.5**	**4.6**	**0.5**
Portugal	1.24	44.3	42.7	47,999	46.4	45.5	6.5	1.6
Sweden	3.27[e]	28.3[e]	57.3	83,551[e]	69.7	26.7	3.4	0.2
Spain	1.22	40.9	45.8	200,866	52.5	28.1	19.1	0.2
United Kingdom	1.67	27.7	49.0	413,860	66.0	25.3	6.6	2.0
EU 15[e]	**2.10**	**31.4**	**56.0**	**2,552,534**	**64.6**	**22.9**	**11.4**	**1.1**
Estonia	1.49	46.4	41.0	5,636	46.1	41.4	10.8	1.8
Latvia	0.62	32.7	20.0	5,570	24.7	49.7	25.6	.
Poland	1.00	41.8	39.0	109,249	46.6	28.9	24.4	0.2
Slovak Republic	1.18	31.9	25.1	17,591	28.0	43.8	27.9	0.4
Slovenia	2.20	19.9	69.2	14,225	76.3	10.2	13.5	0.0
Czechia	1.93	32.2	34.5	66,433	54.3	24.9	20.4	0.4
Hungary	1.36	34.6	49.7	36,847	73.4[d]	12.1[d]	13.3[d]	.
Romania	0.49	41.7	37.3	31,331	44.0	17.4	38.3	0.3
EU-28[e]	**1.96**	**31.7**	**54.7**	**2,885,830**	**63.6**	**23.1**	**12.2**	**1.0**
Australia	1.88[e]	34.6[1]	61.9[1]	147,809[e, 2]	53.4[e]	30.6[e]	12.7[e]	3.2[e]
Chile	0.38	42.6	32.8	15,261	34.3	38.5	7.8	19.4
Iceland	2.19	32.0	33.3	2,941	64.7[d]	30.5	4.8	2.8[b, e, 3]
Israel[d]	4.27	12.8	34.3	77,143[4]	85.1	12.2	1.7	1.0
Japan	3.28	15.4[e]	78.0	875,005	78.5	12.3	7.9	1.3
Canada	1.65	32.2[e]	41.6	237,280[6]	52.1	40.3	7.1	0.5
Korea	4.22	23.7	74.5	442,027	77.5	9.1	11.7	1.6
Mexico	0.53[e]	70.3[e]	19.7[e]	59,073[5]	30.0[e]	26.8[e]	37.9[e]	5.4[e]
New Zealand	1.28	37.1	43.1	26,400	49.8	29.9	20.3	.
Norway	1.93	44.9	44.2	42,409	53.9	31.1	15.0	.
Switzerland	3.37	24.4	63.5	81,451	71.0	26.7	0.9[d]	1.5
Turkey	0.88	27.6	50.1	122,288[e]	50.0	39.7	10.3	.
United States[d, p]	2.74	25.5	62.4	.	71.7	13.0	11.3	4.0[e]
OECD total[e]	**2.36**	**26.7**	**61.4**	**.**	**69.1**	**17.5**	**11.0**	**2.4**
People's Republic of China	2.07	21.3	74.7	3,758,848	76.8	7.0	16.2	.

Source: OECD (MSTI 2017-2), Statistics Austria (Bundesanstalt Statistik Österreich).

b) Break in the time series. – d) Different definition. – e) Estimated values. – p) Preliminary values.

1) 2008. – 2) 2010. – 3) 2011. – 4) 2012. – 5) 2013. – 6) 2014. – 7) Statistics Austria; Results of the 2015 survey on research and experimental development.

Full time equivalent = person year.

Table 19: Austria's path from the 4th Framework Programme for research, technological development and demonstration activities up to Horizon 2020

	FP4	FP5	FP6	FP7	H2020
	1994–1998	1998–2002	2002–2006	2007–2013	Data as per March 2017
Number of approved projects with Austrian participation	1,444	1,384	1,324	2,452	1,472
Number of approved Austrian participations	1,923	1,987	1,972	3,589	2,188
Number of approved projects coordinated by Austrian organisations	270	267	213	676	439
Promotion for approved Austrian partner organisations and researchers for which a contract has been signed, in € millions	194	292	425	1,192	871
Percentage of approved Austrian participations among all approved participations	2.3%	2.4%	2.6%	2.6%	2.8%
Percentage of approved Austrian coordinators among all approved coordinators	1.7%	2.8%	3.3%	2.7%	2.5%
Austrian share of approved development funds	1.99%	2.38%	2.56%	2.63%	2.85%

Sources: Proviso Overview report from fall of 2013 (FP4-FP6); EC 11/2015 (FP7)

Processing and calculations: Austrian Research Promotion Agency (FFG)

Table 20: Austria's results in the 7th EU Framework Programme for research, technological development and demonstration activities

	All countries	Austria	Burgenland	Carinthia	Lower Austria	Upper Austria	Salzburg	Styria	Tyrol	Vorarlberg	Vienna
Projects		**2,448**	**10**	**142**	**253**	**255**	**106**	**636**	**254**	**29**	**1,902**
Participations	**136,388**	**3,595**	**11**	**141**	**254**	**254**	**105**	**638**	**253**	**29**	**1,904**
Higher education	50,719	1,314	-	31	52	87	54	263	146	5	676
Non-university research	33,791	872	-	5	61	46	26	139	2	1	592
Business enterprises	41,297	1,154	11	104	128	113	21	230	101	21	420
Public institutions	6,246	171	-	1	4	3	2	1	3	-	157
Other	4,335	84	-	-	9	5	2	5	1	2	59
Declared SME	25,048	778	11	42	101	51	8	159	73	12	318
Not a declared SME	111,340	2,817	-	99	153	203	97	479	180	17	1,586
Coordinations	**25,205**	**669**	**-**	**24**	**48**	**33**	**18**	**97**	**43**	**1**	**405**
Higher education	14,338	359	-	1	28	22	10	45	38	-	215
Non-university research	7,006	162	-	-	7	7	6	26	-	1	115
Business enterprises	2,991	126	-	23	11	3	2	26	5	-	56
Public institutions	461	15	-	-	-	1	-	-	-	-	14
Other	409	7	-	-	2	-	-	-	-	-	5
Declared SME	1,792	79	-	17	10	1	1	17	5	-	28
Not a declared SME	23,413	590	-	7	38	32	17	80	38	1	377

Source: EC 09/2016.

Processing and calculations: Austrian Research Promotion Agency (FFG).

Table 21: Austrian results in Horizon 2020

	All countries	Austria	Burgenland	Carinthia	Lower Austria	Upper Austria	Salzburg	Styria	Tyrol	Vorarlberg	Vienna
Projects	**17,345**	**1,472**	**13**	**68**	**150**	**146**	**46**	**347**	**88**	**15**	**889**
Participations	**77,506**	**2,188**	**14**	**93**	**153**	**183**	**48**	**467**	**100**	**16**	**1,114**
Higher education	25,105	614	2	15	37	33	20	117	49	0	341
Non-university research	16,086	450	5	3	27	42	7	120	1	0	245
Business enterprises	28,403	896	5	70	83	96	18	213	44	15	352
Public institutions	4,550	128	1	3	1	4	2	6	5	1	105
Other	3,362	100	1	2	5	8	1	11	1	0	71
Declared SME	18,048	560	5	23	69	59	7	149	26	5	217
Not a declared SME	62,187	1,616	8	52	97	138	45	308	80	14	874
Coordinations	**17,345**	**439**	**1**	**21**	**45**	**29**	**7**	**84**	**21**	**1**	**230**
Higher education	8,082	181	-	1	29	5	3	21	16	-	106
Non-university research	4,933	150	-	20	11	11	2	45	4	1	56
Business enterprises	3,663	86	1	-	5	13	2	17	-	-	48
Public institutions	372	12	-	-	-	-	-	-	1	-	11
Other	295	10	-	-	-	-	-	1	-	-	9
Declared SME	4,181	127	1	15	10	17	-	37	3	1	43
Not a declared SME	11,865	277	-	5	32	8	7	44	18	-	163

Source: EC 03/2018.

Processing and calculations: Austrian Research Promotion Agency (FFG).

Table 22: Overview of projects and participations in Horizon 2020

	Approved participants (all countries)	Approved Austrian Participations	Austria's share in all countries [in %]
H2020	**77,506**	**2,188**	**2.8**
EC Treaty	76,652	2,182	2.8
Excellent Science	24,690	555	2.2
Industrial Leadership	17,383	563	3.2
Societal Challenges	32,545	981	3.0
Spreading excellence and widening participation	613	20	3.3
Science with and for Society	972	54	5.6
Cross-theme	449	9	2.0
Euratom	854	6	0.7

	Approved projects (all countries)	Approved projects with Austrian participation	Austria's share in all countries [in %]
H2020	**17,345**	**1,472**	**8.5**
EC Treaty	17,297	1,468	8.5
Excellent Science	9,521	429	4.5
Industrial Leadership	2,847	316	11.1
Societal Challenges	4,577	656	14.3
Spreading excellence and widening participation	153	18	11.8
Science with and for Society	99	41	41.4
Cross-theme	100	8	8.0
Euratom	48	4	8.3

Source: EC 03/2018.

Processing and calculations: Austrian Research Promotion Agency (FFG).

Table 23: Austrian Science Fund (FWF): shares of new approvals by discipline (ÖFOS 2012 3-digit level), 2015–2017

Discipline	New approvals					
	2015		2016		2017	
	in %	in € millions	in %	in € millions	in %	in € millions
Mathematics	9.21	18.36	14.14	25.99	11.51	25.02
Computer science	4.42	8.82	4.41	8.11	5.68	12.33
Physics, astronomy	16.84	33.57	10.85	19.94	10.8	23.47
Chemistry	5.74	11.43	4.36	8.02	4.52	9.82
Geosciences	3.01	6.01	3.35	6.15	3.49	7.59
Biology	21.68	43.21	20.04	36.84	19.94	43.33
Other natural sciences	0.7	1.39	0.31	0.57	0.24	0.51
Construction	0.83	1.65	0.46	0.85	0.42	0.92
Electrical engineering, electronics, information technology	0.8	1.6	0.82	1.51	0.58	1.25
Mechanical engineering, machinery	0.2	0.39	0.05	0.09	0.27	0.59
Chemical industry and petrol industry, basic materials chemistry	0.04	0.09	0.03	0.06	0.14	0.31
Advanced materials			0.57	1.05	0.37	0.8
Medical engineering	0.11	0.22	0.2	0.37	0.5	1.09
Environmental engineering, applied geosciences	0.36	0.72	0.24	0.45	0.48	1.04
Environmental biotechnology			0.05	0.1	0.06	0.13
Industrial biotechnology	0.1	0.2	0.22	0.4	0.45	0.99
Nanotechnologies	0.28	0.56	1.04	1.92	0.55	1.19
Other engineering	0.41	0.81	0.16	0.3	0.19	0.41
Medical/theoretical sciences, pharmaceutics	10.44	20.81	11.87	21.82	10.8	23.47
Clinical medicine	2.54	5.07	4.43	8.13	4.07	8.85
Health sciences	0.29	0.57	0.86	1.58	0.91	1.97
Medical biotechnology	0.07	0.14	0.2	0.36	0.1	0.22
Other human medicine, health sciences	0.24	0.48	0.04	0.08	0.12	0.27
Agriculture and forestry, fisheries	0.73	1.46	0.29	0.54	0.54	1.17
Livestock breeding, animal production	0.05	0.1	0.4	0.73	0.03	0.06
Veterinary medicine	0.12	0.24	0.5	0.92	0.26	0.57
Agricultural biotechnology, food biotechnology	0.03	0.07	0.05	0.09		
Other agricultural sciences	0.59	1.17			0.14	0.31
Psychology	1.05	2.08	1.46	2.69	1.29	2.8
Economics	0.99	1.98	3.16	5.81	3.12	6.79
Educational sciences	0.18	0.37	0.42	0.76	0.15	0.33
Sociology	0.93	1.86	1.39	2.56	1.74	3.78
Jurisprudence	0.62	1.24	0.82	1.51	0.47	1.02
Political science	0.85	1.69	0.4	0.73	0.4	0.86
Human geography, regional geography, spatial planning	0.23	0.45	0.51	0.95	0.27	0.58
Media and communication sciences	0.17	0.33	0.2	0.37	0.44	0.96
Other social sciences	1.39	2.77	0.3	0.54	0.24	0.51
History, archaeology	3.91	7.79	3.35	6.16	3.71	8.07
Linguistics and literary studies	4.4	8.77	2.89	5.32	4.03	8.75
Philosophy, ethics, religion	1.7	3.38	2.37	4.35	2.68	5.83
Art sciences	3.15	6.27	2.09	3.84	2.53	5.5
Other humanities	0.62	1.23	0.66	1.22	1.77	3.85
Total	**100**	**199.32**	**100**	**183.8**	**100**	**217.34**

Source: AUSTRIAN SCIENCE FUND (FWF).

Table 24: Austrian Science Fund (FWF): shares of new approvals by organisation type, 2015–2017

Organisation type	2015		2016		2017	
	in %	in € millions	in %	in € millions	in %	in € millions
Universities[1]	83.72	166.9	82.97	152.5	85.14	185
Universities of applied sciences	0.09	0.2	1.33	2.4	0.46	1
Private universities	0.85	1.7	1.13	2.1	0.56	1.2
Academy of Sciences	8.92	17.8	7.83	14.4	7.81	17
Non-university research locations[2]	6.43	12.8	6.74	12.4	6.03	13.1
Total	**100**	**199.3**	**100**	**183.8**	**100**	**217.3**

Source: AUSTRIAN SCIENCE FUND (FWF).

1 Including the University for Continuing Education Krems.

2 Including research locations abroad.

Table 25: Austrian Research Promotion Agency (FFG): shares of new approvals by topic area of the promotion, 2015–2017

	2015		2016		2017	
	in %	Total funding in € millions	in %	Total funding in € millions	in %	Total funding in € millions
Energy/Environment	16.9	79.1	16.9	88	15.0	84.2
ICT	17.6	82.2	20.3	105.7	20.9	117.8
Mobility	13.5	62.9	11.6	60.4	12.5	70.2
Production	24.3	113.7	22.8	118.7	23.1	129.9
Life Sciences	9.8	45.8	10.7	56	10.6	59.5
Safety	2.8	12.9	1.6	8.1	1.5	8.4
Space	0.0	0.1	1.5	7.6	1.4	8
Other	15.1	70.5	14.8	77	15.0	84.4
Total	**100.0**	**467.1**	**100.0**	**521.5**	**100.0**	**562.5**

Source: AUSTRIAN RESEARCH PROMOTION AGENCY (FFG).

Table 26: Austrian Research Promotion Agency (FFG): promotion by regional government, 2015–2017

Regional government	2015		2016		2017	
	in %	Total funding in € millions	in %	Total funding in € millions	in %	Total funding in € millions
Burgenland	1.3	5.9	1.3	6.7	1.3	7.6
Carinthia	5.8	27	4.6	23.7	4.6	25.6
Lower Austria	6.1	28.5	8.9	46.6	7.3	40.9
Upper Austria	21.2	99.3	19.8	103.2	19.5	109.5
Salzburg	3.2	14.8	3.7	19.1	3.3	18.4
Styria	29.4	137.5	23.3	121.4	29.9	168
Tyrol	5.9	27.7	5.9	31	7.2	40.4
Vorarlberg	1.8	8.2	3.2	16.8	3.2	18.2
Vienna	23.9	111.8	28.1	146.6	22.9	128.9
Abroad	1.4	6.4	1.2	6.3	0.9	4.9
Total	**100.0**	**467.1**	**100.0**	**521.5**	**100.0**	**562.5**

Source: Austrian Research Promotion Agency (FFG).

Table 27: Austrian Research Promotion Agency (FFG): project costs and funding by Subject Index Code, 2017

	Total costs [in €1,000]	Total funding [in €1,000]	Cash value [in €1,000]
SIC	**1,102,544**	**562,477**	**434,270**
Electronics, microelectronics	166,697	71,121	47,464
Industrial manufacturing	137,327	67,391	44,334
Advanced materials	94,803	50,419	33,376
Information processing, information systems	106,562	47,923	42,888
ICT applications	88,530	46,039	35,673
Surface transport and technologies	75,341	40,560	30,683
Energy storage, conversion and transport	49,203	27,994	27,332
Automation	54,062	19,458	16,991
Biosciences	26,712	15,934	11,371
Medicine, health	22,718	15,044	8,911
Construction engineering	22,563	14,309	8,986
Other technologies	27,412	12,118	8,972
Energy savings	17,257	11,630	10,942
Renewable energy sources	13,937	10,096	8,717
Medical biotechnology	17,830	9,691	8,741
Measuring techniques	15,875	7,980	4,080
Agriculture	19,286	7,225	7,225
Space	8,173	6,569	6,569
Safety	9,165	6,254	6,254
Environment	8,836	5,410	4,598
Industrial biotechnology	7,563	5,157	3,414
Robotics	7,211	4,759	4,622
Nanotechnologies and nanosciences	5,631	4,344	4,344
Waste management	9,590	3,846	3,243
Aviation and technologies	6,212	3,666	3,518
Information, media	5,327	3,218	1,894
Regional development	7,071	3,172	3,172
Mathematics, statistics	4,925	3,163	2,359
Sustainable development	4,514	3,101	2,956
Foodstuffs	4,515	2,986	2,121
Economic aspects	6,899	2,568	1,829
Business aspects	2,724	1,721	1,126
Research ethics	3,255	1,602	304
Innovation, technology transfer	2,656	1,256	1,256
Other energy topics	1,777	1,166	1,166
Agricultural biotechnology	2,413	1,094	954
Network technologies	1,187	912	912
Telecommunications	1,618	889	599
Geosciences	793	590	543
Project management methods	942	491	491
Water resources and water management	577	484	484
Employment	719	473	302
Meteorology	515	289	289
Social aspects	376	224	224
Coordination, cooperation	277	196	90
Rights to intellectual property	309	185	185
Laws, regulations	261	185	185
without classification	30,395	17,579	17,579

Source: Austrian Research Promotion Agency (FFG).

Table 28: Austria Wirtschaftsservice (aws): shares of new approvals by topic area of the promotion (industry), 2015–2017

Discipline, topic area or industry sector	2015		2016		2017	
	in %	in € millions	in %	in € millions	in %	in € millions
Services	15.5	128.2	19.3	156.6	24.7	282.4
Electricity, gas and water supply	0.2	1.9	0.2	1.4	0.8	9.0
Trade, maintenance, repair	14.4	118.6	15.0	121.2	13.3	152.5
Food products, beverages and tobacco, LW, FW	11.5	94.8	12.8	104.0	12.9	147.6
Manufacturing	45.6	376.3	37.7	306.0	36.1	413.9
Other industries	1.1	9.0	0.7	6.0	1.7	18.9
Tourism	6.8	56.3	9.8	79.7	6.5	74.5
Transport and communication	2.2	18.1	2.0	15.9	1.8	20.1
Not classified	2.7	22.4	2.5	20.1	2.3	26.4
Total	**100.0**	**825.6**	**100.0**	**810.9**	**100.0**	**1,145.4**

Source: Austria Wirtschaftsservice (aws).

Table 29: Austria Wirtschaftsservice (aws): shares of new approvals by enterprise size, 2015–2017

Organisation type	2015		2016		2017	
	in %	in € millions	in %	in € millions	in %	in € millions
Sole proprietorships	9.7	80.2	7.7	62.8	8.5	97.3
Microenterprises	13.4	110.6	17.3	140.2	14.4	165.0
Small enterprises	25.8	213.1	15.1	122.8	17.8	204.1
Medium-sized enterprises	29.6	244.5	29.7	241.0	28.0	320.2
Large enterprises	19.1	158.1	27.6	223.6	29.1	333.5
Not classified	2.3	19.1	2.5	20.6	2.2	25.4
Total	**100.0**	**825.6**	**100.0**	**810.9**	**100.0**	**1,145.4**

Source: Austria Wirtschaftsservice (aws).

Table 30: Austria Wirtschaftsservice (aws): overview of funding performance by region, 2016–2017

Region	Confirmed		Financing amount in € millions		Cash value in € millions		Total project costs in € millions		New jobs	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Burgenland	63	95	4.5	17.7	0.9	3.9	11.7	48.4	73	146
Carinthia	359	410	74.1	71.4	4.5	7.9	127.4	271.0	398	508
Lower Austria	490	775	135.6	201.4	17.6	44.0	350	650	690	1,802
Upper Austria	1,082	1,629	313	435	24.9	73.6	537.4	1,089.7	1,711	2,869
Salzburg	257	343	53.6	56.6	6.8	13.2	106.4	191.5	250	387
Styria	457	647	77.2	93.6	10.3	29.1	164.7	539.3	423	1,109
Tyrol	301	388	46.6	77.6	8.2	21.7	113.5	308.9	258	608
Vorarlberg	84	157	15.9	37.9	1.6	9.2	33.1	313.8	51	502
Vienna	737	952	68.9	113.6	22.8	43.2	209.1	482.7	834	1,364
Abroad	37	80	10.9	31.8	0.9	3.8	28.8	86.2	63	153
Without classification	7	6	10.7	8.4	8.0	8.4	10.2	9.6	0	3
Total	**3,874**	**5,482**	**810.9**	**1,145.4**	**106.6**	**258.0**	**1,691.88**	**3,990.92**	**4,750**	**9,451**

Source: Austria Wirtschaftsservice (aws).

Table 31: CDG: CD laboratories by university/research institute 2017

University/research institute	Number of CD laboratories	Budget [in €]
University for Continuing Education Krems	1	186,000.00
Medical University of Graz	2	148,306.00
Medical University of Innsbruck	6	1,217,236.16
Medical University of Vienna	8	3,168,052.81
University of Leoben	8	2,737,823.26
Graz University of Technology	7	2,170,712.01
Vienna University of Technology	14	4,309,593.29
University of Natural Resources and Life Sciences Vienna	9	3,419,081.79
University of Innsbruck	1	214,098.00
University of Linz	7	2,340,920.75
University of Salzburg	1	432,993.95
University of Vienna	5	1,384,868.85
University of Veterinary Medicine Vienna	3	790,771.82
Vienna University of Economics and Business	1	163,269.05
Austrian Academy of Sciences	1	521,742.33
Forschungszentrum Jülich GmbH	1	436,762.00
University of Cambridge	1	371,151.00
Total	**76**	**24,013,383**

CDG: JR Centres by university of applied sciences, 2017

University of applied sciences	Number of JR Centres	Budget [in €]
Fachhochschule Joanneum Gesellschaft mbH	2	383,984
Carinthia University of Applied Sciences – non-profit foundation	1	337,795
Fachhochschule Salzburg GmbH	1	192,065
Fachhochschule St. Pölten GmbH	1	377,500
University of Applied Sciences Technikum Wien	1	246,940
Fachhochschule Vorarlberg GmbH	2	373,819
FH OÖ Forschungs und Entwicklungs GmbH	2	311,837
IMC Fachhochschule Krems GmbH	1	336,128
Total	**11**	**2,560,068**

Source: CDG

Note: Budget data 2017 are plan data as of 1 Dec. 2017.

Table 32: CDG: development of the CDG 1989–2017 and JR Centres 2012–2017

Year	Expenditures of the CD laboratories and JR Centres [€]	Active CD laboratories	Active JR Centres	Active member firms
1989	247,088	5		
1990	1,274,682	7		
1991	2,150,389	11		
1992	3,362,572	16		
1993	2,789,910	17		
1994	3,101,677	18		
1995	2,991,214	14		
1996	2,503,325	14		6
1997	2,982,793	15		9
1998	3,108,913	18		13
1999	3,869,993	20		15
2000	3,624,963	18		14
2001	4,707,302	20		18
2002	7,295,957	31		40
2003	9,900,590	35		47
2004	10,711,822	37		63
2005	11,878,543	37		66
2006	12,840,466	42		79
2007	14,729,108	48		82
2008	17,911,784	58		99
2009	17,844,202	65		106
2010	19,768,684	61		110
2011	20,580,208	61		108
2012	22,167,259	64	1	114
2013	23,666,522	73	4	131
2014	25,634,725	71	5	129
2015	24,954,856	73	7	145
2016	23,967,799	72	9	136
2017	26,717,280	76	11	147

Source: CDG

Note: Budget data 2017 are plan data as of 1 Dec. 2017.

Table 33: Christian Doppler Research Society (CDG): CD laboratories by thematic cluster, 2017

Thematic clusters	Number of CD laboratories	Budget [in €]
Chemistry	8	3,049,077
Life Sciences and environment	17	6,479,655
Manufacture of machinery and equipment, instruments	6	2,008,697
Mathematics, informatics, electronics	16	4,448,193
Medicine	15	3,542,207
Metals and alloys	8	2,572,988
Non-metal materials	4	1,465,640
Economics, social sciences and jurisprudence	2	446,926
Total	**76**	**24,013,383**

Source: CDG

Note: Budget data 2017 are plan data as of 1 Dec. 2017.

Table 34: Christian Doppler Research Society (CDG): JR Centres by thematic cluster, 2017

Thematic clusters	Number of JR Centres	Budget [in €]
Chemistry	-	
Life Sciences and environment	1	200,000
Manufacture of machinery and equipment, instruments	1	36,068
Mathematics, informatics, electronics	6	1,683,248
Medicine	1	336,128
Metals and alloys	-	
Non-metal materials	2	304,624
Economics, social sciences and jurisprudence	-	
Total	**11**	**2,560,068**

Source: CDG

Note: Budget data 2017 are plan data as of 1 Dec. 2017.