Austrian Research and Technology Report 2017

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

This report was commissioned by the Federal Ministry of Science, Research and Economy (BMWFW) and the Federal Ministry for Transport, Innovation, and Technology (BMVIT). It was written by a working group consisting of the Austrian Institute of Technology (AIT), JOANNEUM RESEARCH (JR) and the Austrian Institute of Economic Research (WIFO) with the support of the Centre for European Economic Research (ZEW).
Team of authors: Wolfgang Polt & Jürgen Streicher (Coordination, JR), Peter Biegelbauer (AIT), Julia Bock-Schappelwein (WIFO), Bernhard Dachs (AIT), Michael Dinges (AIT), Matthias Firgo (WIFO), Silvia Hafellner (JR), Kathrin Hofmann (WIFO), Jürgen Janger (WIFO), Agnes Kügler (WIFO), Karl-Heinz Leitner (AIT), Peter Mayerhofer (WIFO), Michael Peneder (WIFO), Michael Ploder (JR), Christian Rammer (ZEW), Sybille Reidl (JR), Helene Schiffbänker (JR), Claudia Steindl (AIT), Anna Strauss (WIFO), Maximilian Unger (JR).

Imprint
Owners, Authors and Publishers:
Federal Ministry of Science, Research and Economy, 1010 Vienna
Federal Ministry for Transport, Innovation and Technology, 1030 Vienna

Designed and produced by:
Peter Sachartschenko & Mag. Susanne Spreitzer OEG, Vienna
Translated by: Young Translations LLC, Vienna
Cover: © monsitj - Fotolia
Printed by:
Druckerei Berger, Horn

Vienna, 2017

Preface

Digitalisation is penetrating all of our social, economic and scientific fields of activity and permanently changing the way we live and work. The digital transformation is not only effecting the day-to-day work done by researchers at universities, research institutes and firms, it is even itself becoming the subject of their research. These developments therefore call for RTI policy measures that can promote them and at the same time focus on specific lines of approach. Targeted investments in information technology, the expansion of RTI infrastructures, questions about the protection of intellectual property, data protection and data security which arise in connection with Open Data, Open Science and Open Innovation, all play an essential role. One important first step in this regard was the Digital Roadmap put forward in January of this year. This joint strategy paper of the federal government bundles together the current tasks for the first time – around 150 measures across all ministerial departments – creating the framework to ensure that our society as a whole can benefit best from digitalisation.

New innovation paradigms that will be promoted in the course of digitalisation, such as Open Innovation, which uses the approaches of collaborative, user-driven innovation and crowdsourcing, are another area focussed on in this year's Austrian Research and Technology Report. Firms that pursue open innovation strategies invest more on average in research and development.

Overall, the latest forecast of Statistics Austria points towards a very positive trend. We are expecting expenditure on research and development (R&D) in the amount of €11.3 billion for 2017. That corresponds to an R&D intensity of 3.14% of GDP. This new record shows that we are putting the right initiatives in place and taking the necessary action. The forecast growth rate of 3.8% from 2016 to 2017 is also above the expected increase in gross domestic product of 3.3%. The most important contribution to this growth is made by the federal government with an expected increase of €178 million, or 5.5%. Around €100 million are accounted for by the additional expenditure of the federal government to increase the research tax premium from 10% to 12%, as decided in 2016. Overall, the federal government is expected to invest €3.4 billion in R&D in 2017, of which a total of €627.7 million in the context of research tax premiums for firms. The business enterprise sector, with an expected €5.5 billion in R&D expenditures, remains the most important source of funds, with an estimated share in the corresponding expenditure of 48.2%. The financial contribution from abroad is estimated to be €1.7 billion, which is a share of 15.4%.

In an EU-wide comparison, Austria's R&D intensity is in an outstanding second place behind Sweden (3.26%) and well above the average research intensity (R&D expenditures as a percentage of GDP) of the EU-28 of 2.03%. We must continue to drive this trend forwards. Our next step should be to magnify the results of this innovation, creating added value in research and knowledge-intensive sectors and improving the market positions of Austrian businesses.

Dr Reinhold Mitterlehner
Vice Chancellor and Federal Minister of
Science, Research and Economy

BM Mag. Jörg Leichtfried
Federal Minister for Transport,
Innovation and Technology

Table of Contents

Executive Summary

The Austrian Research and Technology Report 2017 is a status report on the country's federally funded research, technology, and innovation. It was commissioned by the Federal Ministry of Science, Research and Economy (BMWFW) and the Federal Ministry for Transport, Innovation and Technology (BMVIT). 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.

It includes the latest global estimate of trends in R&D expenditure in Austria for 2017, and a picture of Austria's position in international rankings The report also describes recent developments in the implementation of the federal government's RTI strategy and other strategic initiatives in RTI policy. Other key themes include: an outline of emerging innovation paradigms and their significance for Austria; description and discussion of developments in the areas of research, business enterprise and the labour market resulting from current trends in digitalisation and the increasing significance of R&D and knowledge-intensive activities. The status of Austria's position in the European Research Area (ERA) is also examined from various perspectives and analysed with reference to the national ERA Roadmap.

Global estimate of R&D expenditure in 2017

The current global estimate published in April 2017 by Statistics Austria predicts a total expenditure on research and development (R&D) of €11.33 billion in 2017. This would mean an increase of €419.3 million or 3.8% on 2016 and would result in a slight increase in the estimated R&D intensity (gross domestic expenditure on R&D relative to gross domestic product) by 0.02 percentage points to 3.14%. Similar to the previous two years' level of 3.12% (2015 and 2016, revised values as compared with the global estimate for 2016), this would thus be again above the European target level of 3%. The expected increase of 3.8% from 2016 to 2017 is also above the expected growth rate for gross domestic product of 3.3%.

The public sector funding is expected to account for 36.0% of Austrian R&D expenditure in 2017, with the greatest contribution (30.4%) provided by the federal government. This also constitutes the largest projected increase compared to the previous year, at 5.5% (+€178.3 million) and is essentially attributable to the increase in the research tax premium, i.e. the tax-deductible R&D expenditure by firms, from a ratio of 10% to 12% in 2016. The additional cost to the federal government for reimbursing expenditure incurred in 2017 is expected to be around €100 million. Federal government funding for R&D is therefore expected to total €3.44 billion in 2017. Funding from the regional governments is estimated at €514.5 million, which would be an increase on 2016 of approximately 4.3% or €21.4 million. Other public institutions (municipal authorities, chambers of commerce, social insurance institutions) account for €121.9 million, representing an expected increase of 2.7% (+€3.2 million). Overall, the proportion of public funding relative to gross domestic product is thus forecast at 1.1%.

However, the business enterprise sector remains the largest source of funding, with an estimated share in total R&D expenditure of 48.2%. This corresponds to a projected funding volume of €5.5 billion, an increase of around 3.1% or €163.1 million. As such, the business enterprise sector will fund R&D at an estimated rate of 1.5% of gross domestic product in 2017.

A 3.1% increase (+€52 million) is also expected in the funding contribution from abroad, bringing it up to €1.74 billion in 2017 (equating to 0.5% of gross domestic product). The majority of this is R&D financing from foreign firms for their own Austrian subsidiaries, but it also includes returns from EU research programmes. The proportion attributable to the private non-profit sector remains low with a projection of 0.5%, which would mean a slight increase of 2.9% or €1.4 million.

With a research intensity of 3.12% in 2015 (the last year for which international comparative figures are available), Austria was second behind Sweden (3.26%), and ahead of Denmark (3.03%), Finland (2.90%) and Germany (2.87%) in EU comparisons. The average research intensity for the EU-28 in 2015 was 2.03%.

Austria's position in international innovation rankings

In recent years Austria has improved its performance in research and technology and made progress towards its ambition to become one of the innovation leaders. In terms of the key indicator of total R&D intensity, Austria reached a value of 3.12% in 2015, which was the fifth highest in the world, and the second highest value in the EU-28. There have also been significant improvements in the last few years in other key indicators such as patent applications, with clear evidence of a catching-up process. Although substantial increases have similarly been recorded in scientific publications, Austria still lags behind the leading countries in this area. Taking a broader view of innovation capability, based on a selection of indicators from the European Innovation Scoreboard (EIS), which also includes factors such as education and the market results for innovation, since 2008 Austria has almost halved the gap with the leading countries. Since 2014 however there has been no further significant catch-up. In international rankings for innovation, which take account of many different indicators – not all of which are in fact closely connected with innovation performance – Austria is still positioned in the mid-range of the highly developed industrial countries. A closing of the gap to the innovation leaders is evidently still some way off.

Austria's advance towards the most research-intensive countries shows that with a long-term strategy and substantial efforts on the part of industry and the government, quantifiable successes can be achieved. However, once various other indicators are taken into account, there does not appear to have been any significant progress in recent years towards closing the gap. In an international environment where all highly-developed countries are focused on boosting their innovative potential, improvements within this group of countries cannot be achieved rapidly or necessarily on a permanent basis; instead this requires sustained effort and ongoing investment. At the same time, the successes achieved in R&D intensity provide a good basis for increasing the innovation results in future, either in the form of additional value creation in research and knowledge-intensive industries, or through improved market positions for the Austrian economy.

Implementation of the Austrian government's RTI strategy

In 2011 the Austrian federal government adopted the Strategy Plan for Research, Technology and Innovation as the central reference framework for defining domestic RTI policy. The aim of the strategy was – and still is – to bring Austria into the group of European innovation leaders 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 Task Force was created to define and coordinate implementation of the strategy at a high administrative level, under the leadership of the Federal Chancellery (BKA) in collaboration with representatives of the relevant federal ministries (Federal Ministry of Finance (BMF), Federal Ministry for Transport, Innovation and Technology (BMVIT), Federal Ministry of Science, Research and Economy (BMWFW) and Federal Ministry of Education (BMB)). Intensive and regular contact and exchange of information in key focus areas helps to increase cooperation between the RTI ministries and to shape the relevant governance structures more efficiently.

To achieve the objectives of the RTI strategy, the ministries have also designed and developed a series of specific initiatives at different levels and in differing contexts of political responsibility and self-commitment. As already established in the 2016 Mid-term Report on the RTI Strategy [1], further substantial efforts are needed to build on the progress already made with implementing the RTI strategy, and to achieve the agreed targets by 2020.

New innovation paradigms

The ways in which innovation activities are initiated, organised and carried out, and to what extent they may influence the outcomes of innovation activities, are constantly changing. Science and industry today are increasingly involved in collaborative, user-driven innovations, co-creations and crowdsourcing. These approaches are frequently grouped together under the concept of "Open Innovation". The idea behind this is the trend amongst firms to open up actively to customers, research institutes, suppliers, competitors, and other stakeholders to develop and implement innovations together, and to take advantage of the innovative ideas and market potential of third parties. Before innovations are commercialised it is vitally important to be able to protect knowledge and innovative resources. Intellectual Property Rights play an important role in this. Empirical findings in Austria underline the central importance of cooperative projects with customers, universities and research institutes. These kinds of cooperative activities help firms to recognise new trends and developments in the market, or even to create them. Internet-based forms of cooperation and interaction are (currently) only used to a small extent. Firms that pursue open innovation strategies invest more, on average, in research and development (R&D). By European standards, Austrian firms seem to be particularly advanced when it comes to using open innovation in the form of opening up the acquisition and exploitation of intellectual property.

Another important area, and one which is widely discussed in RTI policy-making in many countries, not only in Austria, is the support of "radical innovation". Due to its multi-layered meaning this concept has been presented consistently in this report to refer to the quality of scientific understanding, technological inventions and innovations as different parts of the innovation process. The term radical innovation refers to the degree of novelty of the functions or the usefulness of an innovation. Radical innovations are not necessarily resulting in any greater economic effects than for instance those produced by incremental innovations. Nor do scientific excellence and/or breakthrough discoveries necessarily result in radical innovations – i.e. new findings from basic research and discoveries cannot always be realised as new products or processes. Based on an international comparative study of performance in terms of the quality of science, discoveries and innovations, Austria is positioned by much-quoted publications in the upper mid-range for the EU, and based on an analysis of patent data, on the level of leading innovation countries. Due to data measurement problems, which are partly reflected in results that are not very plausible, case studies play a special role in the analysis of radical innovations. Intervention programmes stemming from RTI policy, for example as conceived for the support of so-called "Major Innovations", can provide some insight into the possible influence of RTI policy in this respect.

1 See Austrian Research and Technology Report 2016, 42 et seq., BMWFW, BMVIT (2016); http://www.bmwfw.gv.at/ftb

In Austria, as elsewhere, the concept of "Responsible research and innovation (RRI)" is increasingly attracting attention as a new paradigm for innovation. As an interdisciplinary issue in Horizon 2020, RRI aims to integrate various different aspects (e.g. participation, openness, ethics and gender) of responsible research and innovation in line with society's expectations into specific research activities. The practical implementation of RRI in Austria includes building up and establishing alliances such as the "Alliance for Responsible Science", as well as a range of further specific measures designed to advance discussions about RRI in Austria, and to deepen the interaction between science and society. Citizen Science programmes are one way of strengthening the dialogue between these two areas.

Digitalisation: research, innovation and the work environment

Today digitalisation permeates all areas of life, society and the economy. The scientific research process has also been influenced in recent years by digitalisation and technological change. New information technologies (IT), social networks, the collection and availability of large amounts of data, and artificial intelligence are increasingly changing research processes and the way researchers work – in universities, research institutes and in firms. Concepts like Open Access and Open Data, i.e. making publications and research data freely available, are by now established as trends and are being specifically encouraged in Austria. Information technologies also facilitate the involvement of citizens in the scientific process in many different ways, advancing developments in Citizen Science. The enormous amount of data which is now available also demands novel methods of processing (for instance using artificial intelligence), which are also becoming increasingly significant as research methods. Lastly there are new options for communicating results via the Internet more quickly, to a broader public and through a greater variety of channels, thus increasing the influence of research achievements. At the same time, digitalisation itself is becoming a topic for research as its effects on society are examined and technologies are designed in collaboration with citizens and users. The umbrella term of Open Science is often used as a term for the possibilities opened up by digitalisation for the scientific community, and this term is also a key concept for the European Commission's RTI policy. These trends present many challenges for RTI policy, which require investments in specific infrastructures, but also include legal framework requirements such as data protection and data security.

As far as digitalisation in the business enterprise sector is concerned, the focus is particularly on the diffusion of Industry 4.0 technologies, including information and communication technologies (ICT), and on the role of innovative, knowledge-intensive services. Analyses of the use of Industry 4.0 technologies show that they have begun to spread throughout Austrian industry, although their distribution still seems to be limited to large, internationally active firms and serial manufacturers. Specialised ICT service providers, which are developing dynamically in Austria, could play a key role in the diffusion of these technologies. Knowledge-intensive services are generally highly productive themselves and in addition help increase productivity in industries which use these services. The dynamic development in specialised, innovative, knowledge-intensive services is particularly beneficial for small and medium-sized enterprises (SMEs), where for reasons of size it is not economically viable for them to develop this kind of expertise for themselves.

Political discussion and society's attention are increasingly focused on the impact of technological change and automation on the future of work. In order to assess the associated changes more effectively and in an attempt to contribute to objective debate, this report links various perspectives, taking account of the working conditions in innovative firms, the potential for automation in different occupations and work activities, and the future demand for workers and changing qualification requirements. These resulting findings show that while in many areas, particularly in industry, the automation process is already far advanced, these developments vary widely from one sector to another. Additional employment opportunities are seen in particular for jobs featuring predominantly analytical and interactive non-routine activities as well as routine cognitive activities. In contrast, jobs in the manufacturing sector featuring largely manual routine activities are expected to become less significant. The penetration level for new technologies in firms providing services is still very low and only expected to rise at a moderate rate over the next few years. Increasing digitalisation clearly brings new requirements for qualifications and further education and training. Employees will be required in future to have abilities that machines are not (yet) able to develop, such as skilled manual proficiency and creative ability, combined with digital competencies.

Austria in the European Research Area

The Treaty of Lisbon included a resolution to create a shared European Research Area (ERA), with the aim of creating better networking and improved conditions for research, contributing to overall competitive strength of Europe. The key instrument for developing the ERA is the EU Framework Programme for Research and Innovation. In the current framework programme, Horizon 2020, Austrian stakeholders are particularly successful in the area of industry-oriented and applied research, due to the country's strength in these fields at the national level. In the "Excellent Science" pillar, on the other hand, Austria has a below-average share of funding, primarily as a result of the low level of funding in the context of research infrastructure programmes. Despite very high success ratios for Austrian applicants to the European Research Council (ERC), the overall share of funding is no more than average. The number of applications relative to the size of population, and relative to the number of researchers, is significantly lower than the average for the leading innovation countries. Success at EU level requires a strong national basis, as can be seen from the example of Switzerland, where a well-endowed science fund is coupled with marked success in the ERC. This illustrates the point that deficits at the national level cannot be compensated for at EU level. Austrian research in the area of "societal challenges" obtains slightly above-average funding allocations, with some areas, such as energy and transport, performing particularly well, while others such as food and water still have the potential for improvement. Overall success ratios in the areas of "societal challenges" and "industrial research" reflect Austria's technological strengths. At the same time, success ratios under Horizon 2020, compared to the 7th Framework Programme are generally lower due to a sharp increase in the number of applications in some areas, although Austria's success ratio has in fact not fallen by as much as the EU average.

Parallel to this, transnational R&D cooperation 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, is growing in significance (e.g. joint programming initiatives, ERA-nets and joint technology initiatives). Over and above bundling national resources to achieve "critical mass" in particular topic areas, they are an important instrument in anchoring bottom-up topics and priorities at the EU-wide level. Austria and Austrian stakeholders have been involved in this bilateral and multilateral networking right from the start and are amongst the leaders in the EU Member States, both in relation to the number of participations in this kind of initiatives and in relation to the share of expenditure in the national public R&D budget.

In May 2015 the EU Competitiveness Council adopted the so-called ERA Roadmap 2015–2020, which defines the central milestones for further development of the European Research Area. Building on this, the "Austrian ERA Roadmap" was adopted by the Council of Ministers in May 2016, and formulates core ambitions at the national level in line with six ERA priorities. Key milestones include the assessment of establishing an "Austrian Research, Technology and Innovation Hub" (ARTIH) in Brussels as an information and communication hub for Austrian RTI stakeholders at EU level, and the initiation of an OECD review of the Austrian innovation system, the results of which will be available by the end of 2018. To support the implementation of the Austrian Roadmap, a specific set of indicators has been developed to monitor progress towards the objectives (ERA Dashboard). The findings of the first ERA Dashboard show a mixed picture, with individual areas where Austria is the leader in Europe (quality of project proposals under Horizon 2020, innovation collaboration between science and industry), but other areas where Austria lags behind even in comparison to the EU average (e.g. in gender equality, with the exception of the "Glass Ceiling Index"). In most areas however, Austria's performance is above average and in the upper mid-field, but not yet among the leaders. This is consistent with the performance in research, technology and innovation in other areas, such as Austria's position on the European Innovation Scoreboard (EIS). For successful implementation of the ERA Roadmap, it is clear that additional efforts are needed to specifically address the existing weaknesses.

1 Current Trends

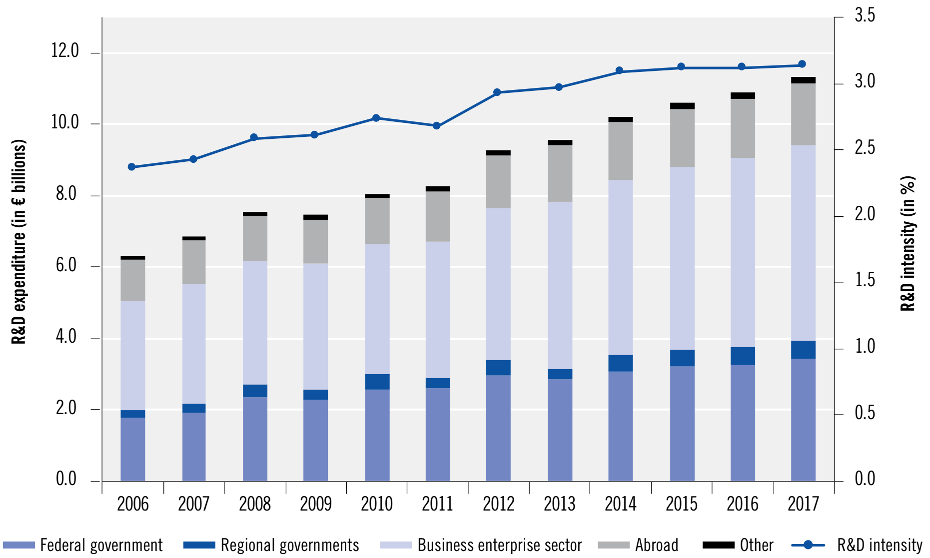
1.1 Trend of R&D expenditures based on new global estimate

The current global estimate published in April 2017 by Statistics Austria predicts a total expenditure on research and development (R&D) of €11.33 billion in 2017. This would mean an increase of €419.3 million or 3.8% on 2016 and would result in a slight increase in the estimated R&D intensity (gross domestic expenditure on R&D relative to gross domestic product) by 0.02 percentage points to 3.14%. Similar to the previous two years' level of 3.12% (2015 and 2016, revised values as compared with the global estimate for 2016), this would thus still be above the European target level of 3%. Fig. 1-1 illustrates that the longer-term trend of a rise in overall R&D expenditure in Austria persists following slight falls or stagnation between 2009 and 2011, and with an increase of 3.8% projected from 2016 to 2017 is also above the expected growth in gross domestic product of 3.3%.

With a research intensity of 3.12% in 2015 (the last year for which international comparative figures are available), Austria was second behind Sweden (3.26%), and ahead of Denmark (3.03%), Finland (2.90%) and Germany (2.87%) in EU comparisons. The average research intensity for the EU-28 in 2015 was 2.03%.

Growth in R&D expenditure is expected from all sources of funds (see Fig. 1-2). The most distinct feature is the projected rise in expenditure as compared with the previous year of around 5.5% (+€178.3 million) in R&D expenditure by the federal government. This is essentially attributable to the increase in the research tax

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



Source: Statistics Austria, Global Estimate from April 20th 2017, nominal values.

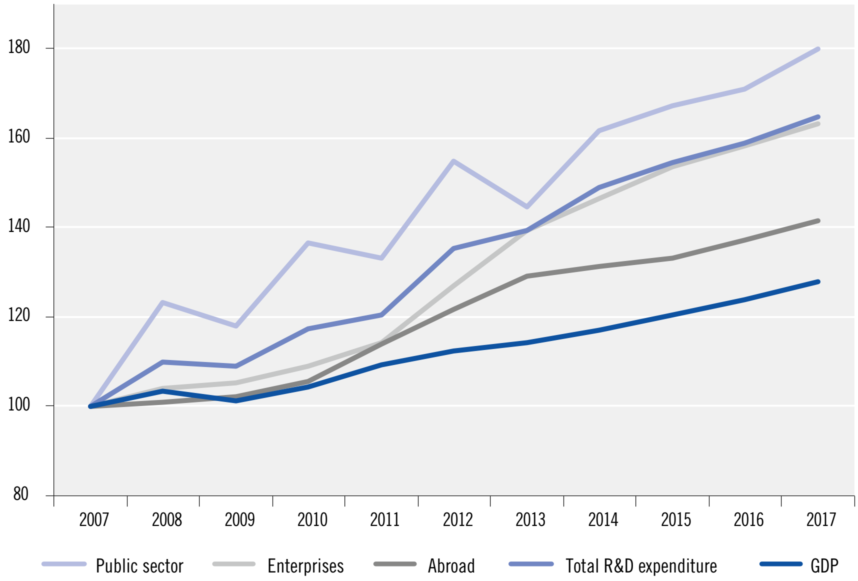
premium, i.e. the deductibility of R&D expenditures by firms recognised for tax purposes, from a funding ratio of 10% to 12% for R&D expenditure from 2016. As a result, the additional cost of the federal government in 2017 for reimbursing expenditure is calculated at around €100 million. Federal government funding for R&D is therefore expected to reach €3.44 billion in 2017. The funding contributed by the regional governments is estimated at €514.5 million, equating to an increase on 2016 of approx. 4.3% or €21.4 million. Other public institutions (municipal authorities, chambers of commerce, social insurance institutions) account for €121.9 million, meaning an expected increase of 2.7% (+€3.2 million). As such the public sector is expected to fund 36.0% of Austrian R&D expenditure in 2017, with the greatest contribution (30.4%) provided by the federal government (see Fig. 1-3). The proportion of public funding relative to gross domestic product is thereby 1.1%.

The largest proportion of R&D expenditure is attributable to the business enterprise sector with an estimated share in total R&D expenditures of 48.2%. This corresponds with a projected funding volume of €5.46 billion, meaning an increase of around 3.1% or €163.1 million. As such, the business enterprise sector will fund R&D at a rate of around 1.5% of GDP in 2017.

A 3.1% increase (+€52 million) is also expected in the funding contribution from abroad to €1.74 billion in 2017 (equating to 0.5% of GDP), which would mean a share of 15.4% of total expenditure. Most of this amount stems from foreign firms financing R&D in their domestic subsidiaries. However, this also includes funds received from EU research programmes. Given that most of the funding from abroad originates from firms, this results in a private funding share of around 63% of total R&D expenditure when counted together with domestic corporate financing, which comes very close to the EU target of a 1/3 to 2/3 split between public and private R&D funding.

The proportion attributable to the private non-profit sector (non-profit institutions whose status is predominantly private or under civil law, sectarian, or other non-public) remains low

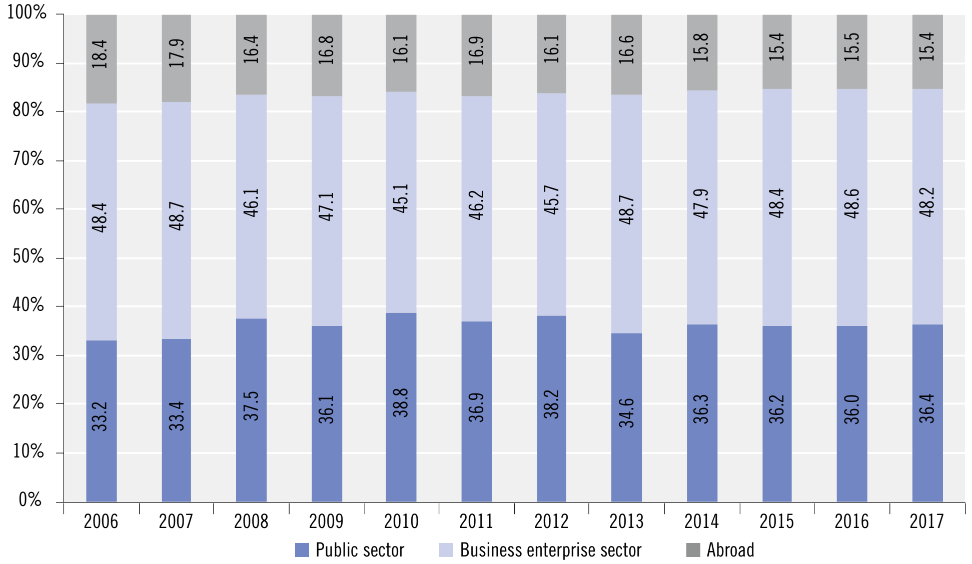
Fig. 1-2: Development of R&D expenditure in Austria by sources of funds (Index, 2007=100)



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

Source: Statistics Austria, Global Estimate from April 20th 2017.

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



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

Source: Statistics Austria, Global Estimate from April 20th 2017.

with a projection of 0.5%, which would mean a slight increase of 2.9% or €1.4 million.

1.2 Austria's position in international comparisons

RTI policy needs comparisons that are as meaningful as possible in order to assess its effectiveness and strategic and operational further development. The different approaches pursued and different measurement parameters currently used in order to be able to compare the research and innovation performance of national economies and determine the position of individual countries are described briefly below:

- **Key Performance Indicators:** Innovation performance is evaluated in this approach using a few indicators that are classified as key. The R&D intensity (R&D expenditure as a % of GDP) is the one most frequently used, e.g. by the European Commission as the key indicator for achieving the Lisbon target from 2000. It is also used by many governments including the Austrian federal government as a target indicator for certain efforts aimed at boosting research and innovation (see the RTI strategy of the Austrian federal government[1]). Some of the benefits of this approach are that progress can be monitored directly and unambiguously and the international position is also easy to determine. However, certain individual indicators are unable to portray all aspects of a multifaceted phenomenon such as "innovation". For instance in the R&D intensity indicator, the transfer of R&D results into technologies and innovations that are successfully introduced on the market is not taken into account. Other indicators frequently used include e.g. patents, which are assumed to represent technological performance and publications, which depict scientific output.
- **Multi-dimensional scoreboards:** Innovation performance is evaluated here using many individual indicators that are aimed at capturing the different aspects of innovation capacity,

1 See BKA et al. (2011).

activity and successes in industry and society. One prominent example for this approach is the Science, Technology and Industry (STI) Scoreboard from the OECD (2015), which includes more than 200 individual indicators. The individual indicators are neither weighted nor are they merged into an overall picture. The Scoreboard provides a differentiated picture of innovation performance, but it does not allow a clear statement to be made either on a country's position in international comparisons or on the progress achieved, since a country generally features both indicators with good or improved performance and indicators with poor or worsened performance.

- **Innovation rankings:** The individual indicators can be merged into an overall index in order to counter the disadvantages with the multi-dimensional scoreboards in not providing an overall picture of innovation performance that can be captured easily. This approach is followed for instance in the European Innovation Scoreboard (EIS) from the European Commission (2016) which aggregates 25 individual indicators into a Summary Innovation Index (SII) in the 2016 edition. Other examples of innovation rankings include the Global Innovation Index[2] and the Innovation Indicator[3]. The overall index allows countries to be ranked and trends to be tracked over time. However, different assumptions do need to be made, for instance related to harmonisation of the measurement level for indicators and their weighting. The overall index is also essentially determined through selection of the individual indicators and their relevance and reliability. Individual indicators which only depict very specific aspects that are often of little significance are capable time and time again of having a major influence on the results of the overall index here. This is why the European Commission also regularly reviews the indicators used in the EIS and makes adjustments, as was done in 2017.
- **Expert assessments:** Measuring innovation using indicators is generally difficult since innovation by definition relates to something new and therefore something that is frequently unique and special and that cannot largely be subject to comparative measurement. Expert assessments are therefore frequently used in addition to the (quantitative) indicators in order to account for the qualitative aspects of innovation more effectively. One example of this approach which covers both the topic of innovation as well as further aspects related to the competitiveness of national economies is the Global Competitiveness Report by the World Economic Forum (WEF)[4]. An executive opinion survey was used to ask around 14,000 firm managers from 135 countries for their assessments on different topic areas. This also captures areas that cannot be captured adequately or at all through quantitative indicators, such as the institutional framework conditions or the quality of the education and research system. Expert assessments are, however, subjective and may be influenced by factors that are not related to innovation, such as political attitudes towards the government or corporate strategic considerations. Managers also often only have a good knowledge of their own country or own firm, and international comparisons of performance based on surveys must therefore always be interpreted with caution.

Different approaches are combined in this chapter in order to portray a picture of Austria's position in research, technology and innovation in international comparisons that is as comprehensive as possible. First, the trends for the three key RTI indicators of R&D intensity, patent intensity and publication activity are considered. These reveal the extent to which funds have been made

2 See Cornell University et al. (2016).

3 See acatech and BDI (2017).

4 See WEF (2016).

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. Secondly, key aspects related to innovation capability and performance and that also include education and market results of innovations are examined using a set of indicators taken from the EIS. Thirdly, Austria's position is examined in international innovation rankings. The report looks at the Global Innovation Index (GII), Global Competitiveness Index (GCI) from the WEF, which includes several innovation-related elements, and the Innovation Indicator (II), which is published by the German National Academy of Science and Engineering (acatech) and the Federation of German Industries (BDI). All three innovation rankings also take expert assessments into account in addition to quantitative indicators. Austria's latest position in the European Commission's European Innovation Scoreboard (EIS) cannot be shown in this year's Austrian Research and Technology Report as the EIS 2017 will not be published until after the Report is printed. The EIS has also undergone a fundamental revision in 2017, meaning that comparisons with Austria's position in the EIS in previous years are of little significance.

The analysis of Austria's position in research, technology and innovation in international comparisons is essentially motivated by the objective set by the federal government of making Austria a member of the group of innovation leaders. 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, 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 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.

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

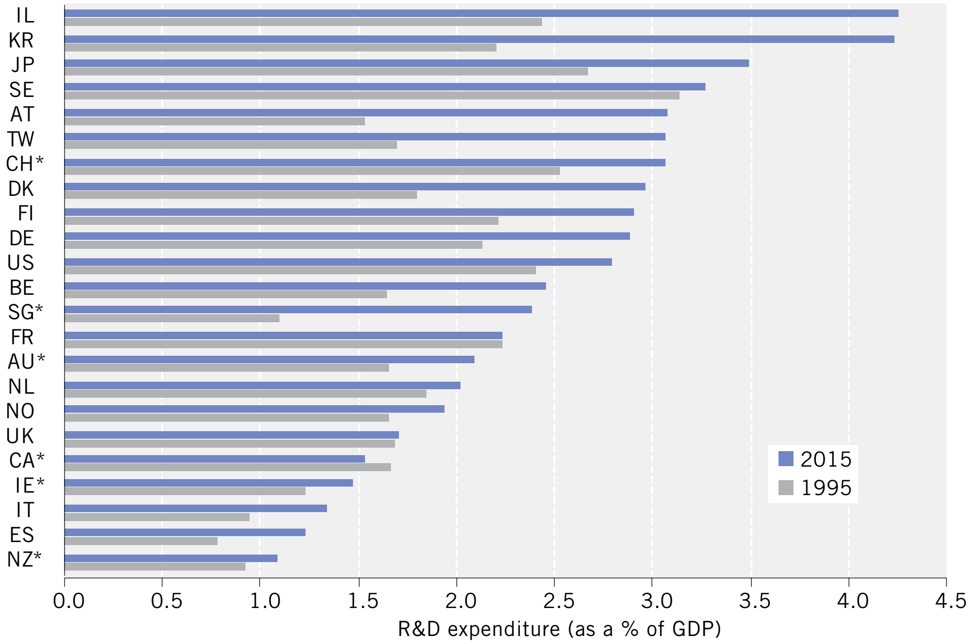
The key performance indicators for research, technology and innovation include the overall economic R&D intensity as a key input indicator along with patent applications and scientific publications, which depict the direct results of R&D.

Total R&D intensity

Austria advanced into the group of the five best-ranked countries in 2015 measured in terms of total R&D intensity. With a value of 3.12% it features the fifth highest value within the reference group (and among all countries in the world). It is ranked 2nd among the EU 28. South Korea, Israel, Japan and Sweden are ranked above Austria (see Fig. 1-4). In 2013, Austria was only ranked no. 9 with an R&D intensity of 2.96%. 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 Switzerland, Denmark and Taiwan, which were all still ahead of Austria in 2013.

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. 1-5). Austria's R&D intensity reached this average value in 2005, since 2008 it has been above average. The gap between the average value for the five top-placed countries on the other hand was barely reduced. This is because individual larger coun-

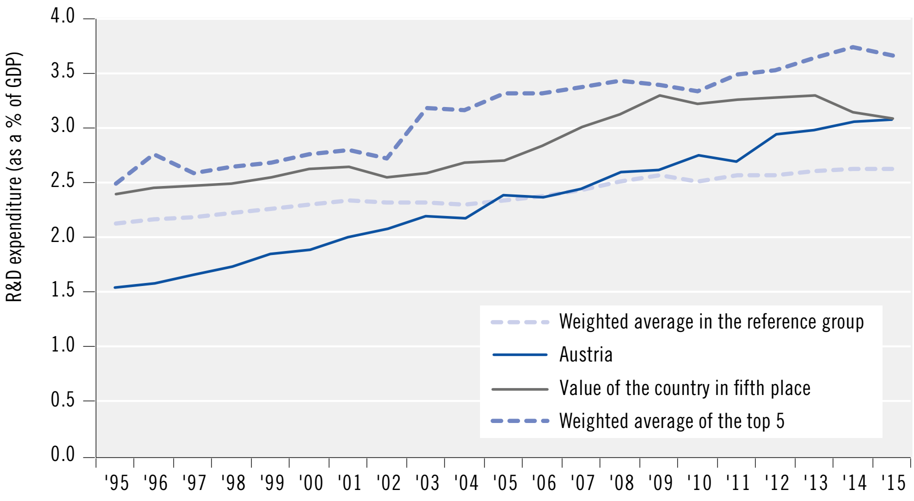
Fig. 1-4: Austria's total economic R&D intensity and that of the reference countries, 1995 and 2013



* values estimated for 2015.

Source: OECD: MSTI, edition 2/2016. Calculations: ZEW.

Fig. 1-5: Development of total R&D intensity in Austria and in the reference group, 1995–2015



Note: estimated or preliminary values for some countries for 2015.

Source: OECD: MSTI, edition 2/2016. Calculations: ZEW.

tries among the top 5 increased their R&D intensity even more than Austria (mid 2000s: Japan, most recently South Korea).

Patent applications

Patent applications are an indication that new technical knowledge is being generated. Only 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 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. This also generally applies to patent applications made on strategic grounds (e.g. in order to block the innovation activity of other firms), since the benefit depends on the fact that the patent actually represents a technical invention. 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 (i.e. a low technical degree of innovation). Only patent applications that are registered internationally, i.e. in different countries, are therefore examined for international comparisons. The OECD 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.[5]

Austria's patent intensity, i.e. the number of triadic patent applications per 1,000 people in gainful employment, was 101 in 2014. This is the tenth highest value among the reference countries (see Fig. 1-6). Japan and Switzerland feature the highest patent intensity. This is followed at a significant distance by Sweden, Germany, South Korea and Denmark. Austria was able to increase its patent intensity by 38 compared with the figure in 1995 and thereby improve on its no. 12 ranking. Only Japan and South Korea feature a considerably higher difference between patent intensities in 1995 and 2014. Switzerland, Israel and New Zealand were able to increase their patent intensity more effectively than Austria, while this was less pronounced for all other countries. Patent intensity even fell considerably in this period in Finland, Sweden and Germany.

As a result of the strong growth in triadic patent applications, in 2014 Austria was able to come close to the average value for the reference group and also came very close to the value of the country ranked in fifth position (Israel) (see Fig. 1-7). The gap between the average value for the five top-placed countries was also reduced considerably. While this average value has experienced a downward trend since 2004, Austria was able to maintain a consistent patent intensity before increasing it significantly once again in 2013 and 2014. Nevertheless the gap between the average for the top 5 remains a significant one.

Scientific publications

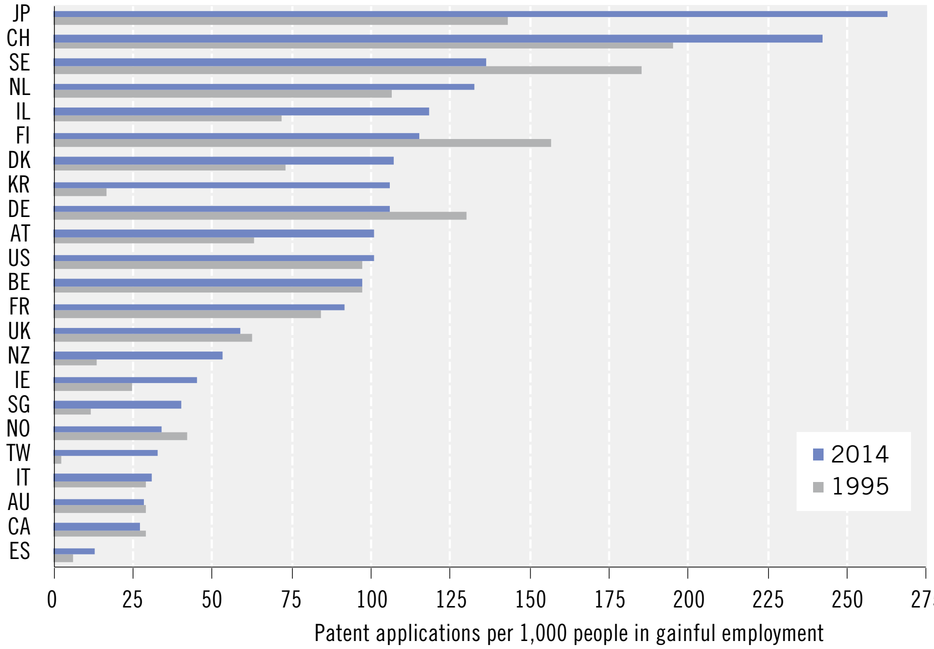
The number of scientific publications is a further indication of the scope of scientific research. There is also a certain control of the relevance since many publications in scientific periodicals and numerous conference papers undergo prior quality control (in the form of a peer review). Publication indicators from SCImago[6] are referred to below as based on the Scopus database and as also used by the OECD for international comparisons on scientific output[7]. This includes all publications of magazine articles, reviews and conference papers recorded in Scopus. Allocation to countries takes place via the authors' institution (main affiliation), with publications by authors from multiple countries counted multiple

5 See OECD (2009).

6 Cf. http://www.scimagojr.com

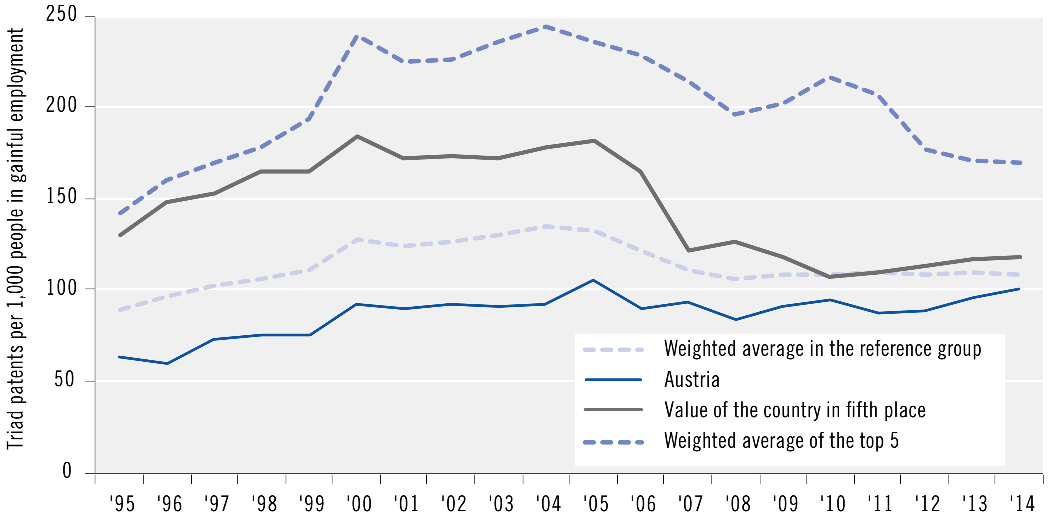
7 See OECD and SCImago (2016).

Fig. 1-6: Patent intensity in Austria and the reference countries, 1995 and 2014



Source: OECD: MSTI, edition 2/2016. Calculations: ZEW.

Fig. 1-7: Development of patent intensity (triadic patents) in Austria and in the reference group, 1995–2014



Source: OECD: MSTI, edition 2/2016. Calculations: ZEW.

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 2014[8] scientists operating in Austria published around 21,000 scientific publications recorded in Scopus. This is around 2.46 per 1,000 inhabitants. As such, Austria is ranked in 12th place among the reference countries (see Fig. 1-8). At 4.67 the publication intensity in Switzerland in 2014 was almost double the amount in Austria. The Scandinavian countries, Australia, Singapore, the Netherlands, New Zealand, Belgium and Canada are also ahead of Austria. If the number of publications is scaled in terms of the number of researchers (calculated as full-time equivalents)[9] instead of in terms of the number of inhabitants then Austria comes closer to the group of leaders. It was ranked 8th in 2014 with a value of 1.32. Ireland, Switzerland, Israel, the Netherlands, Sweden, the USA and Italy are ahead of Austria with this indicator.

The increase in Austria's publication intensity 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 35% above the average value in 2014 (see Fig. 1-9, left chart). The gap between the five leading countries did not decrease, 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. 1-9, right chart). Compared with the relevant best-ranked countries the gap has increased noticeably since 2005. Austria was one of the five best-ranked countries in most years by 2004 with this indicator. 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 full-time equivalents (FTEs) increased by more than 80% between 1995 and 2014 – was essentially responsible for the increase in the absolute number of publications, while the average number of publications per researcher did not increase as a result of the low number of publications per researcher among the new (generally younger) researchers.

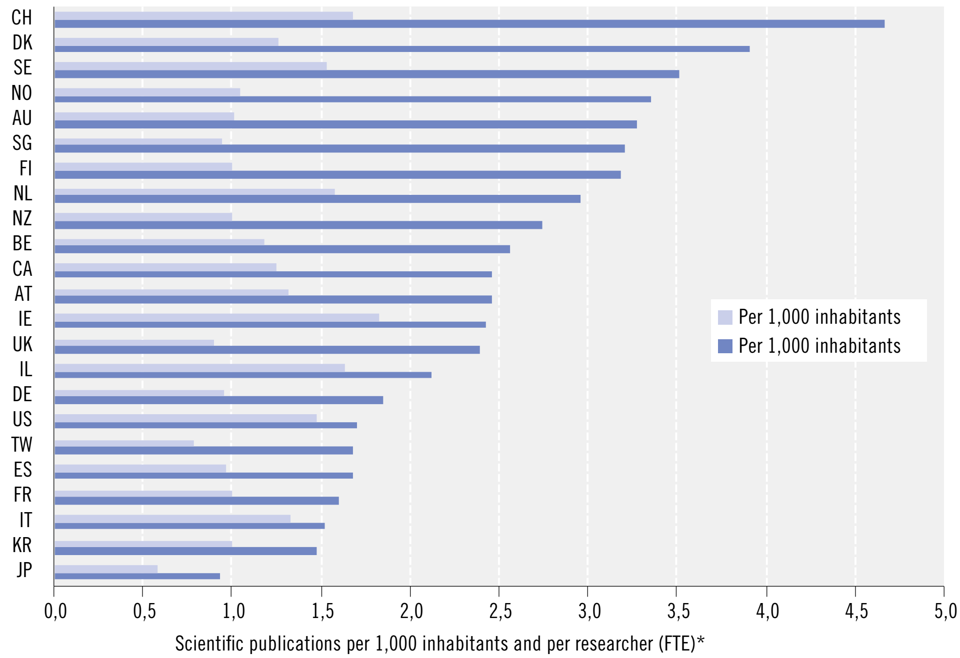
In addition to the number of scientific publications, their reception by the science community also plays a major role, as this reveals the extent to which the research results achieved are seized upon and pursued further by other scientists and academics. The number of times that a publication is cited in other scientific publications serves as an indicator of this. Austria's citation intensity[10] performed more favourably than the reference group average. Austria achieved the av-

8 The SCImago database also contained information for 2015 at the time of evaluation. However, the values appear to have been underreported as they are well below those for the previous years, which is why 2015 is not taken into account.

9 All researchers at universities and state 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 published items at the same rate as researchers from universities and state 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 ("Kooperativer Bereich").

10 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.

Fig. 1-8: Publication intensity in Austria and the reference countries, 2014



* Researchers from universities and government research institutes as well as proportion of researchers in the business enterprise sector in the previous year.

Source: SCImagoJournal & Country Rank; OECD: MSTI, edition 02/2016. Calculations: ZEW.

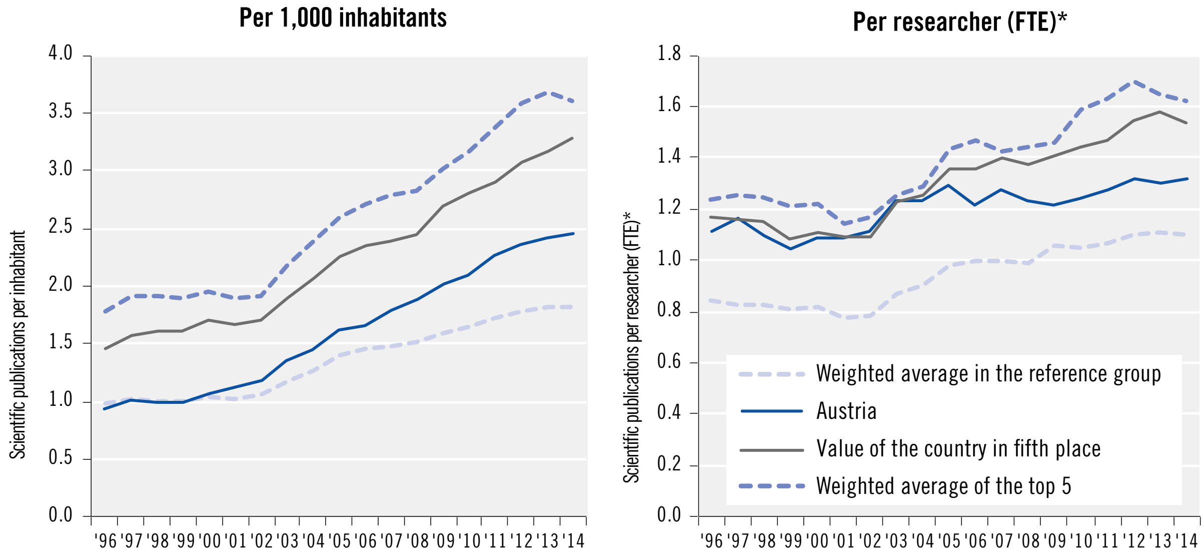
erage value in 2002, since then the gap has increased on average year-on-year (see Fig. 1-10). At the same time Austria has been gradually getting close to the value of the fifth-ranked country. However, the shortfall remains a large one. In 2010 Austria achieved 14th place among the reference countries in terms of citation intensity. Switzerland, Denmark, the Netherlands, Sweden and Singapore occupied the top spots.

1.2.2 Austria's innovation performance from a multi-indicator perspective based on the EIS

The examination of individual key performance indicators of research, technology and innovation presented above masks the fact that it is actually the interaction between many different factors that ensures the long-term success of a national economy in the competition for innovation. High levels of R&D expenditure, numerous patent applications and large numbers of scientific publications are not necessarily an indication of strong innovation performance. It could be that the R&D funds and research results are not used efficiently due to a lack of cooperation, lack of options for funding implementation of new technologies, or because of institutional obstacles. As part of the innovation system approach, the various factors that influence successful innovation activities were arranged conceptually, thereby providing a basis for more comprehensive measurement approaches. The European Innovation Scoreboard (EIS) by the European Commission is one example of this type of comprehensive approach towards measuring countries' innovation performance. The EIS was therefore usually used by the federal government in previous Austrian Research and Technology Reports to gauge Austria's international ranking in research, technology and innovation.

However, this year the EIS cannot be used for the Austrian Research and Technology Report because the deadline for publishing the EIS was set for a date after the Austrian Research and

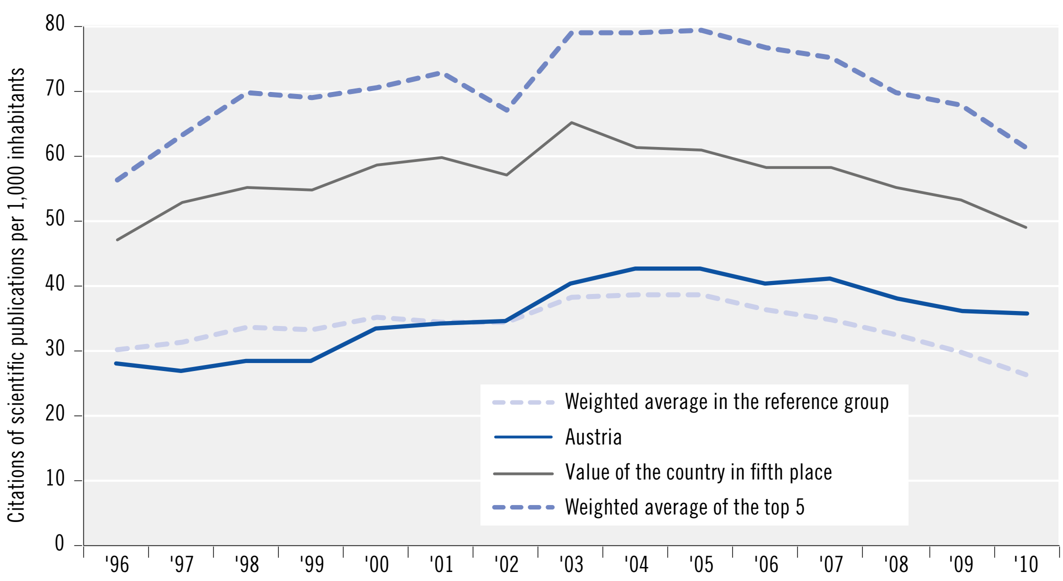
Fig. 1-9: Development of publication intensity in Austria and in the reference group, 1996–2014



* Researchers from universities and government research institutes as well as proportion of researchers in the business enterprise sector in the previous year.

Source: SCImagoJournal & Country Rank; OECD: MSTI, edition 2/2016. Calculations: ZEW.

Fig. 1-10: Development of citation intensity in Austria and in the reference group, 1996–2010



Source: SCImagoJournal & Country Rank; OECD: MSTI, edition 2/2016. Calculations: ZEW.

Technology Report goes to press. The EIS is also undergoing a fundamental conceptual revision in 2017 and the result of this revision is not yet known at the time of reporting. It is therefore not possible to provide a preliminary calculation of Austria's position in the EIS as was done in last year's report.

Instead, an alternative approach has been selected for this Austrian Research and Technology Report that is based on the EIS but only focuses on a subset of indicators. The selection was made in such a way that the indicators map the different aspects of an innovation system's performance and are identified at the same time in international comparisons with high reliability. The following indicators were used:

- New doctorate graduates per 1,000 population aged 25-34
- Percentage population aged 30-34 having completed tertiary education
- International scientific co-publications per million inhabitants
- Scientific publications among the top-10% most cited publications worldwide as a % of total scientific publications of the country
- R&D expenditure in the public sector as a % of GDP
- R&D expenditures in the business enterprise sector as % of GDP
- PCT[11] patent applications per billion GDP (in purchasing power parity – €PPP)
- Employment in knowledge-intensive sectors (manufacturing and services) as a % of overall employment
- Exports of medium and high technology intensity as a % of overall exports

Indicators of scientific publications, patents and on R&D intensity were presented in Chapter 1.2.1. The nine selected EIS indicators also divide the R&D intensity into public and private portions and highlight the level of international integration in science. Two indicators also depict the education system as an important framework condition for successful innovation performance (doctoral graduates and percentage of the population with a tertiary education), two others are (also) impact indicators in that they measure the economic effects of innovation efforts using the proportion of employment in science-intensive industries and the proportion of exports of goods with medium-high to high knowledge intensity. As such, the set of indicators covers many important aspects of an innovation system.

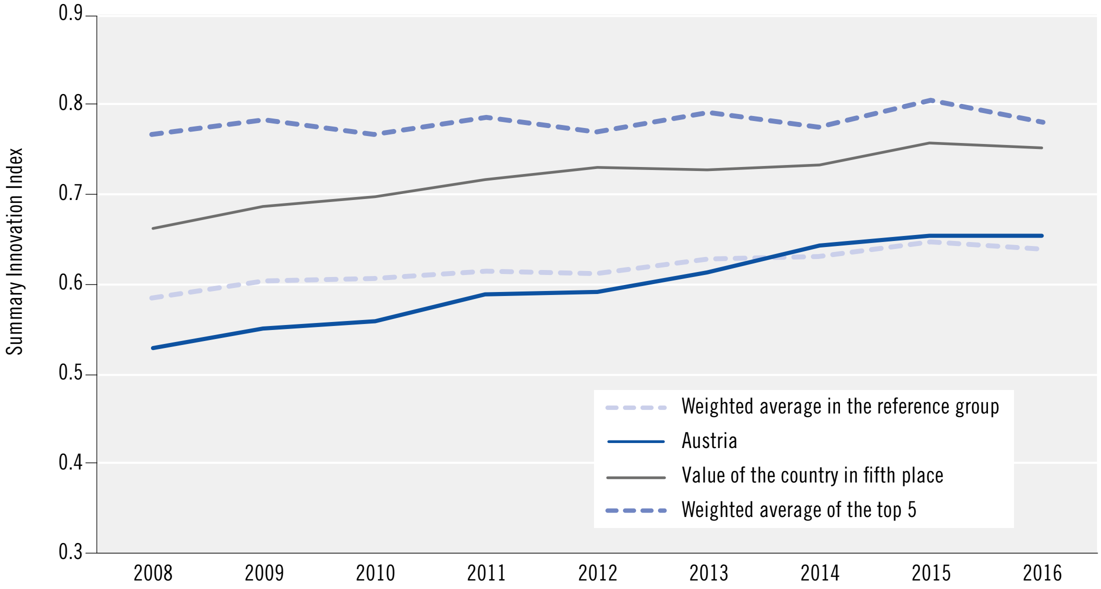
Fig. 1-11 shows the trend for Austria[12] if all nine indicators are scaled identically to the EIS method between 0 and 1 and an arithmetical average of the standardised values is formed for all indicators which can be described as a "Core Summary Innovation Index" (SII). If this indicator is used then a clear catching-up process can be observed since 2008 to the five leading innovation countries and/or to the country ranked in fifth place. The gap between Austria and the top 5 has almost halved significantly from 0.24 index points to 0.13, and has fallen from 0.14 to 0.10 in relation to the country ranked in fifth place. Austria caught up with and just overtook the reference group[13] in 2013. If the process for catching up to the Top 5 progresses at a similar dynamic rate over the next few years then Austria would close in on the group of leading countries in the next five years, based on this reduced EIS set of indicators. However, the gap with the leading countries could not be reduced over the last three years between 2014 and 2016. Austria is currently ranked 8th among all EIS countries in relation to the nine key indicators, which is an improve-

11 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.

12 The EIS publication year is used for this, in accordance with the EIS methodology, i.e. the index value in 2010 corresponds with the values in the 2010 report; however, the underlying indicators stem from previous years.

13 The EIS data is limited in its availability for non-EU countries, meaning that the present reference group only includes 15 countries – the EU countries in the group along with Switzerland, Norway and Israel.

Fig. 1-11: Development in Austria and in the reference group for core SII indicators, 2008–2016



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

ment of two places since 2008, although Austria was ranked in 7th position between 2011 and 2014.

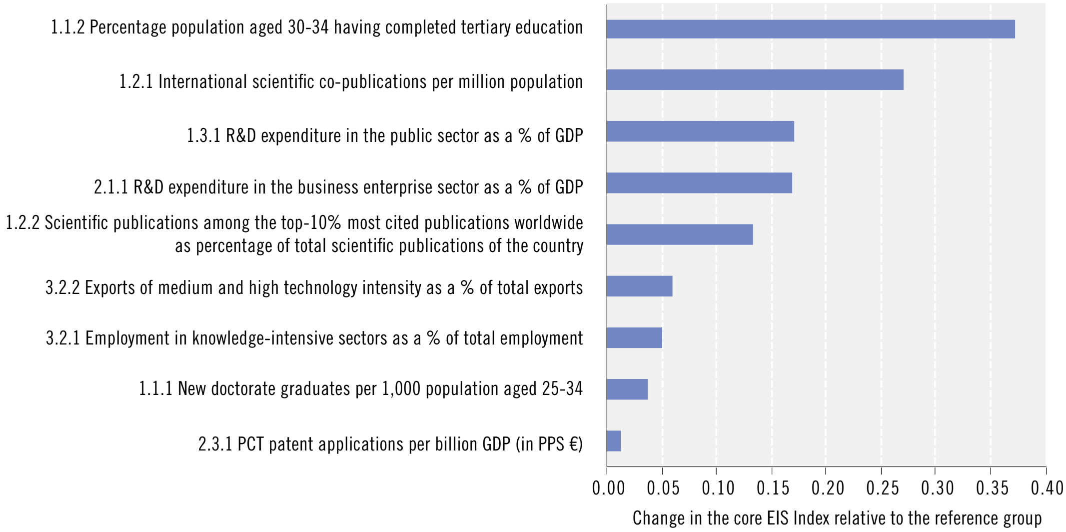
Fig. 1-12 illustrates the change in the individual indicators using the values standardised across all EIS countries, meaning that the change always needs to be interpreted in relation to all countries. Austria always comes off better relative to the other countries. The strongest catching up with the other countries was in tertiary education, with the change from approx. 22% in 2008 to 38.7% in the last available year attributable at a rate of two-thirds to the statistical reclassification of occupational college courses (e.g. higher technical colleges and commercial academies) as tertiary short courses (formerly ISCED 4a, now ISCED 5). There is also a strong improvement resulting from the increase in international co-authorship with Austrian publication authors. The R&D expenditure in the public and business enterprise sectors saw equally strong improvements relative to the other countries followed by the scientific quality of the publications. Smaller improvements can be seen primarily in those indicators that more greatly reflect the result of innovation efforts, such as employment in and exports from knowledge-intensive sectors and patent applications under the PCT procedure. Doctorates are seeing less of an improvement in Austria, not least because doctoral degrees are increasingly designed for scientific careers. In addition, the proportion of doctoral students who are hoping for an additional bonus on the non-scientific labour market through their doctorate is falling.

1.2.3 Austria's position in other international innovation rankings

The Global Innovation Index (GII), the Innovation Indicator (II) and the innovation-related parts of the Global Competitiveness Index (GCI) are three innovation rankings that are created regularly and respected internationally. The GII uses 82 individual indicators and the II 38 individual indicators. The innovation-related parts of the GCI include 31 individual indicators.

Austria is ranked between position 9 (II) and position 17 (GII) in the latest editions of the three rankings (published in 2016/17), which essential-

Fig. 1-12: Development in Austria for core SII indicators, 2008–2016



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

ly reflect the data as at the reference year (see Table 1-1). Austria's position within the EU-28 is between 7th and 10th place. Austria has been able to improve by one position in the innovation-related sub-indicators of the GCI compared with the previous year's editions of the rankings. It remained at position no. 9 in the II but did move down one position in the EU-28 comparison. Austria fell two positions in the GII after moving up two positions in the previous year. The changes in the rankings correspond with similar changes in the Austrian overall index. Austria's result was 1.5 points worse in the GII (from 54.1 to 52.6), while the overall index value remained virtually unchanged at 51.4 as compared with the previous year (51.2). Austria improved on the other hand in the GCI's innovation-related sub-indicators from 5.38 to 5.50 points.

Switzerland is in first place by a clear margin in all three innovation rankings (see Table 1-2) and Finland is also among the top 5 in each ranking. The USA and Sweden are each among the top 5 in two of the three rankings. The gap between Austria and the five countries in the top positions is not very large. In the GCI (innovation-related sub-indicators only), Austria's index value is 4% below the figure for the country in fifth place (following 6% in the previous year), while the gap in the II is 5% (following 9% in the previous year) and 12% in the GII (11% in the previous year)

A comparison of Austria's rankings in the three innovation rankings examined here in the period between 2008–2016 does not provide any clear indication of an improvement in position (see Table 1-3). The current position in the GII (ranked 17) equates to an average ranking. Austria was ranked 14th in 2009, the lowest ranking was 20 in 2013. The gap between the value for the country ranked in fifth place has not changed much over the last few years. The current ranking in the Innovation Indicator represents a relatively good position, and so far Austria has only topped this in 2011 (ranked 8th). The gap between the value for the country ranked in fifth place has never been as small as in 2016. The overall index value is, however, below the values of 2011 and 2013. In the innovation-related parts of the GCI Austria's ranking fluctuates between position 12 (2012 and 2013) and position 15 (2009 and 2010). The gap with the value for the country ranked in fifth place is currently small but does not reveal any clear trend. However, the Austrian index value reached its highest level so far in the latest rankings for 2016.

Global Innovation Index

The GII distinguishes between seven areas with three sub-areas each which, in addition to actual innovation performance, are also aimed at mapping the different framework conditions for innovation activity, including the institutional environment, the infrastructure facilities and the development status for factor and goods markets. The two areas of markets and knowledge/technological output are the main reason for Austria's relatively poor results in the GII compared with the two other rankings; in the markets area this is primarily the unfavourable classification of the credit availability and the evaluation of the stock and venture capital markets summarised under "Investment". The ease of access to credit, the scope of credit granted to industry, protection of minority shareholders, market capitalisation of the domestic firms listed on the national Stock Exchange, the extent of trading of the Stock Ex-

Table 1-1: Austria's position in international innovation rankings, 2016

	Austria's rank			Change compared with 2015 ('+' = improvement in position)		
	all states	EU-28	Reference group	all states	EU-28	Reference group
Global Innovation Index – GII	20	10	17	–2	–1	–2
Innovation Indicator – II	9	7	9	0	–1	0
Global Competitiveness Index – HTBI[1)]	13	8	13	+1	+1	+1

1) Means of the sub-indicators "Human capital and training", "Technological readiness", "Business sophistication" and "Innovation".

Sources: acatech and BDI (2017); Cornell University et al. (2016); WEF (2016). Processing and calculations: ZEW.

Table 1-2: Positions and index values for the countries in the reference group in three innovation rankings, 2016

Ranking	Global Innovation Index – GII		Innovation Indicator – II		Global Competitiveness Index[1)] GCI	
1.	CH	66.3	CH	75.1	CH	6.01
2.	SE	63.6	SG	70.1	NL	5.80
3.	UK	61.9	BE	57.8	US	5.80
4.	US	61.4	DE	55.0	FI	5.77
5.	FI	59.9	FI	53.9	SE	5.75
6.	SG	59.2	UK	52.0	DE	5.74
7.	IE	59.0	DK	51.9	SG	5.73
8.	DK	58.5	SE	51.8	DK	5.65
9.	NL	58.3	**AT**	**51.4**	NO	5.63
10.	DE	57.9	NL	51.4	UK	5.62
11.	KO	57.1	US	51.0	JP	5.58
12.	CA	54.7	IE	50.7	BE	5.58
13.	JP	54.5	KO	50.0	**AT**	**5.50**
14.	NZ	54.2	NO	49.1	IL	5.49
15.	FR	54.0	FR	47.7	IE	5.44
16.	AU	53.1	AU	46.9	FR	5.38
17.	**AT**	**52.6**	IL	46.0	NZ	5.34
18.	IL	52.3	CA	44.8	TW	5.31
19.	BE	52.0	TW	43.2	AU	5.22
20.	NO	52.0	JP	41.8	CA	5.20
21.	ES	49.2	ES	22.8	KO	5.12
22.	IT	47.2	IT	18.3	ES	4.76
23.					IT	4.67
Gap between AT and position 5		12%		5%		4%

1) Means of the sub-indicators "Human capital and training", "Technological readiness", "Business sophistication" and "Innovation".

Sources: acatech and BDI (2017); Cornell University et al. (2016); WEF (2016). Processing and calculations: ZEW.

Table 1-3: Austria's rank and index value in international innovation rankings within the reference group, 2008–2016

		2008	2009	2010	2011	2012	2013	2014	2015	2016
Global Innovation Index (GII)[1)]	Ranking	18	14	18	16	17	20	17	15	17
	Index	3.64	4.46	4.21	50.8	53.1	51.9	53.4	54.1	52.6
	Gap to position 5	16%	7%	9%	11%	13%	14%	12%	10%	12%
Innovation Indicator (II)[2)]	Ranking	12	14	13	8	11	11	14	9	9
	Index	50.3	50.1	49.0	52.6	52.9	53.5	51.4	51.2	51.4
	Gap to position 5	11%	9%	13%	7%	8%	11%	9%	9%	5%
Global Competitiveness Index (GCI)[3)]	Ranking	14	15	15	14	12	12	13	14	13
	Index	5.24	5.15	5.10	5.26	5.44	5.21	5.38	5.38	5.50
	Gap to position 5	7%	8%	6%	6%	4%	6%	4%	6%	4%

1) Change in methodology between 2010 and 2011.
2) Change in methodology between 2013 and 2014.
3) Sub-indicators "Human capital and training", "Technological readiness", "Business sophistication" and "Innovation".

Sources: Cornell University et al. (2016); acatech and BDI (2017); WEF (2016). Processing and calculations: ZEW.

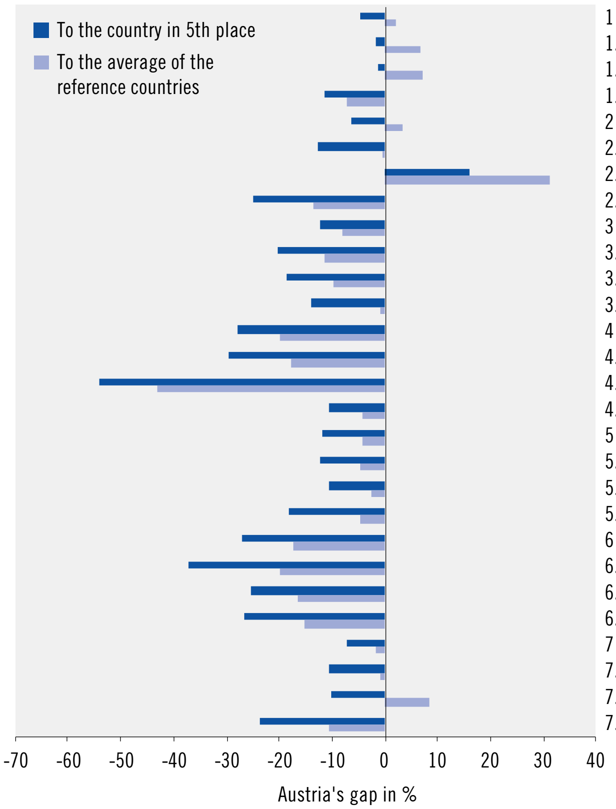
change and the number of venture capital investments are some of the factors examined. Austria is well below the average value for the reference countries for all these individual indicators. In the area of science/technological output it is indicators on scientific publications (which are to some extent measured in accordance with the size of the country[14]), the growth rates in overall economic labour productivity, the start-up intensity and the licensing income from abroad as a proportion of total international trade that drag Austria's ranking down most.

Austria demonstrates a disproportionately good performance in the GII in the area of tertiary education in particular as compared with the average value for the reference group (see Fig. 1-13). The high proportion of foreign students and of university graduates in the natural sciences and engineering are responsible for this. The somewhat poor result in research and development is down to just one indicator which is heavily dependent on the size of the country, i.e. the amount of R&D expenditure of the three firms in a country with the highest R&D expenditure. After New Zealand Austria achieves the second-lowest score here within the reference group; the US and Germany are in the lead. Additional areas of the GII in which Austria is either at or above the average for the reference group are the institutional framework conditions and creative output. The latter is reflected inter alia in a high number of trademark and design registrations, a high number of creative goods and services as a proportion of overall exports, and a high number of top-level domains.

Compared with the previous year Austria was able to improve on its results in the GII 2016 in the areas of tertiary education (student quotas), general infrastructure facilities (investment quota), knowledge acquisition (patent applications), female knowledge workers (employment of highly-qualified women) and creative services (size of the market for entertainment and media services) in particular. The results were clearly worse in knowledge diffusion (direct investments abroad) and online creativity (number of videos uploaded to YouTube). The worst individual result was in the area of trade, competition and market size, since the GII introduced country size (GDP in $ billion in purchasing power parity) as an inno-

14 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.

Fig. 1-13: Austria's position in the Global Innovation Index as compared with the reference group, 2016



Source: Cornell University et al. (2016). Calculations: ZEW.

vation indicator in 2016. There is some doubt as to whether this is a useful indicator since the country size is a given and an increase in GDP through productivity growth is already accounted for in a separate indicator.

Innovation Indicator

The Innovation Indicator assesses a country's innovation performance in accordance with five sub-systems: industry, science, education, government and society. As shown in Fig. 1-14, Austria comes off better than the average of the reference countries in four sub-systems, and the Austrian index value is only below average in the area of society. The poor result in the sub-system society is principally attributable to a low proportion of post-materialist individuals[15] and the low amount of news about research and technology in the media. The sub-system society does, however, only have a low weighting in the overall index, as it only embraces four individual indicators.

Austria's relatively good results in the sub-system industry is attributable in particular to expert assessments on innovation among Austrian

15 Post-materialist individuals are captured in accordance with the Inglehart concept as part of the Global Value Survey. They are characterised by the fact that non-material values are more important to them than material values. This is put into operation in the Survey inter alia using the items "right to freedom of expression" (post-material) versus "fight against rising prices" (material). Higher innovation affinity is imputed to post-materialists, as they have a higher preference for premium quality goods and services.

firms from the survey by the World Economic Forum (WEF), the high R&D expenditure by the firms and a high proportion of public funding of R&D expenditure at firms. Venture capital investments, employment in knowledge-intensive services and the funding of R&D in the science system by firms are negative for Austria. Austria does well in the sub-system science in the indicators international co-publications, number of researchers and amount of R&D expenditure, while the expert assessment of the quality of the research institutes, patent applications from science and publication intensity drag Austria's score down.

The high proportion of employees with a professional education, the high proportion of foreign students and the high number of doctoral graduates in the STEM disciplines[16] contribute to Austria's positive score in the education system. Austria's performance is below average inter alia in terms of the proportion of employees with a university degree, the expert assessment of the quality of education in the STEM area and the results of the "Programme for International Student Assessment (PISA)". The relatively large gap between Austria and the five best-ranked countries in the sub-system government is the result of a relatively low expert assessment of the quality of the education system, relatively low education expenditure per pupil and an unfavourable expert assessment of the government's demand for innovation.

Compared with the previous year's edition of the Innovation Indicator, Austria was able to improve in particular in 2016 on the indicators on foreign students, the number of university graduates, venture capital investments, tax-related R&D funding, patent applications and the amount of news on research and technology. Results were worse in terms of the number of doctoral students in the STEM disciplines, expert assessments of the quality of the education system, public demand for innovation, and the proportion of value creation in the high-technology sectors. It should be noted here that just as with the three other rankings, results may improve or worsen through the fact that other countries increase or decrease their indicators in relation to Austria. The one thing that all rankings have in common is that they determine a country's position for each indicator in relation to the other countries.

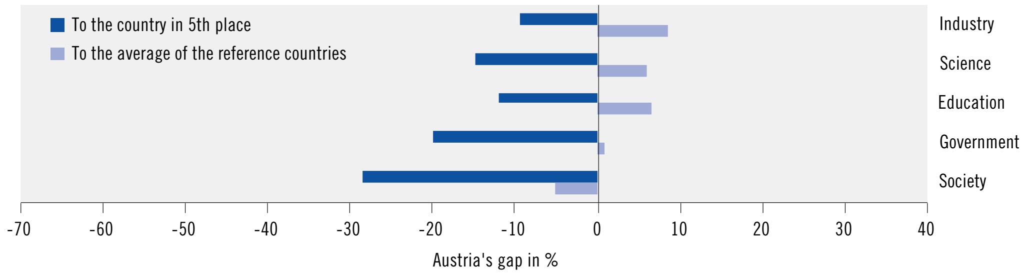
Global Competitiveness Index

The innovation-related areas of the GCI include human capital and education, technological development, business sophistication and innovation. Austria performs particularly well in the area of business sophistication and particularly poorly in technological development (see Fig. 1-15). The three indicators on the IT facilities and usage are responsible for the latter result (broadband connections, internet speeds, mobile internet usage).[17] Austria is in the top 5 of the reference group for four indicators related to business sophistication (expert assessments about the quality of local suppliers, unique selling points, the breadth of value creation chains, and the progressive nature of production methods) and is above average for the reference countries in a further two indicators. Managers of Austrian firms 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 assessment of the availability of further specialised training, the extent of advanced occupational training and the innovation capacities in firms. The gap between Austria and the country ranked fifth in the reference group is particularly large in relation to international patent applications. This is because the applications via the PCT procedure are used in the GCI and not the triadic patent applica-

16 STEM stands for science, technology, engineering and mathematics.

17 Austria's performance is better in other IT-related indicators, see Fig. 1-15.

Fig. 1-14: Austria's position in the Innovation Indicator as compared with the reference group, 2016



Source: acatech and BDI (2017) Calculations: ZEW.

tions, with the former used more frequently by large multinational firms.

Austria was able to improve significantly in the following innovation-related indicators as compared with the previous year's GCI: student quotas, internet speed and in the expert assessments on various aspects on value creation chains, firms' innovative capacities, the quality of scientific research institutes, the availability of scientists and engineers and on various quality-related aspects in the education system. Results were noticeably worse in the expert assessments on the application of technology in firms and on the scope of firms' marketing activities.

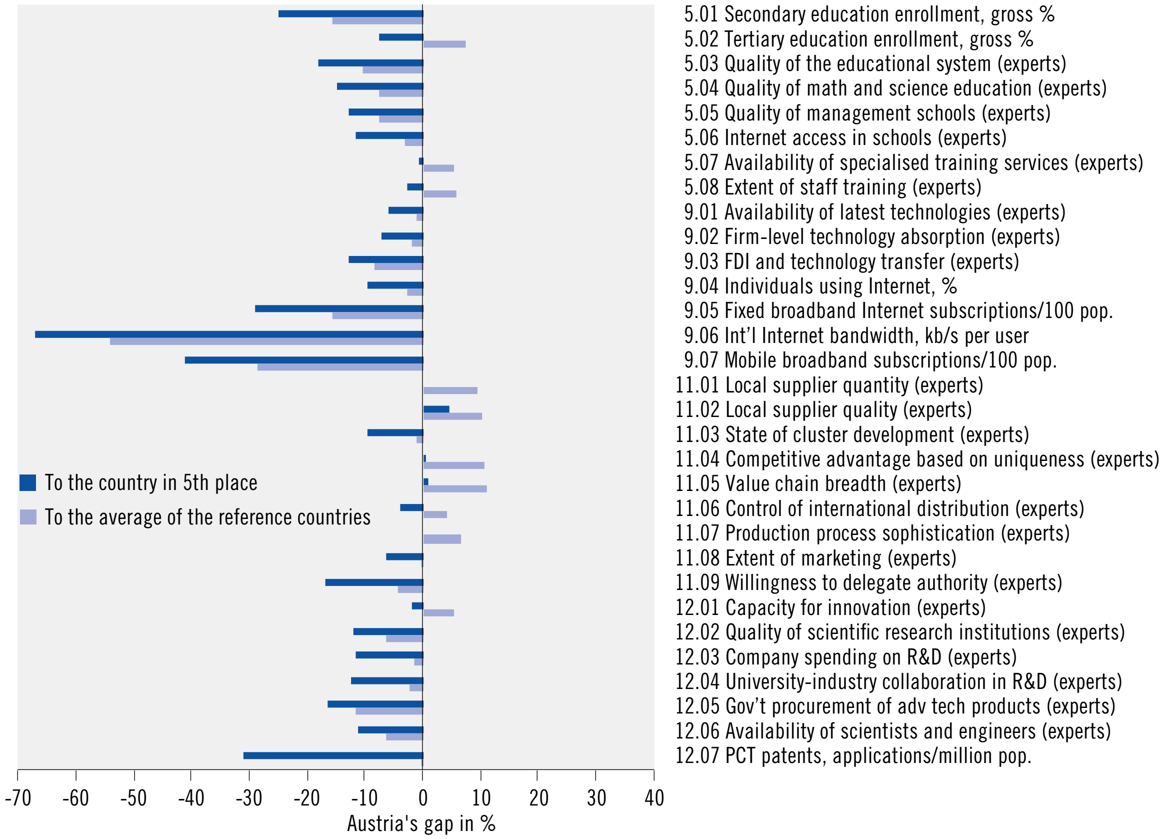
1.2.4 Summary

Austria has improved considerably over recent years in international comparisons with respect to some key performance indicators concerning research, technology and innovations. With a value of 3.12% in 2015 for instance, total R&D intensity reached the second highest value in the EU 28 and fifth highest value among all countries in the world. As such Austria was able to advance into the group of innovation leaders measured against this indicator. There have also been obvious improvements in the last few years for all other key performance indicators such as patent applications, with a clear catching-up process also occurring here, even though a greater gap still remains between it and the leading international countries. Although significant increases have been recorded in scientific publications, these are not enough to reduce the gap with the leading countries, and a fall was even recorded in recent years per researcher in full-time equivalents (FTEs) from a leading position previously. The fact that Austria can first of all progress towards the group of global leaders with R&D expenditure on its way towards becoming an innovation leader is logical to the extent that is needs investment in the research and innovation system before it can then also make progress with the output indicators for research and innovation.

Looking at the broader picture on innovation capability based on a selection of indicators from the EIS which also includes circumstances such as education and the market results for innovation, Austria has almost halved the gap with the leading countries since 2008. However, this is attributable to some extent to reclassification of graduates from occupational colleges, and no clear trend towards closing the gap has been ascertained for the last three years.

In international innovation rankings Austria remains in the middle area of the highly developed industrialised countries and has been unable to move closer to the group of innovation leaders on a sustainable basis over the last few years. This is partly because the catching-up process cannot be observed in all of key performance indicators of innovation. While the dynamic is noticeable with R&D expenditure and patents, scientific publications are currently declining. In addition to this there are also many further indicators used which are often only indirectly related to innovation capability and performance.

Fig. 1-15: Austria's position in the Global Competitiveness Index[1] as compared with the reference group, 2016



1) Sub-indicators "Human capital and training", "Technological readiness", "Business sophistication" and "Innovation".
Indicators with the suffix "(experts)" are based on expert assessments from the WEF survey of corporate managers.

Source: WEF (2016): Calculations: ZEW.

Relatively good results in the Innovation Indicator and in the innovation-related parts of the Global Competitiveness Index are accompanied by rather poor results in the Global Innovation Index. This is to a large extent due to the fact that the Global Innovation Index includes several indicators that are dependent on the size of the country, for which a small national economy such as Austria will never be able to perform well.

Austria's advance towards the group of innovation leaders in the key indicator at least 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. On the other hand there has been no distinct momentum determined in terms of closing the gap in recent years in various more comprehensive indicator systems. In an international environment where all highly-developed countries are focused on boosting their innovative potential, improvements within this group of countries cannot be achieved rapidly, or necessarily on a permanent basis; instead this requires sustained effort and ongoing investment. At the same time, the successes achieved in R&D intensity provide a good basis for increasing the innovation results in future, either in the form of additional value creation in research and knowledge-intensive industries, or through improved market positions for the Austrian economy.

1.3 Strategic measures, initiatives and further developments

The RTI strategy adopted in March 2011[18] constitutes the framework for the targets and longer-term perspectives for the research location Austria. In this vein, the Mid-term Report on the RTI strategy presented in the Austrian Research and Technology Report 2016[19] is another important basis for further work in the context of the RTI strategy. The RTI task force set up with the task of specifying the terms and coordinating the implementation of the strategy and made up of representatives from all relevant ministries (Federal Ministry of Finance (BMF), Federal Ministry of Education (BMB), Federal Ministry for Transport, Innovation and Technology (BMVIT), Federal Ministry of Science, Research and Economy (BMWFW), chaired by the Federal Chancellery (BKA)) also continued its activities in the past year. This boosted the cooperation and reciprocal exchanges with the RTI departments. The past year was characterised by the following priority work areas:

- Discussion and follow-up on the Mid-term Report on the RTI strategy, on the monitoring report by the Austrian Council for Research and Technology Development (RFTE)[20], on Austria's scientific and technological performance, and on the audit report of the Austrian Court of Auditors on research funding in Austria[21]
- Process for dealing with and using patents and the role of the Patent Office
- Implementation of the package of measures aimed at boosting the entrepreneurial culture and start-ups in Austria
- Implementation of the evaluation of indirect research funding
- Exchange of information on strategic initiatives between the ministries (see overview below)
- Conclusion of an inter-ministerial agreement to ensure the organisational anchoring of the Austrian representatives for international science and RTI attachés
- Amendment of the statistics law with the aim of improving the availability of micro data for R&D
- Adjusting the mandates for the working groups deployed by the RTI task force
- Smart Specialisation: implementation of the "Partnership Agreement" between Austria and the European Commission on the European Structural and Investment Funds 2014–2020
- Initial thoughts on a post-2020 RTI strategy and discussion in this regard of an OECD review of the Austrian RTI system

The RTI task force will now meet once a year at the political level in order to discuss the results of operational activities and define a work programme for the next year. The aim is to work on the following topics in particular during 2017:

- Coordination of the preparatory work for the post-2020 RTI strategy, including the Innovation Policy Review by the OECD
- Cost-benefit analysis of a research funding database (in accordance with the Court of Auditors report on research funding in Austria)

In addition to the overall strategy, various ministries have also designed and developed specific initiatives aiming at achieving the targets for the RTI strategy. The following section provides an overview of the latest trends in strategy processes, RTI-related activities, and the implementation of new projects and programmes.

18 See BKA et al. (2011).

19 See Austrian Research and Technology Report 2016, 42 et seq. Federal Ministry of Science, Research and Economy (BMWFW), Federal Ministry for Transport, Innovation and Technology (BMVIT) (2016); http://www.bmwfw.gv.at/ftb

20 Cf. http://www.rat-fte.at/leistungsberichte/articles/leistungsberichte.html

21 Cf. http://www.rechnungshof.gv.at/fileadmin/downloads/_jahre/2016/berichte/teilberichte/bund/Bund_2016_08/Bund_2016_08_3.pdf

Broadband initiative

On the one hand super-fast broadband is a key driver for growth in digitalisation and on the other it also improves the population's quality of life. 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 earmarked as "Broadband billion". The masterplan is based on a flexible funding system in three separate phases. Different funding programmes are aligned with and complement each other in their impact. These tools can be used with differing priorities in the various project phases in order to respond to changes in circumstances.

Around €300 million have been made available in total since 2015 as part of the first phase of the broadband initiative. The monies have been used in individual funding programmes for the Broadband Austria 2020 (BBA2020) funding strategy with various topical foci: BBA2020_Access is dedicated to expanding the broadband networks across the board, BBA2020_Backhaul is being implemented to accelerate upgrades to the existing networks (by connecting with the core networks) and BBA2020_Leerrohrförderung is aimed at prospective planning and establishment of a broadband infrastructure by laying empty pipes as part of digging work. The funds here cover up to 50% of the investment costs for the projects and are awarded based on a technology neutral policy. An external evaluation is planned for each phase in order to record and evaluate the latest broadband cover in terms of surface area and quality as well as strengths and weaknesses of the measures and technologies which can be observed by them.

These three funding programmes support broadband expansion particularly in those areas where there is no existing quality broadband supply and where no plans for expansion over the next few years did exist. 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.

Digital Roadmap for Austria

While there is considered to be enormous and varied potential for digitalisation, the digital transformation also involves major changes and associated challenges for politicians and society. Appropriate political targets and priorities are required along with a commitment from each individual stakeholder in order to make the most of the positive effects of digitalisation and to avoid the critical effects of this transformation process.

The State Secretaries in the Federal Chancellery and in the Federal Ministry of Science, Research and Economy have developed the bases for a digitalisation strategy on behalf of the federal government, supported by a team of coordinators and with the involvement of the federal ministries, municipal authorities, social partners, special interest groups, industry, research and the teaching professions as well as civil society as part of an online consultation. The Digital Roadmap for Austria that resulted from this process[22] was adopted in the Council of Ministers on 24 January 2017.

The activities of all of the ministries are combined and presented in the roadmap in a joint strategic paper from the federal government for the first time. Every ministry is now implementing the necessary measures in its own scope of action subject to the financial coverage by the relevant applicable federal funding framework. Around 150 existing and planned measures and

22 Cf. http://www.digitalroadmap.gv.at

activities implemented with the aim of moving towards the digital future are listed in twelve action areas.

The Digital Roadmap will also be continually updated since digitalisation is an ongoing process. Aside from an accompanying evaluation of the progress with the measures implemented, a Digital Summit will be held at least once a year by the federal government together with stakeholders from the municipal authorities, the social partners, special interest groups, industry, research, and the teaching profession along with representatives from civil society. The federal government uses the "Digital Summit" for the purposes of assessing the challenges and action areas and for drawing the necessary conclusions, and as such it forms the basis for further development of the content of the Digital Roadmap.

"Future of Universities" project

The Federal Ministry of Science, Research and Economy (BMWFW) launched a process in the spring of 2016 with the "Future of Universities" project aimed at ensuring the further strategic development of the Austrian university system, particularly in relation to improving the coordination of study programmes. The corresponding objectives set out in the overall Austrian university development plan 2016–2021 provide the strategic and statutory framework for this project[23], as does the Federal Ministry of Science, Research and Economy's results-based objective of "creating an internationally competitive university and research area with national coordination of teaching and research" in the Federal Finance Act. This is based on the observation that, in an international comparison, there continues to be a high proportion of students in Austria concentrated at the public universities. In addition to expanding capacity in the university of applied sciences sector, the other main objectives for the "Future of Universities" project are setting priorities and improving coordination between the two central areas of the university system. Needs for optimisation have specifically been defined by the Federal Ministry of Science, Research and Economy in the following areas:[24]

- Development of the educational profile for universities (scientific/artistic/professional training – section 3 of the Universities Act (UG)) and universities of applied sciences (practical training at university level – section 3 of the Universities of Applied Sciences Studies Act (FHStG))
- Specialised structuring of the courses offered (coordination of the courses offered)
- Freedom of permeability within the tertiary sector

Corresponding adjustments should be implemented within the framework of the existing legal framework, i.e. with no essential changes to the Universities Act or the Universities of Applied Sciences Studies Act. At the same time, the process represents an important milestone in the move towards the planned introduction of university funding based on capacity.

The process is broken down into multiple stages: Five action areas (AAs) are defined at the first stage in which measures aimed at improving quality and efficiency are due to be developed and implemented in cooperation with representatives from the universities and from the Austrian Science Board:

- AA 1: Alignment between the universities of the courses offered and further development of the universities of applied sciences sector
- AA 2: Life Sciences (particularly in the Greater Vienna area)
- AA 3: Computer science
- AA 4: Humanities, social sciences and cultural studies
- AA 5: Freedom of permeability within and between the higher education sectors

Operational measures and implementation proposals are being developed as part of this coordi-

23 Cf. http://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/wissenschaft/publikationen/2015_goe_UEP-Lang.pdf

24 Cf. https://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/wissenschaft/Zukunft_Hochschulen/Projekt_ZH__INFO.pdf

nation process, which is due to be completed by the summer of 2017. The proposals will then be integrated by the Federal Ministry of Science, Research and Economy in an appropriate form into the various control elements for the universities sector, such as the university development plan, performance agreements, universities of applied sciences, funding plans and the higher education sector structural funds.

Public procurement promoting innovation (PPPI)

The demand-side stimulation of innovation is steadily gaining significance as a complement to the supply-side approaches, such as direct and indirect funding for research, technology and innovation (RTI). The "Guiding concept for public procurement promoting innovation (PPPI) in Austria"[25] adopted by the Council of Ministers in September 2012 forms an important cornerstone for demand-side innovation policy in Austria. The objective is to increase the share of public procurement funding that is used for innovations.

Crucial milestones in the implementation of the PPPI guiding concept under the joint responsibility of the Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry of Science, Research and Economy (BMWFW) up to now include the establishment of a PPPI service centre[26] as a central focal point for PPPI queries, the creation of a network for PPPI expertise and contact points, the inclusion of innovation as an additional procurement criterion in the laws on awarding public contracts, the initiation and support of numerous PPPI pilot projects, and the creation of a Europe-wide one-time online platform[27] for providers and consumers of innovative solutions. Initial steps have also been implemented aimed at developing a comprehensive concept for monitoring PPPI, with valuable practical experience already gained as part of a PPPI pilot survey by Statistics Austria. The award, received in the form of a certificate of recognition at the Austrian Administration Prize 2016, highlights the role of PPPI as a tool in modernising public administration.

The Austrian Council for Research and Technology Development (RFTE) delivers a positive testimonial for PPPI in Austria in its recommendation from September 2016, but does also name some topic areas where there is a need for action: political backing (at the level of tangible, frequently more risky innovation projects) and tangible implementation across-the-board, improvement in the data available on (innovation-promoting) public procurement, raising of awareness and qualification of all those involved in the procurement process along with incentives and distribution of risk.[28]

In November 2016 the Austrian federal government decided to implement further measures in order to exploit the potential of public procurement as a lever for innovation.[29] Adopting the recommendations from the Austrian Council for Research and Technology Development (RFTE), these measures include the introduction of the new procedure for awarding public contracts known as the "Innovation partnership", along with the implementation of pilot projects, expansion of the PPPI project competition as an element that creates incentive, development of a training course for public procurement, and improvement of the data available on procurement and/or PPPI. A total of €10 million is being made available as new funds within the federal funding framework in the period between 2018–2021.

25 Cf. https://www.bmwfw.gv.at/Wirtschaftspolitik/Wirtschaftspolitik/Documents/I%C3%96B-Leitkonzept_2012.pdf

26 Cf. www.ioeb.at

27 Cf. www.innovationspartnerschaft.at

28 See Council for Research and Technology Development (2016).

29 See Federal Ministry of Science, Research and Economy and Federal Ministry for Transport, Innovation and Technology (2016)

Since individual PPPI measures (PPPI events, PPPI service centre) have already been reviewed and judged in a positive light as part of individual assessments, a comprehensive evaluation will be carried out in 2017 of the implementation status for the PPPI guiding concept and the impact already achieved.

IP strategy

Although intellectual property has already become the "key currency" for industry and research today, the awareness of intellectual property, its usage and process for dealing with it professionally are still inadequate in Austria and in most developed countries as well as in international cooperation. Medium-sized Austrian businesses and innovative researchers in Austria in particular can and must be better supported in their efforts to safeguard their intellectual property and in exploiting the commercial property rights arising from this more effectively for future innovations. Only knowledge about the best way to handle and use intellectual property rights strategically will safeguard national and international success and therefore the competitive advantage for Austrian industrial drivers and researchers.

Although Austria performs well in European comparisons concerning intellectual property, a detailed examination does reveal some clear shortcomings. These are in the areas of the legal and institutional framework conditions (government facilities for funding and support), a lack of awareness among the stakeholders of the innovation system for intellectual property, as well as an inadequate understanding and strategic use of the functionalities of the IP system. An understanding should also be created in other topic-based strategy areas of the federal government that IP can also be used as a tool for better achieving the objectives of these strategies.

The IP strategy addresses the following action areas: legal framework, institutional framework, skill sets, raising awareness and conveying knowledge, specific support for innovators and creative types with tangible exploitation of their rights to intellectual property along with interfaces with the federal government's other strategic topics. A total of 36 detailed measures have been developed for these action areas which help improve both the process for dealing with intellectual property rights and the knowledge about these rights, and should make support more effective and efficient.

As a priority, these include the establishment of an overall Austrian portal for the Patent Office (IP-Hub) as a central starting point for all information and services related to intellectual property, redefining and coordinating the service portfolio of the Austria Wirtschaftsservice (aws) (IP coaching at the aws), the Austrian Research Promotion Agency (FFG) and national contact point for knowledge transfer and intellectual property (NCP-IP) as well as inclusion of IP criteria in the funding system, further tightening and sharpening of property right and exploitation strategies at universities and research institutes, establishment of an IP exploitation platform, introduction of a patent cheque to support patenting for research and development, free research for theses and dissertations as well as preliminary patent applications and fast track trademark registration.

A monitoring group is being set up comprising representatives from the relevant ministries, the Patent Office, social partners and selected experts in order to support implementation of the IP strategy.

Creative Industries strategy

As a national economy with a small structure and that is heavily focused on exports, Austria is more reliant than ever on a high level of innovation dynamics as a result of current economic and social upheaval (e.g. globalisation, digitalisation). The creative industries can play a key role in this through their strong innovative and transformative force and can drive changes in industry as a whole.

The first creative industries strategy for Austria presented in June 2016[30] was elaborated in a collective process over several months with the involvement of various stakeholders, and pursues the following objectives:

- Reinforce the Austrian Innovation System
- Boost the competitiveness of the creative industries
- Reinforce the transformational impact of the creative industries on other industries
- Strengthen Austria's image internationally as a country of creative culture and innovation

The eight action areas and 22 measures listed in the creative industries strategy are based on three interdependent pillars aimed at achieving these targets:

- *Empowerment:* measures aimed at boosting entrepreneurial competences in order to make Austria's creative industries even more competitive
- *Transformation:* measures aimed at increasing knowledge and awareness of the transformation potential of the creative industries in order to exploit their transformative impact on other economic sub-sectors, public administration and society
- *Innovation:* measures aimed at improving access to funding and capital in order to broaden innovation skills and expertise in the creative industries and also increase the propensity towards experiments and innovation beyond traditional R&D work

In addition to specific funding programmes for innovation based on the creative industries (such as aws impulse XS and aws impulse XL), the creative industries strategy also provides for improvements in general access to funding. This is why efforts are being made for Austria to participate in the European Cultural and Creative Sector Guarantee Facility which is being administered within the Creative Europe programme, and is aimed at facilitating access to bank loans through collateralisation of the risk.

Strategy for the future for life sciences and pharmaceuticals in Austria

The life sciences and pharmaceuticals sectors are of major importance both from an economic as well as a scientific perspective for Austria as a location for research, innovation and industry. More than 800 firms were operating in the life sciences sector in Austria in 2014 with around 52,000 employees and total revenues of €19.1 billion. A total of 31 universities and universities of applied sciences also have around 59,000 students enrolled in corresponding courses, with around 8,000 of these successfully graduating from their course each year.[31]

A process for developing a "Strategy for the future for life sciences and pharmaceuticals in Austria" was launched in the autumn of 2015 with the aim of further developing the efficiency, excellence, and international visibility of the Austrian life sciences sector and providing the best possible support for this. One key element included in particular anchoring the topic as a key priority for innovation-policy processes and strategies in Austria, in addition to increasing economic and scientific competitiveness.

In order to develop the strategy, 250 stakeholders from science and industry initially analysed the actual status and the ideas for required improvements in a broad-based discussion process. An online consultation on stakeholder involvement was also carried out in addition to round tables and expert discussions. A total of 27 specific measures in nine action areas were formulated on this basis which were put forward in November 2016.[32] The measures include:

30 Cf. https://www.kreativwirtschaft.at/kreativwirtschaftspolitik/kreativwirtschaftsstrategie

31 See aws (2015).

32 Cf. https://www.bmwfw.gv.at/Innovation/Publikationen/Documents/Life_Science_Strategie_barrierefrei.pdf

- *Basic research:* boosting competitive basic research, increasing efficiency and better use of synergies in teaching and research
- *Research infrastructure:* guaranteeing access to a state-of-the-art research infrastructure at national and international levels
- *Big Data:* developing a forward-looking and sustainable concept for e-infrastructures and data management; reviewing involvement in relevant European and international initiatives
- *Personalised medicine:* better coordination of national research activities in the area of personalised medicine, linking in with international initiatives
- *Clinical research:* safeguarding Austria's appeal as a location for clinical research; formation of a working group on clinical research for exchanging information and process optimisation
- *Cooperation between science and industry and translation:* continuing successful programmes for cooperation between science and industry and ensuring effective and efficient processes for the transfer of research findings to industry through formation of a Translational Research Centre (TRC)
- *Firms:* creating excellent conditions for location of firms; leveraging the potential of the funds available for reinforcing the capital market, identifying simplified administrative efforts through a mixed working group (stakeholders, social partners and ministries) and expanding marketing for the location
- *Production and market:* boosting domestic production through improved framework conditions; preparing improvements to market access by employing a mixed working group and pushing forward with innovative public procurement
- *Dialogue between science and society:* broad public acceptance for the significance of science and research as a priority in achieving quality of life, well-being and competitiveness; intensifying the level of knowledge on life sciences in society through continuation of successful initiatives and implementation of open innovation approaches

The time frame varies for implementing the planned measures but the projects generally involve processes for the short to medium term.

Open Innovation strategy for Austria – monitoring implementation

In July 2016, Austria became the first EU member state to put forward a comprehensive open innovation strategy (OI strategy).[33] With the intensive participation of the population and relevant stakeholders, an open-end strategy was created in a development process that demonstrated a vision for 2025. It consolidated the existing challenges into three central action areas, with 14 specific measures derived from them related to how open innovation (OI) can be enshrined in the innovation system as a guiding principle for action.

The national OI strategy pursues three tangible targets: Firstly the Austrian research and innovation system should be developed further through the inclusion of new sources of innovation and by interlinking the various stakeholders. Secondly, innovations should increasingly be generated by incorporating citizens and users into the process, thereby also improving the awareness with respect to innovation among the population. Thirdly this strategy ought to boost the efficiency and focus on results within the Austrian innovation system.

The measures set out in the Austrian OI strategy are implemented by the individual ministries and the relevant stakeholders within their sphere of action. Stakeholders at the federal, state and municipal levels are also encouraged to ensure a vigorous strategy as best they can. At the same time the federal government explicitly invites interested parties from various sectors to initiate their own OI activities.

33 Open Innovation Strategy for Austria, http://openinnovation.gv.at/wp-content/uploads/2016/08/Open-Innovation-barrierefrei.pdf

A monitoring group has been set up with the task of monitoring implementation and further development of the OI strategy. The group surveys the current implementation status for the OI strategy in an annual stakeholder roundtable and then reports on it as part of the Austrian Research and Technology Report. The website[34] represents an important communication tool in this context where examples of best practices and other items can be updated on an ongoing basis. The first status survey for existing examples of implementation in December 2016 revealed a large number of initiatives and projects, of which only a few are stated here as examples.[35]

As the ministries in charge of the process, the Federal Ministry for Transport, Innovation and Technology (BMVIT) and Federal Ministry of Science, Research and Economy (BMWFW) intend to implement the measures set out in the OI strategy for Austria promptly. Administration for the application of OI methods is supported in this context using a matchmaking platform, crowdsourcing challenges and community management within the scope of the Public Procurement Promoting Innovation initiative (PPPI) supported by both ministries. The Federal Ministry for Transport, Innovation and Technology also set up the online platform open4innovation [36] in September 2016 which makes project results from funded research and technological development available to the public[37]. Ministries such as the Federal Chancellery (though GovLab Austria) and the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) and the Federal Ministry of Education (BMB) are also making crucial contributions to the OI strategy in their relevant spheres of action. At the regional government level, Salzburg stands out with its offer to SMEs of strong support and networking for OI. In Upper Austria the city of Steyr has established itself as an important OI player with the project Steyr2030 and the follow-up Nature of Innovation initiative.

In terms of Austrian funding agencies the Austrian Research Promotion Agency (FFG) has a new pilot programme aimed at supporting greater use of open innovation methods and incorporation of different stakeholders in project development processes associated with this. The Austrian Research Promotion Agency (FFG) is also making a crucial contribution to the OI strategy with innovation laboratories and innovation workshops, incentives for early user involvement and setting of OI priorities for SME-specific tenders. The same can be said of Austria Wirtschaftsservice GmbH (aws). Here measure no. 9 in particular is being dealt with, through the establishment of a working group on compensation mechanisms for OI. The planned development of an OI toolkit designed for SMEs could also make it much easier to implement measure no. 10. For the purposes of implementing measure no. 12, "Embed principles of open data and open access in research", the Austrian Science Fund (FWF) is continuing to develop its open access policy consistently in such a way that almost 100% of quality-reviewed publications from FWF projects will be open access by 2020. The Austrian Patent Office is also playing its part in enshrining OI in the R&D community, offering services such as Patent Scan and a planned open data initiative.

In relation to measure no. 6 "Build up research competence for application of open innovation in science", efforts to establish OI in the Science Research and Competence Center (OIS Center) were initiated in the autumn of 2016 by the Ludwig Boltzmann Society (LBG), and funded by the National Foundation for Research, Technology and Development. The universities of applied

34 Cf. www.openinnovation.gv.at

35 An overview of the measures and associated initiatives aimed at implementation can be found in Table 8-4 in Appendix I.

36 Cf. http://www.open4innovation.at

37 The open4innovation platform is based on the success of the professional platform www.nachhaltigwirtschaften.at from the Federal Ministry for Transport, Innovation and Technology (BMVIT) which has been providing research results for more than 15 years as one of the pioneer initiatives in the open access area.

sciences contribute to various measures in the strategy with projects inter alia in the areas of eHealth, IT, awareness & gender, and also provide a large number of examples of best practices on the OI website. The Austrian Institute of Technology and AustriaTech are increasingly relying on OI in the mobility area at times, particularly in the form of innovation and experimentation environments, as stated in measure no. 1. The first of a total of twelve funded projects was launched in summer 2016 as part of the Top Citizen Science funding initiative supported by the Federal Ministry of Science, Research and Economy, Austrian Science Fund (FWF) and OeAD, and to which OI projects can now be submitted. Two further rounds of tenders are due to take place by the end of 2017.

Companies belonging to the federal government such as ASFINAG AG and ÖBB Holding AG are also getting firmly to grips with the issue of OI. ÖBB Holding AG is already implementing specific initiatives that have a broad impact with an OI platform including innovation challenges. At the same time, industry is also heavily incorporated into monitoring of implementation, represented by the Federation of Austrian Industry and the Austrian Federal Economic Chambers.

The examples listed here are merely a selection of ongoing OI initiatives, but they do provide a very good illustration of the existing interest and considerable implementation readiness for OI on the part of industry, science, research and administration. Implementation of the OI strategy is aimed at achieving the vision set out there of positioning Austria as an international role model for the design and control of open innovation systems in the digital age by 2025, based on an active OI policy. Further information on OI is provided in Chapter 3.1.

Austria and FP9

The latest European Research Framework Programme Horizon 2020 is now halfway through its term. Preparations are currently underway for a follow-up programme with the working title FP9. The European Commission is planning to submit the Commission proposal earlier than previous framework programmes because of the elections for the European Parliament in May 2019 and the delay in negotiations they will bring about. The Commission currently plans for a proposal for the Fiscal Framework to be submitted before the end of 2017 for the EU's next budget from 2021. The proposal for the 9th Research Framework Programme (FP9) will be then provided in the spring of 2018. For this reason deliberations on structuring the next framework programme have also started earlier at the national level. Due to the mediating role Austria will play during the presidency of the EU, which is expected to be during a decisive stage of the FP9 negotiations, a deliberate decision has been taken for the federal government not to formulate an official position on the FP9. The Federal Ministry of Science, Research and Economy and Federal Ministry for Transport, Innovation and Technology have instead launched strategic positioning processes.

A group of renowned Austrian experts in the area of RTI policy was appointed as the "FP9 Think Tank"[38] by the Federal Ministry of Science, Research and Economy as the ministry responsible for the EU RTI Framework Programme under the Federal Ministries Act, and had the task of deliberating on future European RTI policy and in particular the next framework programme and developing recommendations. The "Thesis Paper for the next EU-RTD Framework

38 The Think Tank comprised the following people: Martin Baumgartner (Austrian Research Promotion Agency (FFG)), Josef Glößl (University of Natural Resources and Life Sciences, Vienna), Sabine Herlitschka (Infineon), Manfred Horvat (Vienna University of Technology), Andrea Höglinger (FFG), Katja Lamprecht (FFG), André Martinuzzi (Vienna University of Economics and Business), Helga Nowotny (ERA Council Forum), Georg Panholzer (Federal Ministry of Science, Research and Economy (BMWFW)), Wolfgang Polt (JOANNEUM RESEARCH), Martin Schmid (BMWFW, rapporteur), Klaus Schuch (Centre for Social Innovation (ZSI)), Michael Stampfer (Vienna Science and Technology Fund (WWTF)), Brigitte Weiss (Federal Ministry for Transport, Innovation and Technology (BMVIT)) and Matthias Weber (Austrian Institute of Technology (AIT)).

Programme" was published in October 2016 as a first result of the discussions in the Think Tank.[39] A second more detailed paper was presented by the FP9 Think Tank at the end of March 2017.

All stakeholders were invited to discuss the FP9 against the background of the thesis paper as part of the discussion event organised by the Federal Ministry of Science, Research and Economy together with the Austrian Research Promotion Agency (FFG) and the FP9 Think Tank on 10 October 2016. This discussion process was continued in an online consultation on the ERA Portal Austria. The results of the online consultation were consolidated in the "Summary report on the stakeholder consultation for the next (9th) EU Research Framework Programme" and published on ERA.Portal.Austria.[40]

With its technology programmes in the RTI priority areas of energy and environment, mobility/transport, air transport, space, ICT, production and security as well as its structural programmes aimed e.g. at accelerating the pace of cooperation between science and industry and at starting up firms from the academic sector, the Federal Ministry for Transport, Innovation and Technology is ensuring that some important prerequisites are met which enable national stakeholders to participate in the Framework Programme and in European RTI cooperation initiatives (this refers to public-public and public-private partnerships, initiatives under Article 185 and joint programming initiatives). This international linkage is also essential for the high quality of national RTI.

A process was launched by the Federal Ministry for Transport, Innovation and Technology aimed at formulating some key requirements for the EU's future framework programme for RTI from the point of view of applied and/or corporate research. Crucial stakeholders from industry, applied research, the Austrian Research Promotion Agency (FFG) and the Federation of Austrian Industry and the Austrian Federal Economic Chambers were included in this process, which ran between June and October 2016. Positions were worked out with involvement from employees in the Innovation division and the technology transfer and security research team at the Federal Ministry for Transport, Innovation and Technology, working together with the stakeholders involved in the process, based on their extensive experience with the EU's research framework programmes. A position on FP9 was prepared for the Federal Ministry for Transport, Innovation and Technology as a result which sets out the key structural and political, organisational and contextual requirements for FP9.

Silicon Austria

There is a large consensus internationally that the "electronic-based systems" industry (EBS) is increasingly playing a special role for highly developed national economies. This hybrid industrial sector includes firms operating in the areas of electronics and electrical engineering, new high-tech materials, software, frequency technology, measurement technology, automation, process and control technology, micro and nanoelectronics, as well as photonics and system integration. The relevant products include micro and nanoelectronic components, assemblies and measurement, production and control devices along with the associated embedded software, which represent the basis for the value creation chains for complex physical/digital systems, and as a result make countless applications possible in production, energy, transport, health, security, logistics and services. The challenges that will result over the next 20 to 30 years can be seen in the deep structural transformation processes currently taking place: robotisation, digitalisation, automation, "digital smartification" of processes, systems and products. None of this could be achieved without the functionalities of electronic-based systems (EBS). Without EBS automated

39 See Austrian FP9 Think Tank (2016).

40 Cf. https://era.gv.at/object/document/3036/attach/FP9_Synthesebericht_endg_.pdf

driving, the internet of things, smart homes and smart cities as well as applications for Industry 4.0 (to name just a few examples) would all be unthinkable. The Federal Ministry for Transport, Innovation and Technology announced a technology-driven funding and investment programme called SILICON AUSTRIA at the European Forum Alpbach 2016, which is aligned towards industrial policy and has high systemic aspirations. The aim is to bring the innovation ecosystem in the Austrian EBS industry to world class levels. The concepts for this were developed over the last three years in close coordination with the relevant leading Austrian businesses, universities and research institutes.

Silicon Austria is based on the innovation-specific environment that EBS industries require in order to create growth, solve and industrialise complex technological problems, and thereby conquer new markets. The aim is for several tools for intervention to be consolidated in a coordinated and coherent manner in an implementation plan that covers several years.

- The plan is that 3–4 endowed professorships will be established to play a crucial role in eliminating the critical shortages in highly qualified staff over the next few years.
- Between 1–2 pilot factories to address critical issues related to EBS development should be put out for tender in coming years in order to aid faster industrialisation processes (rapid prototyping) and the best possible development environments at the interface between universities and research institutes.
- Two Fab Labs as well as between 4–6 connected regional Makerspaces will be tendered at Austrian universities in order to increase transfer capacities at the universities and raise the number of start-ups in the EBS sector.
- The key element in the programme, however, is the creation of a new world class research centre for EBS, SILICON AUSTRIA LABS (SAL), in order to combine the hitherto fragmented and dislocated capacities in non-university research into a central unit. The SALs are designed to be a clearly identifiable physical centre with long-term prospects and a corresponding infrastructure that represents a permanent landmark in EBS research in Austria and has a differentiated international research portfolio in order to become a leading non-university research centre in Europe.

The Federal Ministry for Transport, Innovation and Technology is stepping up its activities in the areas of electronics and microelectronics through cooperation with the firms involved through the "Silicon Austria" funding initiative. A key element of the initiative is the establishment of a research centre which will begin work during the course of 2017. The centre is complemented by a pilot factory and at least three endowed professorships that will carry out research in the areas of electronics and microelectronics.

2 Major Federal Funding Agencies in Austria

Research, technology and innovation (RTI) make a significant contribution to actively addressing economic, ecological and demographic challenges and strengthening Austria's competitiveness and innovative potential. Austria's funding system for RTI is 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 2016, 624 projects received support from the Austrian Science Fund (FWF), amounting to a total of €183.8 million. The approval rate of 23.7% 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 experimental 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 2016 the Austrian Research Promotion Agency (FFG) approved 3,186 projects with a total funding volume of €398.3 million (cash value). The approval rate for project proposals was 65.4%.
- 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 2016 the Austria Wirtschaftsservice (aws) approved 3,874 funding applications (mainly credits and guarantees), with an overall financing volume of €810.9 million. The approval rate (including competitions and calls for proposals) was 48.3% (70.5% for guarantees and 79.6% for credits).

2.1 The Austrian Science Fund (FWF)

Legal framework and funding aims

The Austrian Science Fund (FWF) is the Austrian central 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, FTF-G). The Federal Ministry of Science, Research and Economy (BMWFW) is responsible for administration of the Austrian Science Fund (FWF), as defined by section 2 of the Research and Technology Promotion Act (FTF-G). 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 planning and programmes of work).
In accordance with section 2 of the Research and Technology Promotion Act (FTF-G), 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 – Society" (supporting practical basic research, funding artistic research, publication and communication and expanding Austrian Science Fund (FWF) grant funding).

Funding approvals fell by approximately 7.8%, from €199.3 million (2015) to €183.8 million (2016)[1] (see Table 2-3). The number of applications considered (2,569) was also smaller, with a total volume of €790 million, which was almost 2% less than the previous year. (Table 2-1) These trends can be attributed to a fall of approximately €22 million in the Austrian Science Fund (FWF) budget available. 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 only criterion used for awarding these competitively allocated funds is scientific quality. For this purpose 4,723 expert opinions were gathered from 66 different countries.

The largest proportion by far of the Austrian Science Fund (FWF) grants is accounted for by staff costs, amounting to approximately 80% spent on employing researchers. On 31.12.2016 almost 4,000 people employed in scientific research were financed by the Austrian Science Fund (FWF). In terms of full time equivalent (FTE) postspositions, most of these were employed as pre-doctoral (1,341.9 FTE) and post-doctoral researchers (1,101.1 FTE). The proportion of female research employees financed by the Austrian Science Fund (FWF) fell by 2.8 percentage points, or equivalently by 6.5%, amongst post-docs in the last year and by 0.6 percentage points

1 The total volume of approvals including supplementary grants fell by around 8%, from €204.7 million (2015) to €188.1 million (2016).

Table 2-1: Number of grants in 2015–2016

Programme	Project proposals		Projects led by women (in %)	Project employees [1]	Stakeholders (Research institutes)	New approvals		Approval rate in %
	2015	2016	2016	2016	2016	2015	2016	2016
Stand-alone projects	1,152	1,090	25	512	43	306	285	26.1
International programmes	599	552	23	110	21	93	98	17.8
Priority research programmes (SRA, NRN) – new applications (Sub-project level)	44	52	17	27	7	9	26	13.6 [2]
Priority research programmes (SRA, NRN) – extensions (Sub-project level)	61	29	14	27	8	53	17	58.6
START Programme	82	70	19	11	3	8	6	8.6
Wittgenstein Prize	21	22	9	n.a.	1	1	1	4.5
Doctoral Programmes– new applications	4	-	-	-	-	4	-	-
Doctoral Programmes – extensions	6	6	33	883	9	6	6	100
Schrödinger Programme	147	182	35	64	17	59	64	35.2
Meitner Programme	185	202	38	50	13	49	50	24.8
Firnberg Programme	78	71	100	16	10	22	16	22.5
Richter Programme (including Richter Programme for the Development and Inclusion of the Arts / PEEK)	77	71	100	29	10	19	16	22.5
Clinical research programme (KLIF)	59	81	31	17	6	5	14	17.3
Programme for Arts-Based Research (PEEK)	40	49	37	31	9	8	8	16.3
Science Communication Programme	27	22	41	9	5	7	6	27.3
Tyrol-Trentino International Project Network	35	-	-	-	-	6	-	-
Top Citizen Science Funding Initiative	-	27	33	14	5	-	5	18.5
Partnership in Research	-	43	21	7	6	-	6	14.0
Total	**2,617**	**2,569**	**31**	**1,012**	**554**	**655**	**624**	**23.7**

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

2 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.

3 This figure includes proposed project staffing and proposed PhD places “fully funded by the Austrian Science Fund (FWF)” (PhD places: 81). Additional PhD places with partial funding (“associated”, total: 134) are not included.

4 The “Total” figure is not the sum of the figures under “Stakeholders”, as any stakeholder involved in more than one programme is only counted once in the overall view.

Source: Austrian Science Fund (FWF).

Table 2-2: R&D staff financed by the agency, 2015–2016

R&D staff	FTE (full time equivalents) 2015 at 31 December	Including women in %	FTE (full time equivalents) 2016 at 31 December	Including women in %	Change in number of women in %
Researchers					
Post-docs	1,207.23	43.0	1,101.07	40.2	-6.5
Pre-docs	1,377.66	43.7	1,341.92	43.1	-1.4
Technical staff*	363.44	56.5	328.75	57.0	0.9
Total staff	**2,948.33**	**45.0**	**2,771.74**	**43.6**	**-3.1**

* Technical and other staff.

Source: Austrian Science Fund (FWF).

Table 2-3: Total funding in € millions, 2015–2016

Programme	Value of funding applications Applications/project proposals		New approvals		Approval rate (approvals/applications) (in %)	Total costs [1]
	2015	2016	2015	2016	2016	2016
Stand-alone projects	356	347.5	91.7	88.1	25.4	89.2
International programmes	148.4	142.6	21.4	22.1	15.5	22.3
Priority research programmes (SRA, NRN) – new applications	16.3	19.8	3	11.7	13.4[2]	11.7
Priority research programmes (SRA, NRN) – extensions	25.7	11.7	21.7	6.9	58.4	7.1
START Programme	95.6	81	9	7	8.6	7
Wittgenstein Prize	31.5	33	1.5	1.5	4.5	1.5
Doctoral Programmes– new applications	9.8	-	8.5	-	-	-
Doctoral Programmes – extensions	16.6	17	13.9	13.7	80.9	14.6
Schrödinger Programme	16.6	22	6.3	8.5	38.5	9.2
Meitner Programme	27.4	31.1	7.2	7.7	24.8	8.2
Firnberg Programme	17.7	16.2	5	3.7	22.5	4.1
Richter Programme (including Richter Programme for the Development and Inclusion of the Arts / PEEK)	22.3	20.2	5.5	4.5	22.1	4.7
Clinical research programme (KLIF)	14.9	20.4	1.2	4	19.4	4
Programme for Arts-Based Research (PEEK)	13.7	15.9	2.6	2.8	17.7	2.8
Science Communication Programme	1.2	1	0.3	0.2	23.4	0.2
Tyrol-Trentino International Project Network	4.5	-	0.5	-	-	-
Top Citizen Science Funding Initiative	-	1.3	-	0.2	18.8	0.2
Partnership in Research	-	9.4	-	1.3	13.6	1.3
Total	**818.2**	**790**	**199.3**	**183.8**	**21.4**	**188.1**

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 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).

(1.4%) among the pre-doctoral researchers, but was expanded slightly amongst technical staff by 0.5 percentage points (0.9%).

In 2016 the majority of new approvals were in the field of Biology (approximately 20%) (see Table 17 in the statistics appendix), followed by Mathematics (approximately 14%) and Medical Sciences / Pharmacology (approximately 12%). At a higher, aggregated level, these structures remain comparatively stable from year to year. This is reflected in the three subject categories of the Austrian Science Fund (FWF) ("Biology and Medicine", "Natural sciences and Engineering", and "Humanities and Social Sciences"), with a rough distribution of 40-40-20.

Consistent with the goal of increased support for basic research, universities were the largest group of funding recipients (see Table 18 in the statistics appendix). They received about 83% of new funding approvals in 2016, followed by the Austrian Academy of Sciences (about 8%) and non-university research institutes (about 7%).

Differentiating between provinces shows that those provinces where there are several university research institutes understandably had/have a competitive advantage in grant approvals So in 2016 Vienna was the region with the highest level of Austrian Science Fund (FWF) funding, with around €109 million, i.e. 59% of the total amount. The remaining federal provinces received a combined total of approximately €75 million (41%) from the Austrian Science Fund (FWF): the largest of these were Tyrol with approximately €26 million (14.3%) and Styria with approximately €23 million (12.6%). Research centres abroad received €0.1 million (0.1%).

The National Foundation for Research, Technology and Development (NFTE) provided matching funds, based on cooperation agreements between the Austrian Science Fund (FWF) and most provinces. 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 regional governments 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 NFTE. In 2016 there were 17 such projects across five states which received a total of €4.2 million in financing.

Strategic developments

The new executive committee of the Austrian Science Fund (FWF) took office on 1 September 2016 under the chair of Klement Tockner. This completed the implementation of the amended Research and Technology Promotion Act (FTF-G): the post of President of the Austrian Science Fund (FWF) is now a full time professional role rather than voluntary.

For several years the Austrian Science Fund (FWF) has supported an effective open access policy. In 2016, 92% of all quality-checked publications listed in Austrian Science Fund (FWF) final reports were available on an open access basis. Working closely with Austrian research institutes and international partners, through initiatives such as the Max Planck Society's "OA2020", the aim is to make almost all quality-checked publications freely accessible by 2020.

Trends in the portfolio of instruments

The Austrian Science Fund (FWF) also seeks private funding for basic research. Existing support from the "Dr. Gottfried und Dr. Vera Weiss-Wissenschaftsstiftung" and the "ASMET-Forschungspreis" was enhanced in 2016 by two further foundations - the "Herzfelder'sche Familienstiftung" and the "Internet Privatstiftung Austria" (IPA). Together these four foundations provide financing for Austrian Science Fund (FWF) research projects totalling €1.6 million per year.

In 2017 the funding portfolio is to be expanded by two new initiatives which will strengthen the competitive elements in research funding. The "1,000 Ideas Programme" focuses on support for new, innovative fields of research, which have great potential, but are also a high-risk category. The strategic plan of the Austrian Science Fund (FWF) also includes financing 100 additional Futures professorships between 2018 and 2021, to help establish the international appeal of Austria as a science location.

The federal government has promised the Austrian Science Fund (FWF) a total of €281 million for 2018–2021, as announced in the presentation to the Austrian Council of Ministers on 8 November 2016. The current allocation of €184

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

Funding programme/initiative	Target group	Objective
Financial funding instruments		
1000 Ideas Programme	Researchers	Funding for research in new, high-risk areas with potential
"Futures professorships"	Universities and research institutes	Creation of competitive career options for top young research talent and promotion of Austria as a research location
Networks	Universities and research institutes	Pooling, processing, analysis and publication of large volumes of digital data in international and interdisciplinary working groups

Source: Austrian Science Fund (FWF).

million p.a. for the Austrian Science Fund (FWF) is being increased year on year with new government funding from the Federal Ministry of Finance (BMF) up to €290 million by 2021. This budgetary increase is intended to facilitate increased scope for innovative projects, to open up research and to establish new forms of cooperation. It could also alleviate emergency measures introduced due to budgetary limitations, such as the "Two-project limit" and the upper limit of €400,000 for funding applications. In addition the Austrian Science Fund (FWF) also plans to take an even more prominent leading role in future in developing the quality of expert evaluation and selection processes. The FWF is also working with research institutes to expedite the further development of an Open Science strategy, as a basis for Open Innovation (see chapter 4.1).

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 of Science, Research and Economy (BMWFW). As a provider of funding services the Austrian Research Promotion Agency (FFG) also works for other national and international institutions (e.g. the Federal Ministry of Finance (BMF), 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 improved equality of 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:[2]

- 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 targeted basic research through to market-oriented development projects (RDI projects), in the form of both stand-alone projects and R&D projects in cooperation 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 talents, develop the qualifications of R&D personnel and improve equality of opportunities
- R&D services required to implement commissioned R&D for research investigations on specific issues

2 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: Number of grants in 2015–2016

Programme structure	Applications		New projects		Participations	Stakeholders	Approval rate in %
	2015	2016	2015	2016	2016	2016	2016[1]
FFG (Total)	**4,392**	**5,270**	**2,803**	**3,186**	**5,497**	**3,113**	**65.4**
General Programmes Area	1,821	2,191	1,198	1,328	1,771	1,322	66.1
Structural programmes area	1,412	1,734	1,186	1,360	2,151	1,352	46.5
Thematic programmes area	1,094	1,264	419	470	1,520	922	43.8
Aeronautics and Space Agency (ALR)	65	81		28	55	38	71.8
European and International Programmes	4		3				75.0

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

Source: Austrian Research Promotion Agency (FFG).

In the 2016 reporting period the Austrian Research Promotion Agency (FFG) received 5,270 applications for funding, of which 3,186 were approved. This represents an increase of approximately 20% in applications, while the number of approvals grew by around 14% compared to the previous year. In the 2016, 65% of all funding applications were approved. The general funding area ("General Programme"), which particularly covers stand-alone projects, saw an increase in project approvals of almost 11%. The structural programmes area, which particularly covers the COMET programme for competence centres, saw an increase of almost 15%, while in the area of topic-based programmes it was 12%.

With regard to the volume of approved funding, in the 2016 reporting year new funding (including loans and liabilities) amounted to €521.5 million. This corresponds to a cash value of €398.3 million. Around 42% of the total cash value of new funding approvals was allocated to the general funding area, 41% to the topic-based programmes area, 15% to structural programmes and 2% to support for the Aeronautics and Space Agency (ALR). There were no funding programmes during the reporting year in the area of European and International Programmes. Within the general funding area the 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 COIN programme which is focused on improving the transposition of knowledge into innovation. In the topic-based area the research emphasis is on energy, mobility, manufacturing and ICT.

As far as the range of topics is concerned, approximately 23% of newly approved funding awards are for the manufacturing sector, 20% for the ICT sector and 17% for energy/environment (see Table 19 in the statistics appendix). Mobility

Table 2-6: Total funding in € millions, in FFG categories, 2015–2016

Programme structure	2015	2016	Cash value 2016	Total costs 2016
FFG (Total)	**467.1**	**521.5**	**398.3**	**1,001.9**
General Programmes Area	283.5	291.7	168.5	563.8
Structural programmes area	26.3	57.9	57.9	131.2
Thematic programmes area	157.1	164.3	164.3	297.5
Aeronautics and Space Agency (ALR)	0	7.6	7.6	9.4
European and International Programmes	0.2	0	0	0

Source: Austrian Research Promotion Agency (FFG).

and Life sciences topics accounted for a further 12% and 11% respectively of the total approved funding in 2016.

An analysis of how Austrian Research Promotion Agency (FFG) funds are distributed among the provinces shows that in 2016, Vienna was the frontrunner with a 28% share (see Table 20 in the statistics appendix). The more industry-oriented federal provinces of Upper Austria and Styria received 23% and 20% of funds respectively. The relative share of funding allocated to Vienna has increased significantly since 2014, and in Styria it dropped significantly in 2016 compared to two years earlier, while Upper Austria maintained its relative share. For the remaining federal provinces the funding statistics show no significant changes.

Strategic developments

In 2016 the Austrian Research Promotion Agency (FFG) placed special emphasis on optimising internal processes. The web-based funding application system eCall was significantly improved and linked to the federal government's business service portal, creating an additional access point to eCall and so to the Austrian Research Promotion Agency (FFG). Further improvements to eCall have made it more convenient for both clients and employees of the Austrian Research Promotion Agency (FFG). To simplify access and orientation for the funding options, particularly for new clients, the Austrian Research Promotion Agency (FFG) and the Austria Wirtschaftsservice (aws) jointly established (in 2016) the internet portal www.foerderpilot.at in 2016. This

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

Funding programme/initiative	Target group	Objective
Financial funding instruments		
Patent.Scheck https://www.ffg.at/programme/patentscheck	SMEs and start-ups	• Improved security for IP • Easier access to professional IP protection • (Timely) Early clarification of the "freedom to operate", providing a sounder basis for decision-making when devising a business model
R&D infrastructure https://www.ffg.at/FuE-Infrastrukturfoerderung_Details	Research institutes and firms	• Update and develop R&D infrastructure as required • Shared use of top quality R&D infrastructure • Support for priority-setting and development strategies for Austrian research institutes • Development and expansion of R&D infrastructure in commercial use by Austrian firms
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	• Create open innovation and experimental spaces (see chapter 1.3 "Open innovation strategy for Austria – monitoring progress") • 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
Services and consultancy		
FFG Quick Check https://www.ffg.at/QuickCheck	all potential funding recipients especially SMEs and start-ups	• Reduce cost of searching for suitable funding opportunities • Develop needs-oriented consulting options for potential funding recipients • Improve targeting of available funding formats

Source: Austrian Research Promotion Agency (FFG).

platform is increasingly becoming the central access point for various federal and state funding programmes, not only for research, innovation and financing.

Trends in the portfolio of instruments

One focus area in 2016 was the further development of cooperation between science and industry, which was reflected partly in thematic calls for proposals in manufacturing, energy research and mobility research, and also in the continuation of structural development projects such as COMET. In 2016 eight new COMET projects received funding amounting to a total of approximately €12 million. These include for example the digitalisation of the waste management industry, or safety aspects of e-vehicle batteries. A new design was also devised for the COMET programme, in collaboration with all stakeholders. Centres are no longer being categorised into two types (K1; K2); this is being replaced by a more flexible modular approach.

There are two new programmes in the portfolio of instruments which aim to expand the traditional scope of R&D project support: research infrastructure funding and funding for patent checking (see Tables 2-7). Research infrastructure funding is designed to help firms and research institutes to install or upgrade R&D infrastructure such as laboratories or measuring equipment, while the "Patent.Scheck-Funding", which is run jointly with the Austrian Patent Office, aims to help start-ups and SMEs with free advice on questions about patents. Demand for both these new instruments has been very high right from the start. The Austrian Research Promotion Agency (FFG) is increasing its efforts to address innovation in all its many forms. Furthermore the approach to innovation, which has previously centred on R&D, is becoming noticeably more open. This will be reflected in the range of programmes available, amongst other things through the "Impact Innovation" programme, which was launched in February 2017. To do justice to the ambition of supporting firms to make more radical innovative leaps and to promote early entry into new areas, a new funding option ("Early Stage"), open to all topic areas, is being offered for enterprise projects at a very early stage of development.

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 of Science, Research and Economy (BMWFW), which appoint the management team and supervisory board of the Austria Wirtschaftsservice (aws). The principals are the owners (the Federal Ministry of Science, Research and Economy (BMWFW) and the Federal Ministry for Transport, Innovation and Technology, (BMVIT)) and other federal ministries, states and public bodies. The Austria Wirtschaftsservice (aws) also supports the implementation of Climate and Energy Fund (KLIEN) programmes.

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 functions of the Austria Wirtschaftsservice as defined in the Act include: protecting and creating jobs, strengthening competitiveness with consideration for the special significance of funding for technology and innovation, supporting research locations by awarding and implementing firm-related federal funding for industry, with consideration of 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 Austria Wirtschaftsservice (aws) focuses principally on five phases of enterprise development through which it supports firms. The enterprise phases, which can be summarised into two core priorities, "new venture" and "growth and industry", are: Entrepreneurial spirit, technology evaluation, new venture, introduction of new products and services, and growth leaps:

- Austria Wirtschaftsservice (aws) guarantees allow the absence or insufficiency of bank collateral to be balanced out, making it possible to obtain third-party financing (credits, mezzanine financing and leasing) and easing this process. In this way they can counteract a capital market failure which inhibits particularly innovative ventures, innovation projects and leaps in business growth, as insufficient securities are particularly common for these projects, giving rise to the concept of a "securities squeeze".
- The Austria Wirtschaftsservice (aws) instrument erp-credit addresses a firm's finance situation, aiming to facilitate access to financing, improve the financing structure and reduce costs of financing. Aws erp-credits offer partic-

Table 2-8: Number of grants in 2015–2016

Programme /Instrument	Applications		Participations	Stakeholders	New approvals		Approval rate in %
	2015	2016	2016	2016	2015	2016	2016
Total	**9,199**	**8,025**	**n.a.**	**n.a.**	**5,126**	**3,874**	**48.3**
Guarantee	1,503	1,458	n. a.	n. a.	975	1,028	70.5
Loan	1,451	1,416	n. a.	n. a.	1,148	1,127	79.6
Subsidy	5,579	4,467	n. a.	n. a.	2,975	1,676	37.5
Participation	666	684	n. a.	n. a.	28	43	6.3

Source: Austria Wirtschaftsservice (aws).

Table 2-9: Total funding in € millions, 2015–2016

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
	2015	2016	2015	2016	2016	2016	2016
Total	**9,199**	**8,025**	**5,126**	**3,874**	**106.6**	**n.a.**	**1,691.9**
Guarantee	1,503	1,458	975	1,028	14.6	n.a.	408.5
Loan	1,451	1,416	1,148	1,127	18	n.a.	722.6
Subsidy	5,579	4,467	2,975	1,676	73.9	n.a.	527.1
Participation	666	684	28	43	0	n.a.	33.7

Source: Austria Wirtschaftsservice (aws).

ularly high planning security for firms, because of their maturity options and low fixed interest rates.

- Aws grants strengthen the equity basis of a firm and so reduce both existing financing hurdles and the costs of financing. Grants are often awarded for new ventures, technologically oriented developments, projects in creative industries and investment initiatives as well as for development and advisory initiatives or for the implementation of intellectual property (IP) measures.
- Equity capital instruments provided by the aws serve to reduce the financing gap for start-up firms and growth-oriented, innovative firms which results from the failure of traditional finance markets in Austria, particularly in the area of equity capital and venture capital financing. Equity capital allows the realisation of innovative, promising but high-risk projects.
- In addition to the four finance instruments the aws also offers non-monetary support in the form of coaching services for businesses and potential investors, through which the users have access to comprehensive know-how of the aws and to existing networks.

Due to the phasing out of broad-impact programmes (e.g. aws Start-up Premium, aws Start-up Cheque) the 2016 trend for the portfolio of instruments shows a reduction in finance approvals. This is reflected primarily in a reduced number of grants awarded. In the area of guarantees (especially with start-up guarantees and double equity) there was a 5.4% increase in approvals in 2016. The high level of applications for aws guarantees illustrates the challenging finance situation for Austrian firms, which are facing a "security squeeze", due to the reluctance of Austrian banks to finance new ventures, or innovation and growth projects.

Financing of €810.9 million was approximately equivalent to the value of the previous year. The value of guarantees was 6.2% or €13.2 million higher than the previous year. The cash value rose by 3.1% to €106.6 million.

With regard to the distribution of grant recipients across different sectors, it can be seen that in 2016 manufacturing accounted for the largest proportion of newly approved funding, with 37% of the total, although this has fallen significantly since 2014 (see Table 22 in the statistics annex). In contrast, the proportion of newly approved funding rose for the services sector, trade and the food and beverages industry.

Around 30% of newly approved funds went to small businesses, followed by 28% to medium-sized enterprises (see Table 23 in the statistics annex). A total of 23% of newly approved funding from the Austria Wirtschaftsservice (aws) was accounted for by sole proprietorships (EPUs) and micro businesses with fewer than ten employees.

The federal provinces of Upper Austria and Lower Austria, with 39% and 17% respectively, received more than half of the total Austria

Wirtschaftsservice (aws) financing in 2016 (see Table 24 in the statistics annex). A further 10% went to Styria and 9% each to Carinthia and Vienna, 7% to Salzburg, 6% to Tyrol, 2% to Vorarlberg and 1% to Burgenland. Compared to 2015, financing was increased in Upper Austria, while the proportion of financing for Styria fell significantly.

Strategic developments

The Austrian Council of Ministers approved the Start-up Package and Investment Initiative, instructing the Austria Wirtschaftsservice (aws) to develop major new financing programmes. In 2017 the aws, as funding bank for Austrian industry, will for the first time offer support totalling over €1 billion – in credits, guarantees, grants and participation as well as services and consulting. New grant instruments will be particularly important here, such as funding for non-wage labour costs, the aws investment premium for growth, the aws venture capital premium, the expansion of aws guarantees and a more flexible approach to aws erp-credits. An additional €100 million per year is planned even for just three Austria Wirtschaftsservice (aws) programmes: Non-wage labour costs for innovative start-ups, Venture capital premiums and Investment premiums for growth. These programmes have been available to funding applicants from January 2017 onwards.

The introduction of the employment bonus to reduce non-wage costs for all firms from 1 July 2017 will not only increase the value of Austria Wirtschaftsservice (aws) financing dramatically, but also make a significant contribution to aws objectives of creating growth and employment. Additional financing of €2 billion will support 30,000 firms in creating 150,000 jobs.

Trends in the portfolio of instruments

Lastly the Austria Wirtschaftsservice (aws) portfolio of instruments has been substantially expanded. At a summit on labour and the economy on 30 October 2015 the federal government had already agreed to strengthen aws guarantees. Measures such as increased upper limits, a greater appetite for risk, reductions in handling fees and guarantee costs, availability of guarantees for non-investment measures for innovation and growth, and a broader geographical base for project guarantees should ensure that from 2017 onwards more guarantees are provided by the Austria Wirtschaftsservice (aws).

The 2017 erp programme and guidelines put forward by the federal government include further improvements and enhancements of the aws erp-credits for firms in Austria: Small aws erp-credits are being expanded to include financing up to €500,000 (with no upper limit for project costs). This allows even more firms very simple access to low-interest financing.

On 5 July 2016 the Austrian Council of Ministers approved two new grant programmes for innovative start-ups: Austria Wirtschaftsservice (aws) funding for non-wage labour costs and the aws venture capital premium. The requirement for both programmes is that the firm applying (to aws for non-wage labour costs), or the firm seeking investors (in the case of aws venture capital premiums) must be an innovation start-up. A subsequent decision by the Austrian Council of Ministers on 25 October 2016 approved the Austria Wirtschaftsservice (aws) investment premium for growth, as an additional financing measure intended to create an incentive for business investments, with the aim of making Austrian firms more inclined to invest, and boosting growth and employment.

The new IP.Coaching and IP.Market schemes continue aws's successful support programme for firms and research institutes seeking commercial realisation of intellectual property rights. The focus of IP.Coaching is on development and implementation of firms' product-specific IP strategies, through coaching and financing. IP. Market is a programme for SMEs in technology development and for research institutes which supports commercial realisation and transition to market for innovations or new technologies, taking them beyond the firm or research institute.

New funding initiatives still at the planning stage involve a programme for funding non-wage labour costs for additional employees, the "Translational Research Center for Life Sciences", and equity capital initiatives. A key factor here is the so-called "Employment bonus", a programme for funding non-wage labour costs for additional employees, approved by the Council of Ministers on 21 February 2017. In line with the strategy for the future "Austria as a research location for life sciences and pharmacology" (see Chapter 1.3), the Austria Wirtschaftsservice (aws) is planning to establish a "Translational Research Center", focusing on medical biotechnology, with co-financing from the industry; this will strengthen the potential for developing drugs and the commercial exploitation of existing research strengths in Life Sciences. Two more equity capital initiatives are also in preparation: The "Uni Spin-off Fund" is intended to mobilise venture capital for entrepreneurial spin-offs seeking commercial exploitation of research results from Austrian universities, and the "Private Equity Growth Fund" provides venture capital to finance Austrian firms in the expansion phase. For both these initiatives a substantial share of the investment capital comes from public funding (via aws).

Table 2-10: Austria Wirtschaftsservice (aws) New initiatives and funding instruments

Funding programme/initiative	Target group	Objective
Financial funding instruments		
aws funding for non-wage staff costs	innovative and high-growth small and micro enterprises	Grant for innovative start-ups providing jobs for the first time
aws venture capital premium	innovative and high-growth small and micro enterprises	This funding programme is designed to facilitate access to venture capital for innovative start-ups. Funding is provided for investors' participation in innovative start-ups.
aws premium for growth investment	SME	New investments in a place of business in Austria
Premium for growth investment for large firms	Large firms (not SMEs)	New investments in a place of business in Austria
aws employment bonus	All firms	Funding for non-wage staff costs for additional employees
AplusB scale-up	Incubators, consortia	RTI-based new enterprises with high growth potential in an academic environment
Translational Research Center	Universities, Biotech, Pharmaceuticals	Commercial implementation of university-based drug development
Uni-Spin-off Fund	Innovative Spin-offs	Venture capital for entrepreneurial spin-offs seeking commercial exploitation of research results from Austrian universities
Austrian private equity growth fund	innovative and high-growth small and micro enterprises	Follow-on financing for (capital-intensive) further development steps for start-ups
Services and consultancy		
aws IP.Coaching	technology-based SMEs	Development and implementation of the IP strategy
aws IP.Market	technology development SMEs and research institutes	commercial exploitation and transition to market for innovations or new technologies, taking them beyond the firm/research institute
Förderpilot.at/24 h Quick Check	All firms	Overview of Austrian research and industry funding

Source: Austria Wirtschaftsservice (aws).

3 New Innovation Paradigms

This chapter presents some current trends that are fundamentally changing the ways or the outcome of innovation activities (also referred to as "new innovation paradigms").

Chapter 3.1 describes such a change using the example of "opening" up innovation processes: science and industry have been confronted with a paradigm changed for some time now – from traditional, somewhat closed innovation concepts in which the innovation activity is primarily focused on a single stakeholder (firm, research institute), to newer approaches that are currently summarised under the term "open innovation" and in which a number of stakeholders collaborate on the innovation process. Examples of such newer and more open innovation processes include collaborative, user-driven innovation, co-creation and crowdsourcing, in which a number of research institutes, firms or users are involved in the innovation process. This chapter will present and discuss the driving forces behind the development of open innovation and which empirical findings have been found for Austria.

A further paradigm shift is being pursed in RTI policy in many countries: attempts are increasingly being made to promote so-called "radical" innovations – against the backdrop of the observation that it is these kinds of innovation in particular that tap into new areas of business, often establish new economic sub-sectors and form the basis for the rapid growth of successful firms. However, there are many characteristics that determine the radical nature of change and thus there are also different concepts underlying the corresponding political approaches. Chapter 3.2 therefore distinguishes between the term "radical innovation" and related terms such as "scientific breakthrough" and "ground-breaking developments" and attempts to establish clear definitions. This is followed by an international comparison of Austria's performance in terms of the quality of research, inventions and innovations as well as a discussion of RTI intervention options to support "Major Innovations" that combine both new technological developments and economic effects. The chapter will conclude with an examination of current discussion processes on a national level regarding support for innovative and risky research.

Finally, a further new innovation paradigm known as "responsible research and innovation" (RRI) has gained traction in Europe in recent years. Established as an interdisciplinary issue in the European Research Framework Programme, Horizon 2020, RRI's goal is to integrate different aspects of responsibly managed research and innovation that meets societal requirements (e.g. participation, openness, ethics, gender) into specific research activities, while also addressing aspects of open innovation. The companies' demands for the quality of the research and innovation process must therefore be specifically defined. Chapter 3.3 presents the practical implementation of RRI in Austria and, among other things, showcases "citizen science" approaches, with the goal being to strengthen the dialogue between science and the general public.

3.1 Open innovation, copyrights and trademarks

The topic of open innovation (OI) has been attracting increasing attention in innovation policy and practice over the past ten years. When looking for new possible solutions for changing technological and market developments (including digitalisation), firms are opening up their networks and innovation processes to select external stakeholders, such as research institutes, suppliers and sometimes even competitors. There have also been signs of increased awareness among firms and researchers for the involvement of citizens and end users in the innovation process ("co-creation") to find new innovative paths together. Exploiting the potential for innovative forms of networking, exchanging knowledge and cooperating in a global digital world present a particular challenge for small, open and highly developed economies such as Austria. Information technology, the internet, new social media and the creation of knowledge markets are the particular drivers and characteristics of OI.

While creating innovation requires a degree of openness, the commercialisation of innovations also needs certain mechanisms (depending on the business strategy) to protect knowledge and resources, with rights to intellectual property playing a major role here. Open innovation processes and deeper cooperation therefore also raise questions about how to handle intellectual property as well as about options to protect it via intellectual property rights (IPR). Although these can represent an incentive for innovation activities, in many cases they also pose a barrier to the exchange of knowledge or the further development and diffusion of innovation. In addition to protecting intellectual property, the commercial options and possibilities for the direct marketing of rights and intellectual property, i.e. licensing, are also relevant here. It is often unclear to many firms and research institutes where they can sensibly implement IPR and which effects are directly associated with this. This poses new challenges both for firms as well as for RTI policy.

Against the background of the open innovation strategy processes (OI strategy) ongoing or already completed in Austria as well as the different options to utilise IPR in innovation processes (see Chapter 1.3 "IP strategy"), the following chapter provides an overview of the goals and motives of OI activities and a glimpse of the empirical findings for Austrian firms. This is followed by an overview of trends on European level as well as a presentation of initiatives and measures on national level.

3.1.1 Goals and motives

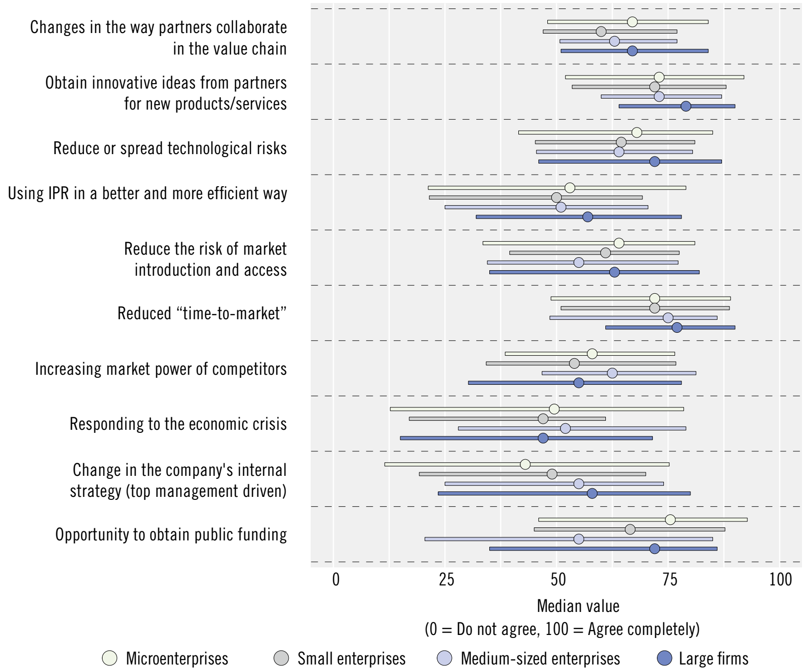
The idea of open and interconnected innovation is based on the premise that firms' innovation activities increasingly comprise information and knowledge that were originally developed beyond their traditional frontiers.[1] Interaction and cooperation with customers play a particularly important role in the use of external sources of ideas and innovation. This type of OI is referred to as an "outside-in strategy". However, OI also means the commercialisation of as many ideas and technologies developed within the scope of R&D activities as possible, with different external sources, stakeholders and channels being used in this process (also known as "inside-out strategy"). Examples of this include the founding and funding of spin-off firms, the licensing of patents and the formation of joint ventures and alliances.

Innovation processes are characterised by phases that have different levels of openness.[2] In practice, this leads to a combination of somewhat closed and somewhat more open innovation activities, with the latter involving primarily complementary partners. The acquisition of external knowledge (outside-in) is interwoven with the marketing of ideas (inside-out) to be able to devel-

1 See Chesbrough (2003).

2 See Dahlander und Gann (2010).

Fig. 3-1: Drivers and motives for cooperation with partners (by size of firm)



Note: n = 465-606.

Source: European Commission (2016). Calculations: JOANNEUM RESEARCH.

op innovations together.[3] A series of such forms and strategies, all of which can be seen as forms of OI, has taken hold in recent years. Examples include the concepts of "user-driven innovation" and "crowdsourcing", in which users are actively involved in the innovation process.

According to a recent study[4] on a European level, firms associate the term OI above all with access to and the use of cooperation platforms, conducting cooperation projects with trustworthy partners, the use of IPR developed externally as well as sharing intellectual assets developed internally with other firms. An interesting finding was that OI is rarely associated with topics such as venture capital and entrepreneurship, crowdsourcing or the in-kind provision of infrastructure for external parties. The main reasons to get involved in OI include:

- Obtaining innovative ideas from partners regarding new products and services (70 % of all firms)
- Reducing the time to market (66% of all firms)
- Decreasing or spreading technological risks (59% of all firms)
- The option to benefit from public funds (56% of all firms)

As Fig. 3-1 shows, the involvement of external partners in the firm is closely connected with the corporate strategy and upper management stipulations. Smaller firms, which typically have a flexible and often more informal structure, are also able to be flexible in their cooperation with external partners. The opportunity to obtain public funding for cooperation projects is also considered to be a major motivation for very small companies. Similarly to large firms, SMEs also

3 See Enkel et al. (2009).

4 See European Commission (2016). The purpose of the study was to create and consolidate an EU-wide basis of information regarding the concepts of open innovation and knowledge transfer (KT) as well as their perception and diffusion in firms, universities and research organisations. An online questionnaire of firms in the EU-28 formed part of this study.

view cooperation with external partners as an opportunity to minimise technology-related risks and to actually launch products on the market. Medium-sized firms are also motivated by the fact that their competitors would potentially be able to expand their market power.

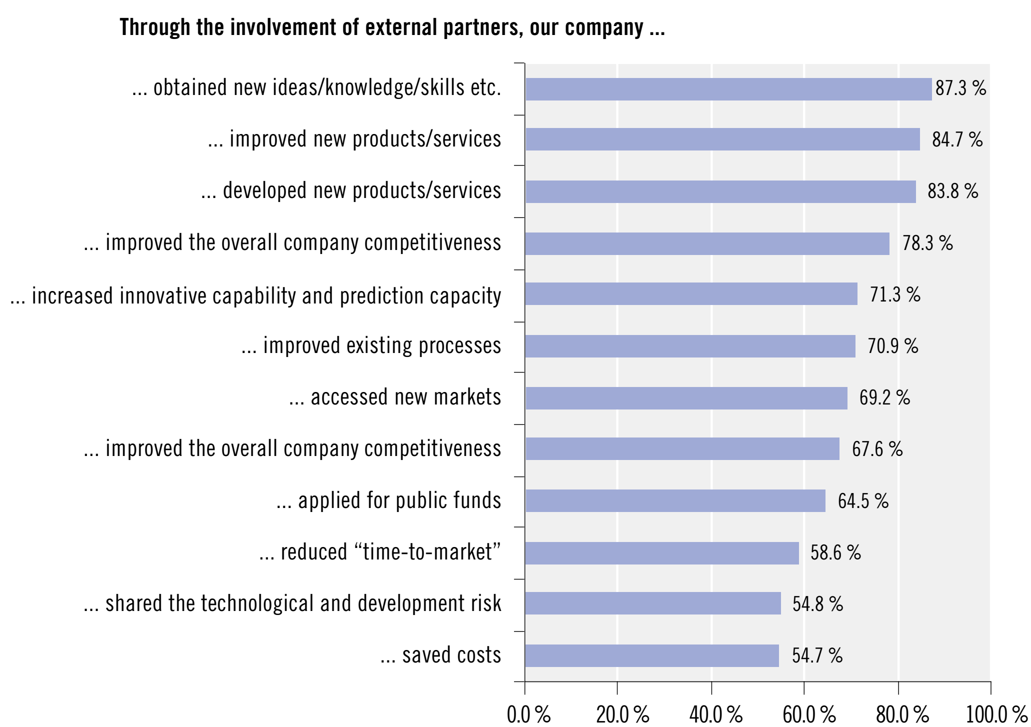
The most important mechanisms of inside-out strategies include (1) confidentiality agreements, (2) contract research and (3) publicly funded cooperation research. Inside-out activities with education and research institutes are preferred over those with other competitors. In addition, it was ascertained that the spin-off activities of larger firms are more likely to take place or be developed with partners of education and research institutes than with other companies. Central outside-in mechanisms include (1) IPR approvals, (2) the use of science parks and (3) recruiting or hiring experts from other firms. Co-creation is therefore taking place more and more throughout the entire innovation process, from R&D to the market-preparation phase.

As presented in Fig. 3-2, the most important effects of cooperation with external partners include (1) the acquisition of knowledge, skills and ideas, (2) the improvement of existing products and services and (3) the development of new products and services. 78% of firms were able to increase their competitiveness by implementing such activities, with 71% improving their innovative performance.

3.1.2 Empirical findings for Austria

The results of an empirical study on the distribution of open innovation models at Austrian firms

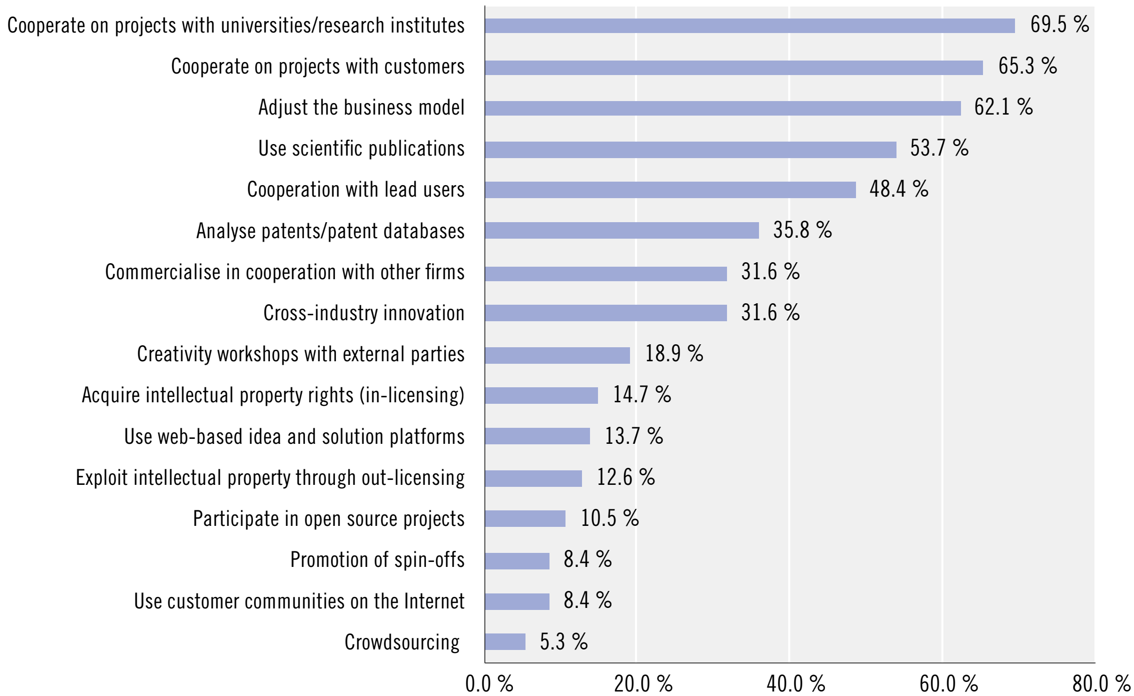
Fig. 3-2: Effects of cooperation with external partners on the innovation process



Note: n = 505-576.

Source: European Commission (2016). Calculations: JOANNEUM RESEARCH.

Fig. 3-3: Use of external sources of information and alternative methods of commercialisation



Note: The question was as follows: Which of the following activities do you do use in order to develop external sources of information or commercialise your own ideas? (The chart shows the proportion of firms that consider their own activities to be relevant or very relevant in the areas).

Source: Leitner et al. (2015).

conducted in 2014 are presented below.[5] The study was conducted at 95 innovative firms with more than ten employees in the production sector and at selected service providers.[6] It provided the first broad, empirical evidence of the significance and prevalence of OI on firm level in Austria.

The study first queried the motives for the increasing opening up of innovation and participation with external parties. It showed that the identification of new technology trends was the most important aspect (87% of firms state that this is relevant or very relevant), directly followed by better information about customer requirements (80%), risk minimisation (65%), time saved (62%) and market access (60%). The results were consistent with the literature, showing that innovation-based motives outweighed efficiency-based expectations.[7]

In terms of motivation, this pattern is therefore largely similar to that in the European-level study mentioned above. The most significant sources from which Austrian firms absorb external knowledge are cooperation projects with customers as well as universities and research institutes, which are used to a large or very large extent by 65% and 69% of firms respectively (see Fig. 3-3). Such cooperation projects enable firms to foresee or even set new trends and developments on the market. More recent online-based

5 The empirical data collection was conducted as part of a study for the Austria Wirtschaftsservice (aws) (see Leitner et al. 2015).

6 Larger firms are somewhat overrepresented, comparatively speaking, which must be taken into account accordingly when interpreting the results.

7 See Enkel (2011).

Fig. 3-4: Barriers to the introduction of Open Innovation

Note: The question was: How relevant are the following barriers in terms of implementing OI strategies in your firm? (The chart shows the proportion of firms that categorise the barrier as relevant or very relevant).

Source: Leitner et al. (2015).

forms of cooperation and interaction, such as crowdsourcing, open-source developments and communities of customers are utilised to a lower extent (only around 10-15% of firms use these to a high or very high extent). These methods are primarily applied in larger firms.

The survey identified further barriers as well as potential strategies and methods for overcoming them. Sixty-seven percent of firms stated that, if they were to open up innovation processes, they would have major concerns about protecting their critical, internal expertise against being leaked (see Fig. 3-4). In business practice, expertise is often kept secret, especially when there are no suitable legal safeguards. Further obstacles to the introduction of business OI strategies come in the form of the organisational changes required, the development of corresponding business models and the lack of financial resources. If the barriers for the introduction of new innovation models are additionally analysed based on firm size, significant differences are found: for instance, large firms have problems forming a suitably open corporate culture and are more likely to complain about drawn-out internal procedures.

A typology for adaptation can be created to analyse the penetration of OI. Based on the application of different approaches and methods of innovation management, three classes can be formed: 24% of firms were categorised as pursuing an OI strategy. This group includes firms that exploit at least four out of twelve new open innovation methods[8] to a large or very large extent. The group of firms that pursue select cooperations with external parties ("selective OI strategy") represents the largest category at 53%. These firms apply select OI methods and have some cooperation with selected customers. The remaining 23% of firms practically have no coop-

8 They were asked about the following: lead users, cross industry, idea and solution platforms, creativity workshops with external parties, crowdsourcing, customer communities, open-source projects, commercialisation in cooperation, spin-offs, firm acquisitions, licensing as well as adapting the business model.

eration with other market stakeholders, and only occasionally with certain customers or other external parties. These can therefore be allocated to the category of "closed innovation strategy". The study also shows that firms that pursue OI strategies invest more in research and development (R&D) on average.

The increasing relevance of OI raises the questions of what is the best way to help firms to introduce new, open innovation models and how the barriers identified can be overcome. For 73% of firms surveyed, financial support for projects with a focus on OI in the form of public funding would be suitable or very suitable to overcoming barriers. This is important for small and medium-sized firms in particular. Public funding would help these firms introduce new innovation strategies and encourage them to find new ways to organise and manage innovation. Exchanging information and experience with other platforms was considered to be beneficial by 69% of firms.

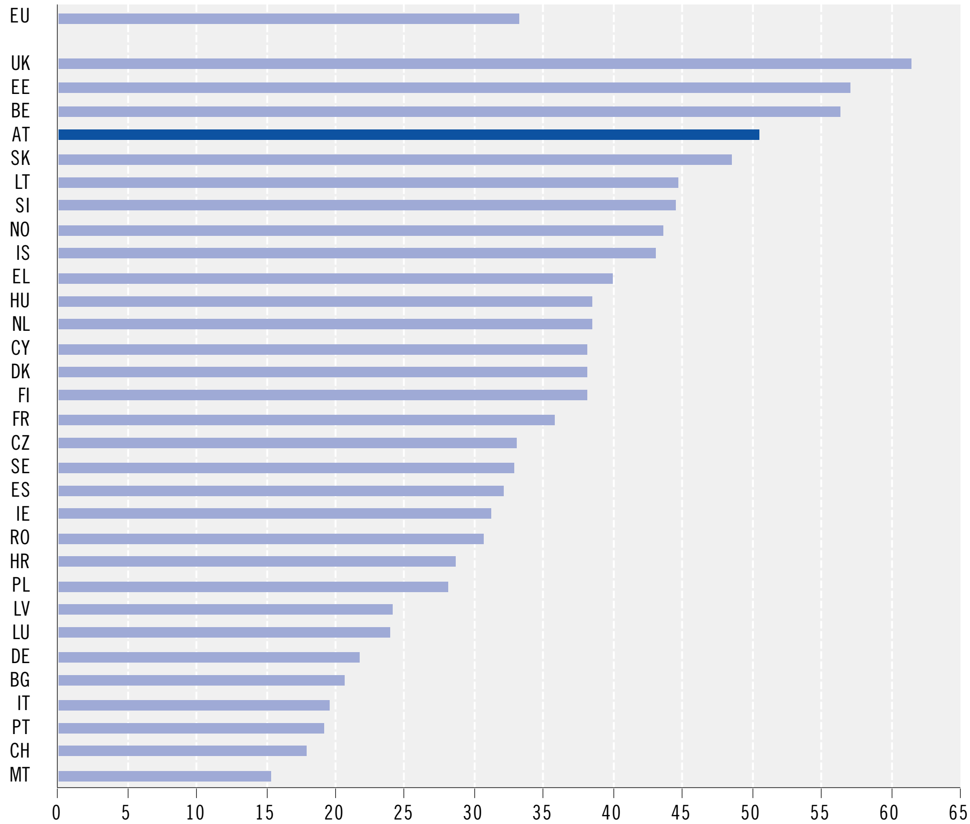
3.1.3 An international comparison of empirical findings

To compare the propagation of OI and the use of protective rights for intellectual property in Austrian firms on a national basis, results of Europe-wide innovation surveys and those conducted by Eurostat (Community Innovation Surveys – CIS) are available. In the most recent survey, which was conducted in 2015 and referred to the 2014 reporting year (CIS 2014), information on, for instance, partnerships as part of innovation activities, the use of IPR as well as the licensing of IPR was recorded. It was found that Austria had a high proportion of cooperating firms. In the 2012–2014 period, 51% of firms had at least one form of cooperation on product or process innovation activities, which is significantly higher than the EU average (33%). A comparison of the results of the four most recent innovation surveys suggested that the focus on cooperation for innovation processes was not part of a long-term strategy in many Austrian firms, as the proportion of innovative firms in cooperations varies greatly: in the 2010–2012 period, this was 43%, and the level in 2008–2010 was the same as in 2012–2014 (51%), but was only 30% in 2006-2008. Thus a clear trend towards an increased focus on cooperation cannot be detected. The situation across the EU as a whole is somewhat different, with the proportion of firms involved in cooperation rising consistently from 24% (2006–2008) to 33% in 2012-2014.

The proportion of innovative firms with innovation cooperation was only higher than Austria in three European countries in 2012–2014 (see Fig. 3-5). The United Kingdom records the highest proportion (61%), with Estonia and Belgium also reporting over 50%. Interestingly, the proportion of cooperating innovative firms in some countries that are generally particularly innovative is very low. This applies to Switzerland (18%) and Germany (22%) in particular. The Scandinavian EU member states were also significantly behind Austria, at rates of between 38% (Denmark) and 33% (Sweden). In any case, the results for Switzerland and Germany indicate that firms that have close and indirect cooperation can also successfully implement innovation strategies.

As Fig. 3-6 shows, Austrian firms cooperate with a variety of different partners. The most frequent cooperation partners in 2012–2014 were suppliers (56% of all cooperating firms), followed by universities (45%), other firms within the same group (43%), customers from the economic sector including private households (37%), consultants, engineering companies and technical laboratories (35%), competitors including other firms from the same industry (29%), research institutes (24%), as well as customers from the public sector (14%). When the firms were asked about their most important cooperation partners, other firms in the same group were on the same level as suppliers (both 24%), followed at some distance by universities (16%) and customers from the industrial sector (13%). In comparison to the EU overall, firms' own corporate group, competitors and customers play a somewhat

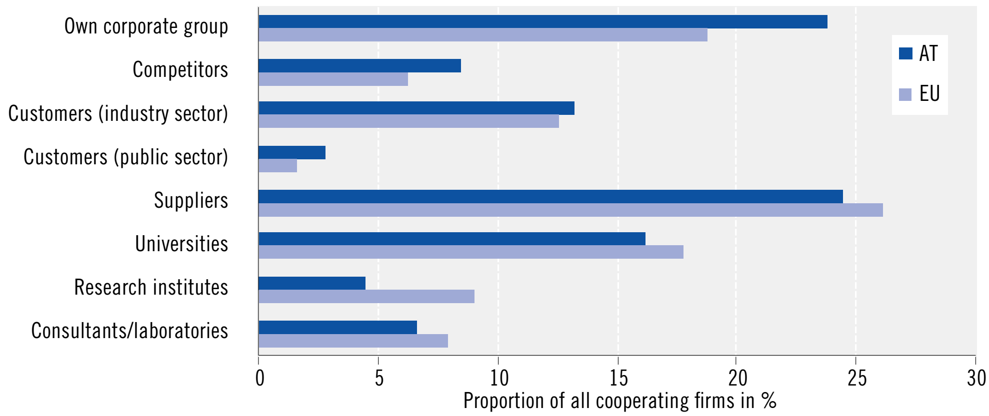
Fig. 3-5: Prevalence of innovation cooperation in firms by European countries, 2012–2014



Number of firms with innovation cooperation as a proportion of all firms with product or process-innovation activities in the previous three-year period. All information refers to firms with ten or more employees.

Source: Eurostat: CIS. Calculations: ZEW.

Fig. 3-6: Most important partners in innovation cooperation of firms in Austria and the EU, 2012–2014



Proportion of all firms with innovation cooperation. Part values add up to 100%. All information refers to firms with ten or more employees.
EU not including BE, DK, IE, LU, FI, SE, UK.

Source: Eurostat: CIS. Calculations: ZEW.

Table 3-1: Prevalence of innovation cooperation in firms from Austria and the EU, 2006–2014

Proportion of all innovating[d] firms as a %		2006–2008	2008–2010	2010–2012	2012–2014
Austria	Industry[a]	31	51	44	50
	Services[b]	28	51	42	51
	Total	**30**	**51**	**43**	**51**
EU[c]	Industry[a]	24	29	29	32
	Services[b]	24	29	33	35
	Total	**24**	**29**	**31**	**33**

All information refers to firms with ten or more employees.
a: Sections B to E of the NACE vers. 2
b: Sections H, J, K and departments 46, 71, 72, 73 of the NACE vers. 2 (departments 59, 60, 72 and 73 from 2012 only)
c: 2008 and 2010 EU 27, EU 28 from 2012; 2012 not including SI, 2008 and 2010 not including EL
d: Innovating relates to product or process-innovation activities in the previous three-year period (i.e. for 2014: 2012 to 2014)

Source: Eurostat: CIS. Calculations: ZEW.

larger role as the most important cooperation partners, with research institutes, universities, suppliers and consultants lagging behind. Overall, the cooperation behaviour of Austrian firms is tailored more strongly towards the market (customers, competitors) than the acquisition of knowledge and technology (suppliers, research, consultants).

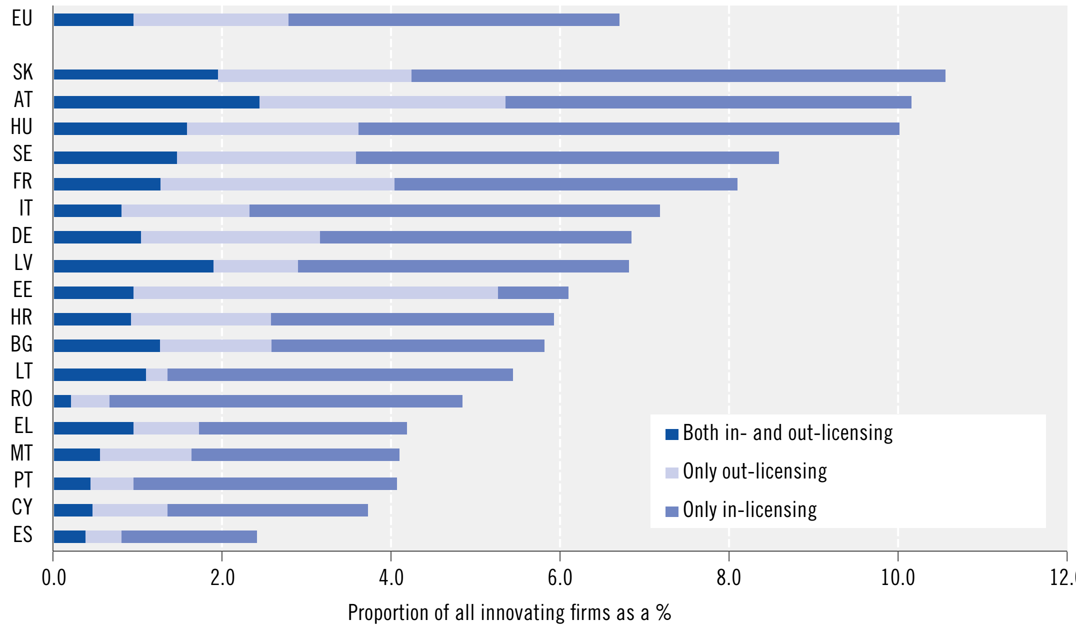
The regional orientation of cooperation differs from the European average in this respect, since a higher proportion of firms in Austria (60%) collaborate with partners from elsewhere in Europe as part of innovation cooperation programmes (EU: 40%). This is probably due largely to the size of the country since the proportion of firms that only cooperate with domestic partners is significantly higher in the larger countries in the EU, primarily reflecting the various cooperation options in a large country with numerous stakeholders. In terms of cooperation partners outside of Europe, the situation in Austrian firms is in line with the EU average.

In addition to cooperation, the in-licensing and out-licensing of knowledge and technology is a further indicator of the openness of innovation processes. This form of exchange of innovation results was compared on a Europe-wide scale for the first time in the 2014 innovation surveys. Out-licensing refers to the licensing or sale of patents, community designs, copyrights or trademarks to other firms or institutions. In-licensing comprises the licensing or purchase of patents, community designs, copyrights or trademarks from other firms or institutions; this does not include the acquisition of licenses for standard software. On the basis of this definition, Austrian firms rank among the most active in the area of in-licensing and out-licensing in Europe (see Fig. 3-7). In the 2012–2014 period, 10.2% of innovative[9] firms in Austria were involved in either in-licensing or out-licensing of the intellectual property rights cited. Slovakia is the only country to beat Austria, with its proportion of innovative firms involved in licensing being slightly higher at 10.6%. If we look at firms that are involved in both in-licensing and out-licensing, Austria ranks first place among all countries in Europe at a proportion of 2.4%. If we only look at the firms that grant licenses for their own intellectual property rights to third parties or sell such rights, Austria is also in first place in a European comparison with 5.4%. Austrian firms are also already very advanced when it comes to the use of OI in the form of opening up the acquisition and exploitation of intellectual property.

The possession of such rights is required before a license can be issued or intellectual property rights sold. Information about the prevalence of

9 "Innovative" here includes firms with product or process innovation activities as well as companies with marketing or organisational innovations.

Fig. 3-7: Firms with out-licensing and in-licensing by European countries, 2012–2014



Proportion of all firms with product or process innovation activities as well as firms with marketing or organisational innovations. All information refers to firms with ten or more employees.
The value for the EU relates to the weighted average for the member states listed.

Source: Eurostat: CIS. Calculations: ZEW.

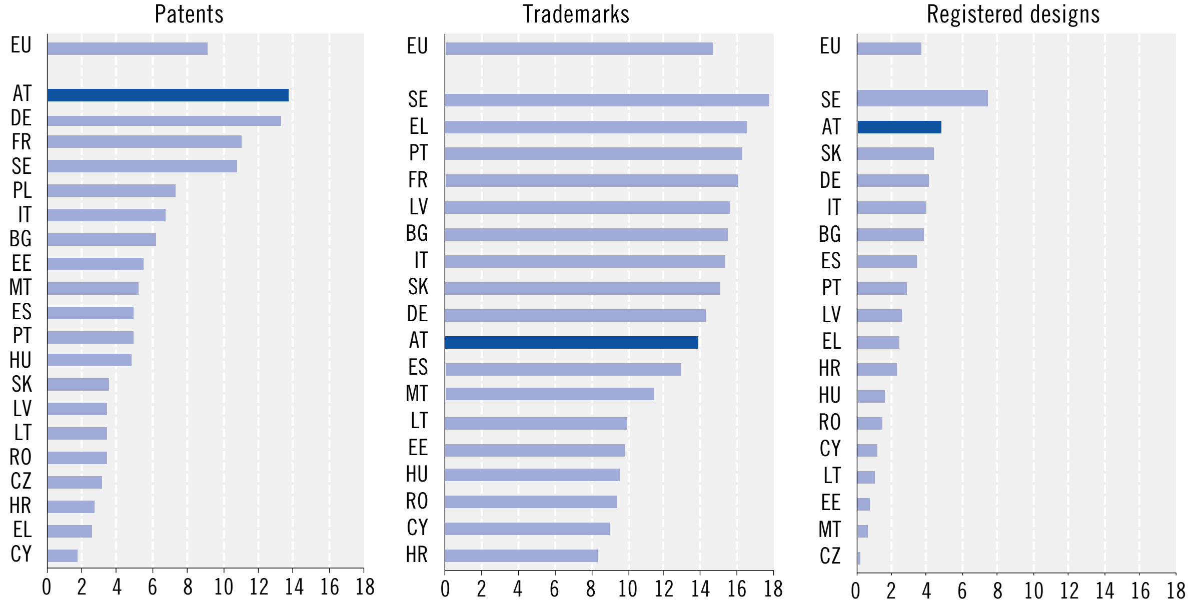
the use of patents, trademarks and community designs among innovative firms was also collected in the CIS 2014. When it comes to utilising patent protection (i.e. when registering a patent with a national or international patent office), innovative firms from Austria also took first place in the European comparison, with a proportion of 13.6% (see Fig. 3-8). They were followed closely by innovative firms from Germany and, at more of a distance, from Sweden and France. When it came to community design registrations, Austria was second after Sweden. This type of intellectual property right was utilised by 4.7% of innovative firms in Austria in 2012–2014. The registration of trademarks is significantly more widespread. EU-wide, 14.7% of innovative firms utilised intellectual property rights to protect their trademarks in 2012–2014 (in comparison to 9.1% for patents and 3.6% for community designs). The proportion of innovative firms in Austria that registered trademarks amounted to 13.9%. When it comes to this type of intellectual property, the relative differences between companies are lower than in the case of patents and community designs.

3.1.4 Open innovation strategies in Europe and Austria

New forms of innovation have received increasing attention in the European Commission's innovation policy over the past few years, such as the recent "Open Innovation, Open Science, Open to the World – a Vision for Europe"[10], the Europe 2020 strategy or the flagship initiative, Innovation Union. To create and increase incentives and awareness for new innovation models, OI strategic objectives were launched in Europe and priorities were set as part of other measures and initiatives to open up innovation processes. In July 2016, Austria became the first EU mem-

10 See European Commission (2016b).

Fig. 3-8: Firms that use patents, registered designs or trademarks, by European countries, 2012-2014



Proportion of all firms with product or process innovation activities as well as firms with marketing or organisational innovations. All information refers to firms with ten or more employees.
The value for the EU relates to the weighted average for the member states listed in each case.

Source: Eurostat: CIS. Calculations: ZEW.

ber state to set out a comprehensive OI strategy. Such a general national approach towards OI remains practically unique on both European and international level.

In other countries in Europe, OI approaches are finding their way into national innovation strategies in particular, primarily driven by EU cohesion policy. While the Spanish and Polish research, technology and science strategies took up the issue of OI to create increasing awareness of new innovation models, for example, Hungary, in addition to incorporating OI aspects in national R&D and innovation strategies, has had an office for research, development and innovation, which also deals with OI, since 2015. The Czech Republic has regional OI initiatives. In Lithuania, Belgium and Estonia, OI has been a key topic in the context of the strategic promotion of firms and scientific innovation for years.

In Scandinavian countries, but also in Luxembourg, France and the United Kingdom, OI has been subject to national debate in recent years and implemented in particular by established large companies, economic clusters of academic institutions and think tanks. However, no national OI strategies currently exist in these countries. SMEs have not yet gained a foothold when it comes to the implementation of OI.

The "OI strategy" pursued by the Austrian government[11] picks up on the international trend of increasingly opening up and interconnecting innovation processes. In the context of changing innovation patterns, it formulates ambitious targets and creates a joint policy framework for ongoing and future initiatives and measures from different fields. Against the backdrop of current findings in innovation research and in particular the concept of the "quadruple helix" and the "knowledge triangle", the OI strategy includes measures in the areas of culture and competences, networks and

11 See http://www.openinnovation.gv.at

cooperation as well as resources and framework conditions. It aims for a broad opening, promoting interconnectivity between the areas of industry, research and education, civil society as well as politics and administration.

Building upon a broad stakeholder process, a vision for 2025 has been formulated as part of the OI strategy. By then, Austria should be known internationally for its openness towards innovation and the keen participation of relevant institutions and the country's population in open innovation activities. The core of this vision is openness to new knowledge, a spirit of cooperation and an acceptance of learning from mistakes. Corresponding organisational cultures need to be established in firms, scientific institutions, non-profit organisations and public administration. An active OI policy will allow Austria to become an international role model for the design and control of open innovation systems in the digital age by 2025.

Four significant groups of stakeholders that develop innovations together are industry, society, research and politics/public administration. The OI strategy defines three concrete targets with a total of 14 measures and describes activities that have already been started or are planned, which address these groups of stakeholders and their interaction (see Chapter 1.3 "Open innovation strategy for Austria – monitoring implementation" for details).

The trend towards OI is also based on a broader understanding of innovation. The RTI strategy of the Austrian federal government indicates that modern RTI policy requires a broader understanding of innovation, with"... technological, research-driven and non-technological innovations in manufacturing and in the service sector but also ecological and social innovations, and innovations in the public sector".[12] It then also explicitly mentions the importance of users and consumers in developing innovative products and services. The OI strategy of the Austrian federal government could be viewed as the most recent political initiative to implement this approach.

3.2 Radical innovations

The term "radical innovation" and the suspected lack of such innovations are discussed again and again in Austria.[13] The following chapter will first define the term "radical innovation" to make it more meaningful for measurement and RTI policy. This will be followed by an international comparison of Austria's performance in terms of the quality of research, inventions and innovations as well as a discussion of RTI intervention options to support "Major Innovations", a collective term that refers to both technologically radical and economically effective innovation families. The chapter will conclude with an examination of current discussion processes on a national level regarding support for innovative and risky research.

3.2.1 Making sense of radical innovation and related terms

To differentiate between terms, a conceptual input/output framework[14] is used to illustrate the connection between innovation input, activities, outputs and effects and to pin down the different terms (Fig. 3-9). "Inputs", i.e. resources for innovation activities, not only comprise expenditure for R&D and qualified employees, but also scientific knowledge, the quality or significance of which is determined based on the intensity of their use by research communities.

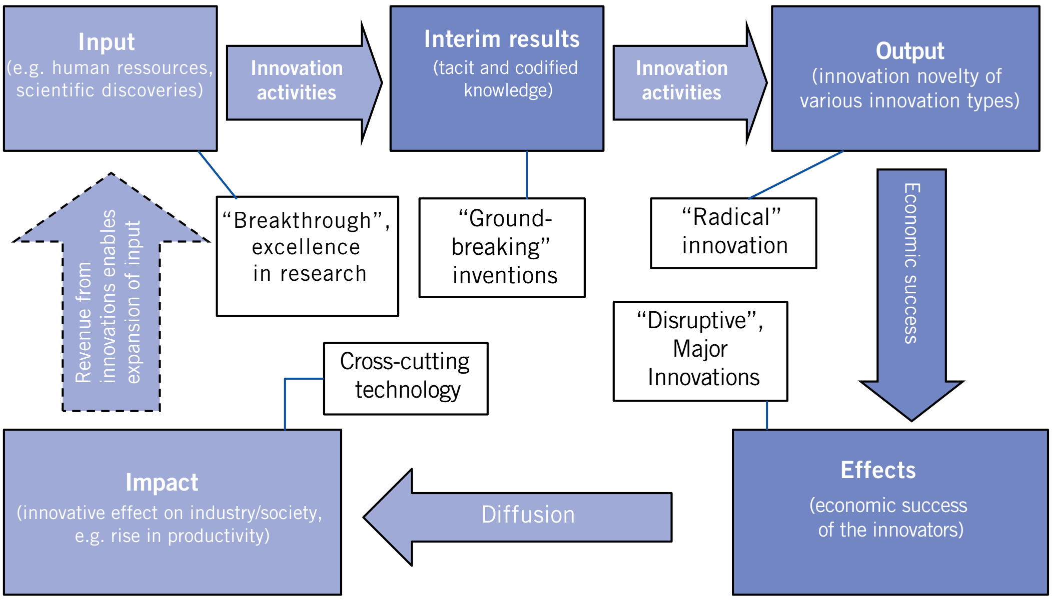
Research results that are used particularly intensively, that partly lead to the emergence of

12 See BKA et al. (2011, 24).

13 See e.g. Warta and Dudenbostel (2016); Friesenbichler and Leo (2007).

14 See Godin (2007); McLaughlin et al. 1999 The figure must not be confused with a linear innovation model. It merely specifies the resources, activities and results required for innovation, with the goal of making them transparent so they can be measured.

Fig. 3-9: An input-output framework for defining the concept of radical innovation



Graphic: Austrian Institute of Economic Research (WIFO).

new scientific fields or resolve central problems, can be identified by how often the underlying publication is cited. These are also known as scientific "breakthroughs". Prizes for research achievement by individual researchers, such as the Nobel Prize, the Fields Medal in Mathematics or Austria's Wittgenstein Prize, are also indicators of excellence in science. Measurements based on use imply that excellent scientific achievement is only identified several years after the research results themselves were published, with the extent of scientific breakthroughs being determined relatively quickly only in exceptional cases (e.g. the discovery of the CRISPR-Cas9 gene scissors).[15] The average time frame in which the number of citations reaches its peak is between two and five years, depending on the field, but can also be even longer for new approaches that initially have difficulty getting accepted. This applies in particular to approaches that for the first time combine fields of science or journals that have never been connected before.[16] There is no precise metric scale that states how many citations a scientific publication needs to have in order to be regarded as a breakthrough or excellent.

Scientific discoveries and knowledge along with many other resources influence firms' specific innovation activities. As a first step, they can lead to knowledge growth within the firms, which either remains "tacit" within the firm (influencing production in an undocumented manner, yet nevertheless creating competitive advantages) or, in the case of codifiability and the inventive character of the knowledge created, may be registered as a patent. The quality of discoveries can be assessed based on various dimensions if they are registered as patents. For one thing, just like with publications, the number of subsequent patents that cite the patent as a reference

15 See Doudna and Charpentier (2014). The original paper on this method was published in 2012. The prestigious journal Science declared this method the "Breakthrough of the Year" in 2015.

16 See Wang et al. (2016).

can be counted. Frequently-cited patents serve as a source for numerous inventions, and therefore the invention has to be significant, at least from a technological perspective.

With the help of citations we can also analyse other dimensions of quality.[17] The distance between the fields of technology of the cited and citing patents can be calculated, and thus conclusions can be drawn about the level of generality of the technology or the technological significance of an invention – the greater the distance, the more an invention radiates beyond its own field of technology and into others. One variant of this measure of distance consists of the spread of the technology fields of the patents cited, regardless of the distance to the field of technology of the patent cited. The technological spectrum of a patent works like a mirror of its technological significance by analysing the patents cited in the patent under examination. On the one hand, the lag in citation can be analysed, i.e. the age of patents cited, and therefore the degree of novelty of the knowledge that the patent is based on. On the other hand, the breadth of the knowledge base that the patent builds on can be determined by looking at the spread of the technology fields of the cited patents. This means that patent data can also be used to calculate the recombination of knowledge, which is an important feature of significant innovations. The literature also refers to particularly significant, paradigm-shaping patents that – if successfully transformed into innovations – could lead to the development of new industries, as "superstar patents".[18]

Patents and inventions can be, but are not necessarily, the basis for innovations. Many innovations are not based on patents, and in turn many patents do not lead to innovations because they cannot be turned into marketable products at a reasonable cost, because there is no market for the invention, or because a firm has only registered it for strategic reasons in order to block competitors from entering the market.[19] The Oslo Manual,[20] which is used as a basis for the collection of innovation data, defines "innovation" as the implementation of a new or significantly improved product by the firm concerned.[21] Every innovation must reach a minimum threshold for novelty – new to the firm that launches the innovation on the market. The Oslo Manual distinguishes additionally between different degrees of innovation novelty based on the following levels: the next level is "new to the firm's market", and the highest level is "new to the world". The novelty can refer to a product's features or the use that buyers can derive from the product; product innovations can be based on new technologies or the unique combination of existing technologies. The Oslo Manual does not make a clear distinction between the use that a product offers purchasers (or the services that are possible with the product) and the technological functionality. Other contributions make a sharp distinction between an improvement to the qualities of a product on an unchanging market and a new market development made possible by innovations.[22] For example, the digital camera or jet plane represent a major functional improvement using new technologies over the existing film camera and propeller plane. Both still provide the same service, , namely taking photographs or flying passengers from A to B. The smartphone, however, combined primarily existing technologies, but creat-

17 See Unterlass et al. for an overview. (2013).

18 Reinstaller et al. (2017) propose a PageRank algorithm, essentially what the Google search engine uses, in order to identify these "super patents".

19 For a discussion of the restrictions on the use of patents as indicators of innovation see Janger et al. (2017).

20 See OECD and Eurostat (2005).

21 The definitions for process, marketing and organisational innovations are similar but are not explained in detail here for reasons of space.

22 See Saviotti and Metcalfe (1984).

ed a new global product category and even a new market.

The Oslo Manual only uses the term "radical innovation" in one paragraph, as a term related to "new to the market" or "new to the world". Yet this really refers to disruptive innovation in terms of the economic effect of innovations (see next paragraph). In the terminology of the Oslo Manual, "radical" would consistently be a major improvement i) to functional product characteristics, e.g. the speed of passenger planes, and ii) to the use or the services enabled by the product, such as the option to use your phone additionally as a navigation tool, newspaper, email client or word processor.

None of these definitions are synonymous with the economic effect or commercial success of an innovation. The Oslo Manual clearly talks about the initial market launch of a product, i.e. that it is principally available on the market, but it doesn't mention market shares or revenue growth achieved through innovations. The term "innovation" therefore clearly refers to the "output" or "performance level" of the input/output framework, and not to the "outcome" or "effect level", that also includes the commercial success of an innovation. This means that radical innovation does not necessarily lead to a greater commercial success than incremental innovation: there are many examples of radical technological innovations that did not achieve any commercial success or only achieved high levels of revenue after complementary, incremental innovations (see e.g. Betamax vs. VHS video cassettes or Teflon), and in turn there are many incremental innovations that achieved great commercial success, such as successful models of cars or new versions of the Windows operating system.[23]

There are two approaches to measuring the degree of novelty of an innovation. The objective approach focuses on technological product or process characteristics, such as measuring the improvement of product characteristics from old to new, e.g. the difference in speed between a propeller and a passenger plane of comparable size. This information can be compiled e.g. on the basis of information in technical journals.[24]

In the subjective approach, firms are asked about the degree of novelty of their innovations, i.e. for a subjective estimation of novelty (new to the firm, the market or the world), which is often skewed by specific national particularities such as language or differences in development.[25] Nevertheless, the subjective approach is currently the only one that provides numbers, such as in the context of the indicators based on the Community Innovation Survey (CIS). Due to these deficiencies in measuring the degree of novelty, case studies play an important role in the area of innovations[26], not least due to the fact that the "radical nature" of innovations, both in terms of their technological and usage characteristics, can generally only be assessed several years after market launch and therefore share the same problem as that seen in the measurement of scientific excellence or the significance of inventions.

The economic effect of an innovation can generally only be assessed based on the revenue, market shares or profits achieved on firm level. This information (the revenue share from innovations that are new for the firm and new for the market) is also available as CIS indicators. There are two problems here: the first is the subjective assessment of novelty mentioned above, and the second is the inherent problem of company surveys being able to obtain accurate information about the revenue share of individual products, in large firms in particular. The idea of "disruptive" innovation was conceived by Christensen

23 See Kline and Rosenberg (1986); Lundvall (2010).

24 See Grupp (1994).

25 See Srholec (2007).

26 See Leitner (2003).

in 1997.[27] This term essentially refers to firms that have recently entered the market (recently founded or expanded from other areas) and have seriously rocked existing market structures thanks to the success of their innovation, which specifically translates into a sharp rise in market share for the innovator and sharp falls in market shares for the existing firms on the market. Recent examples of this include Amazon in the book and general retail sector, Uber for taxis and Airbnb for the tourism sector. Disruptive innovations therefore have to trigger major economic effects, in contrast to the term "radical innovation", which are based on the degree of novelty of the function or use. There are currently no indicators to measure disruptive innovations at the national level on an aggregated basis. For this purpose, information must be collected on the level of the relevant product markets, which in reality are often different to the official classification of the industries in the sector, as well as data on market shares, innovations etc.

The difficulty involved in measuring innovative effects on the basis of the radical nature of the underlying innovation has also led to a suggestion for a new concept at the sectoral level, with the innovative effect being conceptualised either as structural change towards more knowledge-intensive industries or upgrading in existing industries towards more knowledge-intensive segments.[28] This suggestion does not relate to the level of innovation novelty, but rather merely makes clear that radical and incremental innovations can contribute to both structural change and upgrading. For example, the development of breathable clothing was certainly radical from a technological point of view, but primarily led to upgrading in the clothing industry, specifically the option for developed countries to remain competitive despite high wage costs, such as due to more efficient production or the high quality of new products that cannot simply be copied. New versions of the iPhone, on the other hand, are incremental technological developments, but contribute to the growth of the high-tech sector (computers). Radical innovations therefore do not necessarily lead to the growth of the so-called high-tech sectors.

Another term that is used at the European level is "Major Innovations"[29]. These create mainly benefits and improvements in the environmental conditions of socio-economic systems as well as for the individual users themselves. An important aspect of Major Innovations is their fundamental effect on technological (e.g. technological paradigm changes), economic and societal developments. The term therefore covers the quality of the invention, level of the novelty of an innovation and its commercial success. Major Innovations are generally not developed by a single firm. They are made up of a family of individual innovations, that overall have made a measurable contribution to a structural change in the industry or societal trends. The term "innovation family" refers to the close connection and interdependency between sometimes radical individual innovations of different types (product, process and organisation innovations), which are co-evolutionary, i.e. their development is mutually influenced.

When technologies lead to successful innovations and high revenue, not only in the firm or the sector that introduced them, but also diffused throughout the industry as a whole, they are referred to as cross-cutting technologies, which often can trigger a major macroeconomic impact on productivity and the industry, e.g. in the form of long-term economic upswings (also called Kondratiev waves). Examples of current innovations that are eligible for this definition include digitalisation or industry 4.0, and increasingly the switch to zero-CO2 or low-CO2 technologies

27 See Christensen (1997).

28 See Janger et al. (2017).

29 See European Commission (2016a).

in energy production and consumption, such as through renewable energies, the costs of which are consistently falling and will soon have reached the point where they themselves could be cheaper than coal.

Challenges in measuring radical and disruptive innovations in particular make it difficult for RTI policy to formulate relevant goals and to systematically evaluate to what extent they have been achieved. What is common to all industries is the fact that it is often only possible to assess the quality of science, inventions and innovation after a longer period.

It is also necessary to emphasise the variety of the factors involved in determining scientific excellence, groundbreaking inventions, and radical and disruptive innovations. First of all, scientific breakthroughs do not necessarily lead to groundbreaking inventions, which for their part often do not directly transform into radical innovations. Many factors are necessary in order to turn inventions into innovations, such as competitive mass production and in general the ability to overcome difficulties in the commercialisation of scientific and technological knowledge.

In addition, academic research and corporate R&D follow different lines of reasoning in their production.[30] In research, the logic of production is geared towards publishing findings as quickly as possible. In contrast, technological knowledge is developed with the goal of achieving competitive advantages for as long as possible. Invention protection or secrecy surrounding the research results are therefore important determinants of competitiveness and the diffusion of technology. Scientific research is moreover generally driven by curiosity and the quest for understanding, while corporate R&D is applied search for marketable solutions to problems. This also gives rise to very different organisational models for scientific/academic research compared with the management of innovation processes in firms.[31] Science, technology and innovation policy areas are different and need to develop separate strategies if they are to support cutting-edge performance in the respective areas.[32]

3.2.2 Empirical illustration

This section illustrates Austria's performance in an international comparison using selected indicators in the areas of science, inventions and innovations. As described above, citation-based publication indicators are standard for the purposes of measuring excellence in science. The citation intensity of Austrian publications is described based on Scimago data in Chapter 1.2 on the development of Austria's position in terms of the key performance indicators. Fig. 3-10 shows that the number of publications with a high citation rate as a proportion of all publications as a measurement of excellence in Austria is towards the front of the middle range for the EU (including Switzerland).

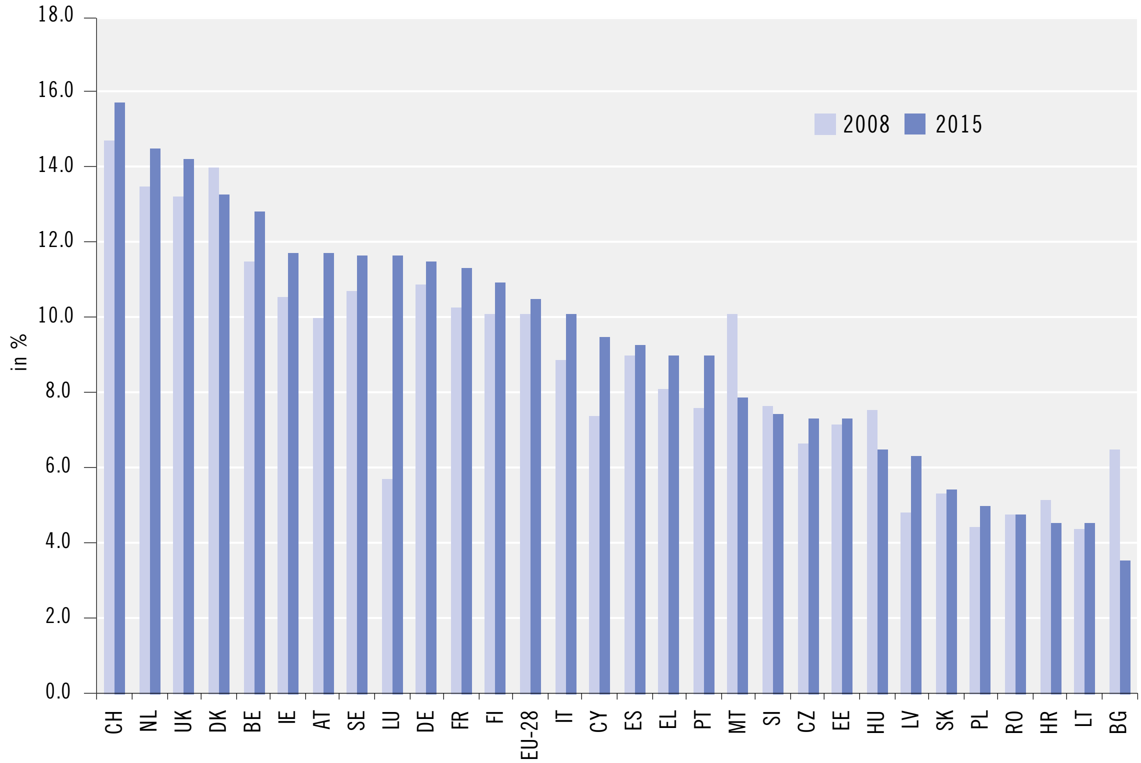
Fig. 3-11 shows several indicators that compare invention quality in Austria with that of the leading innovation countries. This does not simply use citation frequency, but rather the technological reach and "distance" of the citing or cited patents as a measurement of the technological degree of generality of the Austrian invention (technological importance – reach and distance of the citing patents) and for the technological spectrum or the breadth of the invention (reach and distance of the cited patents). A catching-up process can be observed here overall from the 1990s, which has resulted in even higher values than for the innovation leaders on average for both indicators on the breadth of the invention. This means that Austrian inventions, on average, are based on a knowledge foundation that is more broadly defined than that of the comparison

30 See Janger and Nowotny (2016) for the determining factors of a scientific production function; the innovation production function is discussed e.g. in Pakes and Griliches (1984) and Roper et al. (2008).

31 See Aghion et al. (2008).

32 See Janger et al. (2017).

Fig. 3-10: Indicator for evaluating scientific excellence: Number of publications in a country with a high citation rate as a percentage (%) of all publications, 2008 and 2015



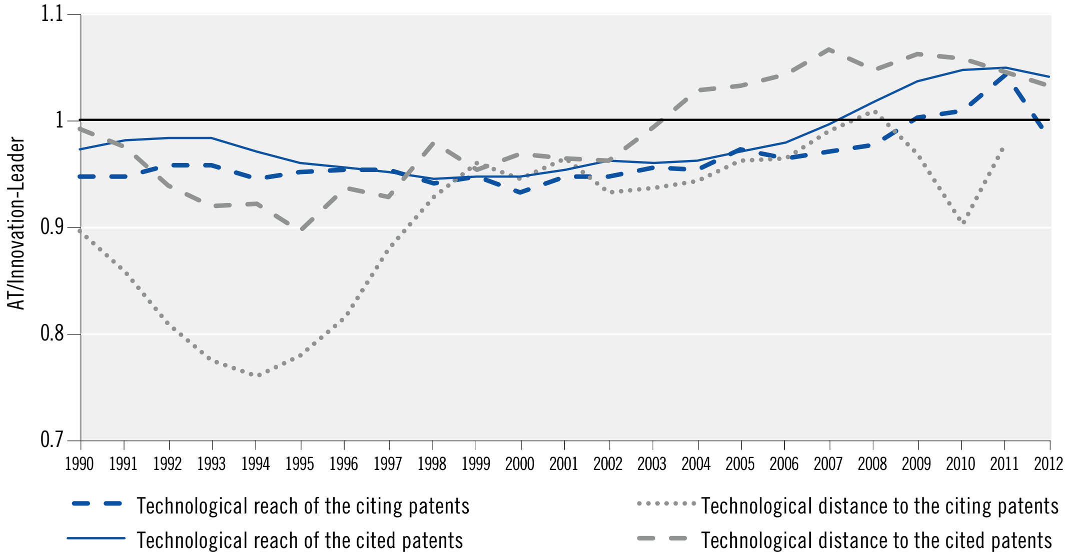
Source: European Innovation Scoreboard (EIS), Indicator 1.2.2. The figures relate to the relevant year of publication for the EIS and not to the actual years.

countries. Both indicators on the technological importance still feature below average values for the latest years available. That is, they indicate that the inventions of the leading innovation countries are cited on average more frequently by patents that are more distant technologically and point, therefore, to a greater degree of generality of the inventions of the innovation leaders.

Finally, Fig. 3-12 attempts to demonstrate the effect of innovations assessed as particularly new (in accordance with the CIS definition, new for the market) based on the share of revenues for these product innovations as a proportion of total revenues for the firms surveyed. The picture revealed is highly heterogeneous as described above: Three of the leading innovation countries are below the average for the EU, and Germany is notably in last place. Eastern European catching-up countries, on the other hand, occupy the first two positions. This shows that corporate surveys are only partially successful at identifying the economic impact of the innovation novelty. Austria is also below the average for the EU with a stable value below 8% of revenue share. Alternatives are required, therefore, for evaluating Austria's innovation performance, e.g. through the concept described on measurement of the effectiveness through structural change vs. upgrading or through increased case studies, as carried out on behalf of the European Commission on the effects of the framework programmes and covered in the next chapter.

Innovation research analyses the innovation events and, in general, also the importance of innovations from the perspective of the individual

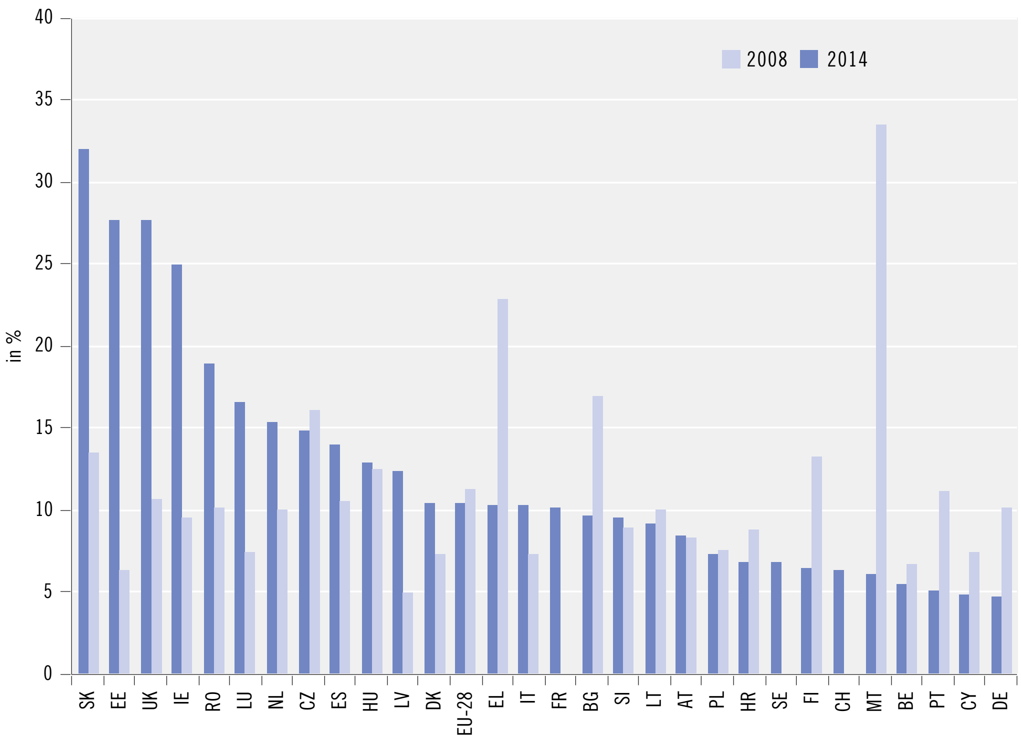
Fig. 3-11: Indicators for evaluating the technological significance and the technological spectrum of Austrian inventions relative to the average for the leading innovation countries, 1990–2012



Innovation Leaders Average for DE, DK, FI, SE, NL = 1.0.

Source: PATSTAT (autumn 2016). Calculations: Austrian Institute of Economic Research (WIFO).

Fig. 3-12: Indicator for evaluating the impact of innovations new to the market (share of revenues as a %), 2008 and 2014



Source: Community Innovation Survey 2008–2014, Eurostat.

firm. Ground-breaking innovations that affect the development of an individual firm or the implementation of an individual product innovation on the market are actually rare. The next section therefore provides an examination of groundbreaking innovations at the meta level.

3.2.3 Determining factors for Major Innovations

An examination of important innovation families is particularly relevant from the perspective of a holistic examination of the impact of political action. This examination takes place, therefore, from the perspective of the innovation object, its development and success, rather than from the perspective of the innovation subject (firm or research facility) as is often the case in the innovation economy.

The European Commission recently commissioned an analysis of selected Major Innovations and their potential contribution to the EU Framework Programme for Research (EU-FP 4, 5, 6 and 7).[33] Ten Major Innovations (including car navigation systems, LED lighting, mobile telephones and personalised medicine) were selected from a pre-selection of 30 and these were subjected to a detailed examination. The innovations examined were at very different stages of maturity (e.g. mobile telephony and personalised medicine). Aside from identifying the essential drivers and factors for success, a further important goal was to ascertain any potential contribution to European research funding and promotion.

The development of the selected Major Innovations from the perspective of relevant R&D, policy, market and society-related drivers was examined initially as shown in Tables 3-2 to 3-5 based on four examples.

Research and innovation promotion, demand development, as well as changes in industrial structures, may be seen as important drivers across all of the Major Innovations examined. However, there are important differences between the various drivers: Regulation, for instance, played an important role in a series of examples. One noticeable example of this is mobile telephony, with the dynamic for this largely triggered through the opening of the telecommunications market in Europe. Opening up the GPS-NAVSTAR satellite system to civil use similarly played a key role. Important societal challenges are accompanied by corresponding policy awareness in other areas, such as LED lighting and personalised medicine.

Car navigation systems are Major Innovations that have largely been driven by private initiative and entrepreneurship.

Navigation systems, LED and mobile telephony are now largely established on the market and have experienced an impressive expansion over the last few years. The area of personalised medicine and the paradigm shift that has accompanied this in the detection of patterns of illnesses, and the associated identification of diagnostics and treatment on the other hand, remains at the initial stage of application on the market.

Fig. 3-13 presents the correlation between the availability of relevant key and/or crosscutting technologies and the level of maturity of the innovations using selected innovation families as examples.

The individual case studies of the European Commission have shown that national and European research and technology promotion have contributed to differing extents to the success of the Major Innovations examined over the course of their development. The examinations do also show, however, that important trends are already set for Major Innovations at the early stages of long-term development. This momentum has been found well before the start of the relevant European research promotion in the case of the Major Innovations examined. National research promotion efforts have obviously played a crucial role here.

In the case of mobile telephony and the leap in

33 See European Commission (2016a).

Table 3-2: R&D-related drivers

✓✓ distinct driver; ✓ contingent driver × no significant driver	Car navigation systems	LED lighting	Mobile phones (MP)	Personalised medicine (PM)
Outstanding scientific knowledge	×	✓	×	✓✓
Technological breakthrough	×	✓✓	×	✓✓
Technological novelty/newness based on (re-) combination	✓✓	×	✓✓	✓✓
Existing standards (e.g. procedures, protocols, etc.)	✓✓	×	✓✓	×
Creation of interfaces between different disciplines	✓✓	×	✓✓	✓✓
Co-creation	×	×	×	✓✓
Data availability / management (data collection, data preparation)	✓✓	×	✓✓	✓✓
Single hotspots and players driving technology development significantly	✓✓	✓✓	✓✓	✓
Fragmented international community driving technology development	×	✓	✓	✓✓

Source: European Commission (2016a). Graphic: JOANNEUM RESEARCH.

Table 3-3: Policy-related drivers

✓✓ distinct driver; ✓ contingent driver × no significant driver	Car navigation systems	LED lighting	Mobile phones (MP)	Personalised medicine (PM)
Political commitment (governmental intervention)	×	✓✓	×	✓✓
Existing regulatory and legal framework	×	✓✓	×	✓
R&D incentives and funding	✓	✓	✓✓	✓✓
Private funding (e.g. venture capital, seed capital, etc.)	✓✓	✓	✓✓	✓✓
Subsidies for end consumer	×	✓✓	×	×

Source: European Commission (2016a). Graphic: JOANNEUM RESEARCH.

Table 3-4: Market-related drivers

✓✓ distinct driver; ✓ contingent driver × no significant driver	Car navigation systems	LED lighting	Mobile phones (MP)	Personalised medicine (PM)
Opening up of a market niche	×	✓✓	×	×
Market readiness	✓✓	✓✓	✓✓	×
Responses to market trends	✓✓	×	✓✓	×
Strong public demand	✓	✓✓	✓✓	✓
Strong private demand	✓✓	✓	✓✓	✓
Change of industrial behaviour	✓✓	✓✓	✓✓	✓
Changes in end user behaviour	✓✓	×	✓✓	×
Demand in emerging countries	✓	✓	✓✓	✓
Becoming an industry standard	✓✓	✓	✓✓	✓
Ease of use & functionality	✓✓	✓✓	✓✓	×
Creation of common eco-system	×	×	✓✓	✓
Provision of necessary infrastructure	✓✓	×	✓✓	✓
Affordability (price cuts)	✓✓	✓✓	✓✓	✓✓

Source: European Commission (2016a). Graphic: JOANNEUM RESEARCH.

Table 3-5: Society-related drivers

✓✓ distinct driver; ✓ contingent driver × no significant driver	Car navigation systems	LED lighting	Mobile phones (MP)	Personalised medicine (PM)
Social commitment/public perception	×	✓✓	×	✓✓
Changes in the social fabric (due to new needs, socio-economic challenges (ageing society) etc.)	✓✓	✓✓	✓✓	✓✓
Demographics (e.g. rise in migration; tourism; but also human characteristics influenced by their geographical location, etc.)	✓✓	×	✓✓	✓✓
Facilitation (Usability) for the end user	✓✓	×	✓✓	×
Growing presence of ICT in every-day life	✓✓	✓	✓✓	×
Reduction of the environmental burden (e.g. energy efficiency)	✓✓	✓✓	×	×

Source: European Commission (2016a). Graphic: JOANNEUM RESEARCH.

development for this towards the smartphone, European research promotion has been able to make a crucial contribution here with the development of key 3G technology.

Table 3-6: Dedication of European research funding of the EU Framework Programmes 5–7 in the area of selected Major Innovations (in € millions), 2000–2017

	R&D activity	Knowledge transfer and interlinkage	Innovation and application	Policy support
Personalised medicine	996	107	159	1
Mobile telephony	886	106	24	37
LED	279	31	36	1
Navigation systems	132	2	4	2

Source: ECORDA. Calculations: JOANNEUM RESEARCH.

Table 3-6 shows the dedication of the funds used by the EU Framework Programmes between 2000 and 2017. Policy support has only received minor funding, except in the case of mobile telephony.

3.2.4 Political options for action

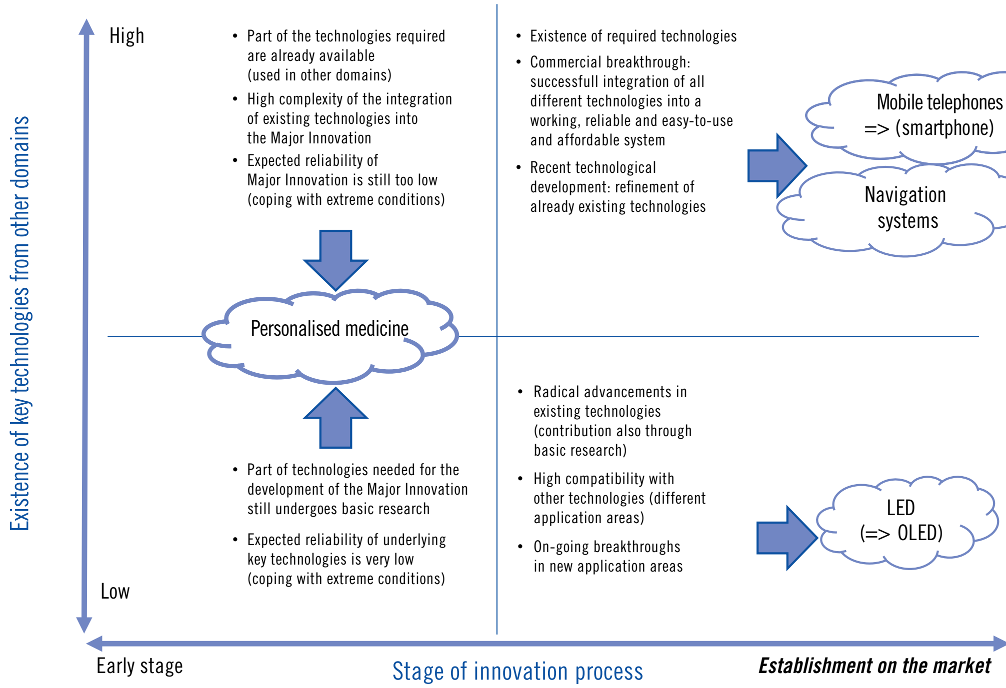
Research and technology funding can cover a range of functions in connection with developing and establishing Major Innovations, with these functions going well beyond the development of knowledge (and including cooperation between science and industry and the mobilisation of R&D resources).[34]

- Public funds can support search and coordination processes that have major significance in the area of systemic development of complex innovation families in particular. In terms of coordination between national governments at the European level, much importance is also attached to proactive policy alignment and the use of multilateral tools[35] in the research funding environment.
- Public funding can also make an essential contribution to disseminating and providing leeway for the development and testing of applications. This was the crucial contribution made, for instance, in the area of navigation systems. Research funding can thereby contribute towards the development of markets and new business models.
- An important contribution can be made in developing legitimacy and public awareness that can be accompanied by R&D in advance of regulation and standardisation measures. Aside from technological development, major importance is also attached to accompanying research on radical innovations in dynamic innovation families in order to avoid unintended negative externalities (unwanted side effects for society and the environment) or rebound effects (systemic or behaviour-related obstacles to the development of positive effects). With reference to the foreseeable developments, a major need can be seen here, for in-

34 See European Commission (2016a).

35 ETP, ERA-Net JTI, JPI, KICs, PPPs.

Fig. 3-13: Status of selected Major Innovations with respect to the relevant technologies and market establishment



Source: European Commission (2016a).

stance, related to developments associated with digitalisation.
- The potential for stimulating the development of business ideas, entrepreneurship and, therefore, direct market implementation of radical innovations based directly (in the short run) on funded research projects, is also increasingly being recognised. A comprehensive survey of experts that examined Major Innovations did, however, also find that this is a blind spot in current research funding in Europe. The reasoning is based less on the form of the funding or the topics covered, and more on the evaluation criteria and thereby also the target results for the projects funded.

As discussed in the previous sections, creativity requires space and diversity for radical innovation to take place, along with a permission to make mistakes and to recognise failure. Success should not be the exclusive measure of creativity, as this also includes the ability to learn from failure and to allow further creative processes to flow from this. The challenges that arise from this for RTI policy are varied in terms of assessing performance and success and establishing open (innovation) cultures and new types of innovation processes. In the search for experience with initiatives that are aimed at providing room for innovative and risky research, stakeholder workshops were held between September 2015 and August 2016 with stakeholders from the Austrian research and innovation landscape together with other Austrian and international experts. Current trends were presented and discussions took place on concepts to guide actions and on specific initiatives. Providing momentum for the creation and development of radical innovations in Austria was, and remains, the goal. Potential starting points for safeguarding and supporting risky projects in RTI funding and promotion at the national level include:

- improving the design and developing new approaches related to the selection of research and innovation projects,

- opening up experimental spaces and
- promotion of new actor constellations.[36]

The latter aspect is aimed at an improved understanding of the environment for radical innovation as a diversely interlinked ecosystem in which the drivers related to policy, market and society discussed above and/or the stakeholders and decision makers behind these are of major relevance and strategic importance.

3.2.5 Summary

This chapter has presented the concept of radical innovation in a consistent context that represents the quality of scientific findings, technological inventions and innovations as different sections of the innovation process. Scientific excellence does not necessarily result in radical innovations, and radical innovations do not necessarily result in greater economic effects than incremental innovations.

The one thing that all areas have in common is that their quality can only be identified afterwards, e.g. in relation to the radical nature or significance of the innovations. While scientific excellence and groundbreaking inventions may be measured, with some limitations using publication and patent data, there is no empirical basis for a reliable international comparison of the radical nature of innovations. This is why case studies play a major role in this area. The last section examined the options for influencing RTI policy using these types of case studies from the European Commission on Major Innovations. The potential role of RTI policy in search and coordination processes, in the development of application leeway and market potential and in the legitimacy of innovations was brought out in this process. Relevant starting points for accelerating and supporting radical innovations and unforeseeable developments are currently being discussed at the national level.

3.3 Responsible Research and Innovation (RRI) and Citizen Science

Responsible Research and Innovation (RRI) has become a new guiding principle in European and national research agendas over the last few years. RRI can be described as follows: "[A] transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products."[37] This addresses the expectations and challenges around the concept that arise during implementation in the everyday research[38] activities: Research should be planned and implemented in such a way that relevant social challenges are addressed and potential societal trends are anticipated, with optional solutions developed and underlying values reflected in the process. Different stakeholders should be actively incorporated into the research process, thereby making research and innovation more relevant in working with and for society. This requires a shift in the understanding of research, not only among the researchers themselves, but also among all societal stakeholders who form part of research and innovation processes, such as the education system, civil society organisations, industry and politics. As such, responsibility and sustainability become more and more important as aspirations for researchers and research funders.

At the European level, these objectives were initiated through long-term activities aimed at improving the exchange between science and society, such as the "Science and Society" action plan (2001) and the "Science in Society" programme (SiS) as part of the 7th EU Framework Programme for Research and Technological Development. Since 2010, attempts have been made to boost interaction between the societal

36 See Warta and Dudenbostel (2016).

37 See Schomberg (2013).

38 See Wickson and Carew (2014).

stakeholders throughout the entire research and innovation process based on the concept of "Responsible Research and Innovation" (RRI). This was continued and developed in Horizon 2020 as part of the "Science with and for Society" programme (SwafS), in which RRI became a central focus for solving the Grand Challenges and for the strategic orientation of the European Research Area. The European Commission has also made corresponding proposals for the monitoring and evaluation of the efforts to implement RRI.[39] In the EU definition, the concept of RRI is based on six dimensions that should be taken into account in designing and reflecting on research practice: governance, open access, ethics, gender equality, public engagement and science education.[40] The Rome Declaration, a position paper developed by the scientific community, sets out the added value of RRI in the following terms: "It ensures that research and innovation deliver on the promise of smart, inclusive and sustainable solutions to our societal challenges; it engages new perspectives, new innovators and new talent from across our diverse European society, allowing to identify solutions which would otherwise go unnoticed; it builds trust between citizens and public and private institutions in supporting research and innovation; it reassures society about embracing innovative products and services and it assesses the risks and the way these risks should be managed."[41]

3.3.1 RRI in Austria

RRI has also made its way into Austrian research and innovation policy: The federal government's RTI strategy[42] emphasises that society demands "dialogue, (...) participation, transparency and responsibility" from science and that actively shaping the relationship between society and science has become a "task for political management". The federal government's open-innovation strategy is also aimed at including citizens in science and innovation (see Chapter 1.3 "Open Innovation strategy for Austria – monitoring implementation" or Chapter 3.1).

Greater incorporation of the various stakeholders in society in the research and innovation process requires changes in skills and approaches, such as a change in communication between the researchers and societal stakeholders, which includes targeted imparting of research by researchers (social literacy), as well as an increased interest in and the understanding of research by the stakeholders (scientific literacy). The focus here is on young people in particular: The existing services on offer aimed at increasing interest in research and innovation have been monitored and assessed in various studies.[43]

Against this background the "Action plan for a competitive research area"[44] provides an important framework for implementing RRI in practice. Implementing responsible science at Austrian scientific institutions is positioned as a priority action area in this along with efforts aimed at ensuring a cultural shift. The Federal Ministry of Science, Research and Economy (BMWFW) implements these objectives within the framework of the performance agreements with universities and non-university research institutes, in accordance with the differing institutional logicat the various institutions. This should encourage activities at the individual research institutes. Specific measures have been stimulated and implemented by the Federal Ministry of Science, Research and Economy aimed at driving forward

39 See European Commission (2015).

40 See European Commission (2013).

41 See https://ec.europa.eu/research/swafs/pdf/rome_declaration_RRI_final_21_November.pdf

42 See BKA et al. (2011, 42).

43 See Engelhart (2016); Reidl et al. (2015).

44 See Action plan for a competitive research area. (2015); http://wissenschaft.bmwfw.gv.at/fileadmin/user_upload/wissenschaft/publikationen/forschung/Forschungsaktionsplan_web.pdf

the discussions surrounding RRI in Austria and intensifying the interaction between science and society.

Some of the approaches aimed at implementing the political objectives related to RRI in Austria in practice are set out below.

Alliance for Responsible Science

The Federal Ministry of Science, Research and Economy formed an "Alliance for Responsible Science"[45] in 2015 as an important initiative in the efforts to implement RRI. This is aimed at initiating closer dialogue between the research institutes and stakeholders in society and incorporating this understanding in everyday research. A memorandum between the Federal Ministry of Science, Research and Economy and partner institutions from science, research and education as well as stakeholders in civil society was signed at the kick-off event in June 2015, with common targets related to strengthening and developing responsible science and ensuring critical reflection for this in research, teaching and social commitment[46]. 37 partner organisations[47] have now signed this memorandum. A cultural shift is being sought by institutions with respect to greater inclusion of stakeholders in society with feedback to these on the results. Pilot projects aimed at implementing this cultural shift are grouped in the "Responsible Science – Science Cultures" expertise network, where specific areas of topic-based research are used in an attempt to discover how science and society can best support and complement each other in the research process, and how researchers' individual responsibility towards society should be regulated.

Further plans aimed at implementing responsible science and scientific communication more effectively relate to awards being granted to research institutes that implement particularly innovative measures aimed at improving cooperation between science and society, and the integration of responsible science principles in research funding and promotion (existing or new promotional measures).

Austrian platform for RRI

The Austrian Platform for RRI (RRI platform) was founded in 2014[48] as a bottom-up initiative from the scientific community with the idea of accelerating implementation of the RRI concept in practice and contributing towards responsible operation of research and innovation in Austria – both in relation to the targets and content of science and research as well as to the needs and concerns of society. Further objectives include exchanging knowledge and discussing recent requirements, providing knowledge in a practical format and raising awareness in the scientific community. Members of the RRI platform include Austrian non-university and university research institutes and universities of applied sciences that support, apply or wish to develop the RRI concept. Building up a network so that relevant knowledge at both the Austrian and international levels along with experience from national and international RRI projects can be collated, exchanged and made available to interested parties was a key first step. This experience is made available online on the platform website[49]. A newsletter updates interested parties on new projects and events, and includes comprehensive discussions on the content-related dimensions of the

45 See http://www.responsiblescience.at/

46 See https://www.fwf.ac.at/fileadmin/files/Dokumente/News_Presse/News/MoU_Responsible-Science.pdf

47 An overview can be found in Table 8-3 in Appendix I.

48 Since early 2016, the RRI Platform has been run via an office at JOANNEUM RESEARCH, which coordinates the platform's activities and acts as a contact point for third parties.

49 See http://www.rri-plattform.at

RRI concept. At the same time, the RRI concept is publicised among stakeholders and a broader public. Networking among the platform members also stimulates scientific exchange and further development of the concept, with joint platform publications also developed. Relevant issues are subjected to scientific discussion and are discussed at public events. These events are seen as steps that support the transfer of the RRI concept into practice, which is one of the platform's key objectives.

An initial event was held by the RRI Platform in February 2016 at the "Haus der Forschung" in Vienna under the title of "Responsible Research and Innovation (RRI) – Quality Criteria and Indicators". Discussions were held on which concepts are already available and suitable for implementing RRI into everyday practice. Attendees also discussed measurability and a potential set of indicators for the RRI concept. An additional event entitled "Ethics in research practice" in December 2016 in cooperation with the Ethics Platform of the University of Natural Resources and Life Sciences in Vienna covered the issue of "ethics" as a key dimension in RRI, with a strong focus on operationalising and institutionalising the concept in research practice. The platform showed itself to be a sponsor of more effective operationalisation of the RRI concept, here also based on the example of ethics.

Further RRI initiatives

The "Responsible Research and Innovation in Academic Practice" platform[50] was also set up at the University of Vienna as an additional stakeholder in the scientific community, and with the aim of creating the corresponding framework conditions for establishing responsible research and science as part of everyday research. The activities of this interdisciplinary platform from the social and life sciences are designed to address the needs and concerns of stakeholders in society more effectively and to provide a space for topic-based discussions through workshops and events. The platform was presented to the public at a kick-off workshop in October 2016.

Further development of the RRI concept also takes place in practice not least as part of projects: European projects, such as those funded under Horizon 2020 (e.g. MoRRI[51], RRI Tools[52]), involve inter alia the development of tools aimed at implementing responsible governance, for instance the "Responsibility Navigator"[53] and the "Self-Reflection Tool"[54].

3.3.2 Excursus: Ethics as a dimension of RRI

Although there has been no consensus so far on a generally binding definition of ethics as a dimension of RRI, the work of ethics committees and similar bodies is still relevant in this context in supporting scientific integrity at research institutes, along with ethics in research funding and promotion. The Austrian Agency for Scientific Integrity[55] (ÖAWI) was formed as a key stakeholder in 2008. In addition to twelve Austrian universities, members of this association also include the Academy of Sciences, the Vienna Science and Technology Fund (WWTF), the IST Austria and the Austrian Science Fund (FWF). The association is funded via members' contributions. The ÖAWI's aim is to create awareness for good scientific practice. This was expressed for

50 See http://www.platform-rri.at

51 MoRRI identifies and analyses manifestations of RRI across Europe, and develops and uses indicators and instruments for empirical surveys of the effects of RRI measures and activities.

52 A range of digital resources aimed at supporting implementation of RRI is collated and developed within the scope of RRI Tools.

53 See http://responsibility-navigator.eu

54 See http://www.rri-tools.eu/self-reflection-tool

55 See http://www.oeawi.at

instance in the "Guidelines on good scientific practice"[56]. The agency's principal task is to investigate allegations of scientific misconduct in Austria, assess these objectively and independently and, if applicable, to propose measures and offer advice or mediation. The ÖAWI also provides talks and workshops on "good scientific practice" for member institutions and is in constant discussions with international bodies of a similar character.

Ethics as a dimension of RRI is of increasing relevance for researchers in applications for research funding both at national and European levels: "Ethics should not be perceived as a constraint to research and innovation, but rather as a way of ensuring high quality results."[57] Approval of a project by an ethics committee is increasingly forming part of the contractual obligations for research funding. This is resulting in more and more universities and non-university research institutes setting up interdisciplinary ethics committees, in line with the long-established practice at the medical universities based on statutory regulations, with these committees evaluating the objectives and implementation of research projects with regard to the ethical aspects.

Ethical issues are frequently raised in connection with the application of new technologies, such as autonomous driving and new techniques in molecular biology or biomedicine (e.g. Clustered Regularly Interspaced Short Palindromic Repeats – CRISPR-Cas9), which are currently being discussed at the international level. Lawmakers are also called upon here to review whether there is a need for regulation and the extent of this.

3.3.3 Citizen science

The topic of citizen science has experienced a boom in recent years. The concept has been discussed in scientific research since the early 1990s, with the focus by the end of the 2000s placed primarily on the issue of democratisation of the sciences.[58] This was debated inter alia in association with the justification for the public funding for research, along with public controls on research activity (principally in relation to contentious issues such as gene technology).

Issues related to the technical feasibility and validity of the results of citizen science have increasingly arisen over the last ten years in scientific research. Incorporating committed laypersons (the "citizens") into research work has become much easier through the use of new forms of electronic communication (smartphones, Internet 2.0, social media), yet there is still a certain amount of scepticism with respect to the validity of the results of these types of research projects on the part of many scientists trained methodically within the scope of comprehensive academic studies.[59]

Funding and promotion of citizen science

At the European level, citizen science has been funded for several years in the Research Framework Programmes, most recently in the "Science with and for Society" programme, which has been reflected in a series of research projects.[60] The topic has been covered as part of the "Open Innovation, Open Science, Open to the World" strategy championed by EU Commissioner Carlos Moedas since 2015 under the area of Open Science.[61]

56 See http://www.oeawi.at/downloads/Broschure_GWP-Richtlinien%20WEB%202017.pdf

57 See European Commission (2015)

58 See Funtowicz and Ravetz (1993).

59 See Del Savio et al. (2016); Palfinger (2017).

60 See https://ec.europa.eu/digital-single-market/en/citizen-science#Article

61 See European Commission (2016b).

There have also been government initiatives for several years in Austria dealing with the issue of citizen science. One example of this is the Federal Ministry of Science, Research and Economy's "Sparkling Science" programme, which includes elements of the citizen science discourse and has promoted and funded cooperation for scientists with pupils since 2007. Citizen science elements have increasingly been supported in this programme since 2015, such as through the new "Citizen Science Award" presented annually since then for people who show outstanding commitment in their participation in Austrian citizen science projects. People can take part in the award announced in the spring of 2017 via app, e-mail, special online platforms or via post, submitting their observations, measurements, photos, tests, etc. to the teams of eight defined research projects currently ongoing. In the "Top Citizen Science" initiative (also supported by the Federal Ministry of Science, Research and Economy (BMWFW), the Austrian Science Fund (FWF) and Austrian Exchange Service (OeAD) since 2015), participants in the Austrian Science Fund (FWF) and Sparkling Science projects have also been invited to submit proposals for project extensions with respect to citizen science objectives. The amount available in each case for this funding approach is €250,000 for the Austrian Science Fund (FWF) and Sparkling Science projects. The Centre for Citizen Science was also set up by the Federal Ministry of Science, Research and Economy (BMWFW) at the Austrian Exchange Service in 2015. This is designed as an information and service office for researchers, citizens and experts, and is meant to link the community with contacts beyond Austria.

Long Night of Research

One key measure related to the dialogue between research & technology and the public is the "Long Night of Research", which is arranged within the direct context of citizen science. This was held for the first time in 2005. It is an event that takes place all over Austria and presents the research output of universities, non-university institutions, universities of applied sciences, manufacturing, infrastructure operators as well as schools. The Long Night of Research is funded by the Federal Ministry of Science, Research and Economy (BMWFW) and the Federal Ministry for Transport, Innovation and Technology (BMVIT), supported by the Federal Ministry of Education (BMB) and run by the Austrian Research Promotion Agency (FFG). The Council for Research and Technology Development cooperates with the coordination point for the Long Night of Research in efforts to coordinate between the federal ministries and regional governments in organising the content of the event. The individual regional governments are themselves responsible for actual implementation, with the actual communication related to research and technology provided by the scientists. The event has taken place every two years since 2005 (with the exception of 2007) and continues to grow in size. Information on the event is disseminated via social media, the event homepage, press releases and conferences, brochures and a programme booklet, reports in newspapers and via media partnerships. In all, 2,183 stations were provided by more than 500 exhibitors in 2016, attracting the interest of more than 180,000 visitors. The next Long Night of Research will take place on 13 April 2018.

Further citizen science initiatives

Citizen Science conferences have been held annually since 2015; this is being organised by the "Österreich forscht" (Austria researches) platform, the Austrian Science Fund (FWF) and the Austrian Agency for Health and Food Safety (AGES) in 2017. The Citizen Science working group in place since 2012 at the University of Natural Resources and Applied Life Sciences operates this platform and also has a website on the issue that continues to grow[62]. The platform also contains a database of all citizen science projects that are currently ongoing in Austria, and thereby provides a basis for further development, teaching activities and the public.

There are now also specific educational programmes for Citizen Science and Open Innovation in Science. The Lab for Open Innovation in Science (LOIS) at the Ludwig Boltzmann Society (LBG) has provided a specific educational programme with an international focus since 2016, with the inclusion of citizens in the research process also one of the topics covered with this. With the Open Innovation in Science project "Reden Sie mit!" (Have your say!), the LBG has targeted the broader public with the aim of including them in working out new research issues for the first time. A total of 400 affected parties, members, doctors, therapists and other experts used the online platform to answer the question of which research issues should be taken up by science in the area of mental illness. Research topics associated with the mental health of children and young people of mentally ill parents are being translated into specific research activities as a result of this. The aim is to form new research groups that stand out because of their high innovative potential and that have the potential to generate new solutions to the problems posed by societal challenges.

The University College for Agrarian and Environmental Pedagogy in Vienna launched the first extra-occupational three-semester citizen science course in August 2016. The Smart Lab Carinthia at the Carinthia University of Applied Sciences in Villach may also be mentioned as a spatial infrastructure (equipped inter alia with 3D printers, design software and a CNC milling machine) provided to students, researchers and citizens.

The Natural History Museum (NHM) also sees itself as a platform for citizen science. In addition to the various activities in the individual departments, the Citizen Science Day held for the first time in 2016 with presentation of a series of projects along with a programme of talks at the Museum must be highlighted here in particular. The NHM, the International Institute for Applied Systems Analysis (IIASA) and the Centre for Citizen Science all collaborated on this.

There are some consistently sceptical attitudes towards research and technology in Austria, as can also be seen from the results of the Eurobarometer Study 2013[63]. The fact that efforts to present research and technological output systemically to the public began comparatively late in Austria must be remembered here; this finding also applies to the area of academic research, politics and administration, as well as to industry to a lesser extent. Decision-making processes in the area of RTI policy are also frequently distinguished by collaboration only between a small group of experts from the worlds of politics, administration, research and industry.[64] However, more importance has at the same time been attached to the presentation of RTI-policy initiatives by politicians and administration in recent years.

A change in attitudes among the public with respect to research and technology will require further concentrated efforts in the policy areas of teaching and education, research and technology, as well as infrastructure and industry. Opening up and improving the presentation of the basic principles and decision-making processes in the area of RTI policy itself could also play a role here.

---

62 Cf. http://www.citizen-science.at

63 See European Commission (2013).

64 See Biegelbauer and Hansen (2011); Degelsegger and Torgersen (2011); Biegelbauer (2013).

4 Digitalisation: Research, Innovation and the Work Environment

For some decades now, digital technologies have been penetrating many aspects of our lives, society and the economy. Recent technological breakthroughs in various areas are now forming the basis for a new wave of "digitalisation" and are expected to have a significant impact in the near future on productivity and economic growth, business models and firm organisation structures, as well as employment and labour markets. These effects will also be felt – probably more strongly than in the last few decades – in the service sector and even in areas such as research work.

The term "digitalisation", however, is not itself clearly defined and can be understood not only in its narrower technical sense but also with various other meanings. In recent attempts to define the term,[1] the rapidly growing availability of digital data (for example as "Big Data"), the use of these data in various contexts (e.g. e-business, e-government), the hardware and software required for these applications (information and communication technologies), including appropriate infrastructure (e.g. broadband networks) as well as the spread of these technologies in various application contexts (research and development, the education sector, business, public administration and many more) are all jointly subsumed under the term "digitalisation".

As a cross-cutting technology, digital transformation is producing change on a broad front both in industry and in society and poses new developmental challenges for politicians. Against this background, the Federal government of Austria defined twelve guiding principles for the future development of digitalisation in Austria by agreeing on a "Digital Roadmap" for the country[2] (see Chapter 1.3). These guiding principles also underpin the key topics of this chapter, in particular the objectives of making Austria a leading international location for the digital industry, providing support for firms undergoing digital transformation, creating more and better jobs through digitalisation, training and qualifying people appropriately for these jobs, and enhancing scientific knowledge and research to make the most of the new digital opportunities.

This chapter deals in detail particularly with the following important aspects of digitalisation in Austria: Chapter 4.1 provides an overview of the current status of, and perspectives on digital transformation in Austria in the area of Science and Research and cites important supporting measures.

Chapter 4.2 describes changes in the domestic business enterprise sector, partly in connection with the scope and impact of digitalisation and partly as a result of the increasing concentration of high-level R&D and knowledge. Particular attention is paid not only to analysing the implementation of technologies for a new industrial revolution ("Industry 4.0"), but also to the service sector.

In conclusion Chapter 4.3 discusses the connection between innovation activities and working conditions, and outlines the observable effects on employment resulting from innovations and technical transformation in the recent past.

1 See OECD (2015).

2 See https://www.digitalroadmap.gv.at/

The chapter closes with a description of the effects on future employment and qualification requirements.

4.1 Digitalisation in the area of Science and Research

Digitalisation has an impact on all areas of society and also influences the ways in which research is conducted. Sometimes this is seen as a turning point or new paradigm for the sciences, as the effects of digitalisation are so far-reaching.[3] New information technologies (IT), social networks, the collection and availability of large amounts of data, and artificial intelligence are changing research processes and the way researchers work – in universities, research institutes and firms. Trends such as Open Access, that is to say free availability of publications, Citizen Science, the involvement of citizens in the scientific process, or Big Data, accessing and analysing large and complex bodies of data, are features of this development. New types of web- and software-based forms of communication and cooperation between scientists go hand in hand with strategies aimed at shared use and integration of data which are already a central component of any research work in chemistry or medicine today.

Digital technologies and applications are not only used within specific research communities, but have also promoted interaction and cooperation between different institutions and scientific fields and have thereby also encouraged interdisciplinary and transdisciplinary research. This in turn has consequences for scientific quality assurance, work distribution and the status of researchers in scientific activities which are increasingly dominated by social media and their conventions. At the same time, digitalisation itself is becoming a topic for research as its effects on society are examined or technologies are designed in collaboration with citizens and users.

Digitalisation lends support to the paradigm of science as it was proposed by the science theoretician Robert K. Merton, in the 1970s, namely that the aim of scientists is to establish their own priority for a scientific discovery, by being the first to publish an advance in knowledge.[4] Digitalisation allows for all information and data generated within the context of research activities to be made available to the public – sometimes even in real time. In addition to the term Open Science, which the European Commission has also postulated as a guiding strategy, terms such as Science 2.0, Open Digital Science, Cyber science or E-Science are also entering into use within the Community.[5]

In this section, some selected developments, important activities and projects in Austria are examined, beginning with an overview of the scope and variety of forms of digitalisation in science and research. The key issue here is the effect of digitalisation on academic research. Although the commercialisation of research results is similarly characterised by digitalisation and is of importance for universities and research institutes, this will not be explicitly examined here. See Chapter 3.1. (Open Innovation, Protection and Property Rights) and Chapter 4.2 (Digitalisation and Innovation in the Business Enterprise Sector) for further details.

4.1.1 Digitalisation of the scientific research process

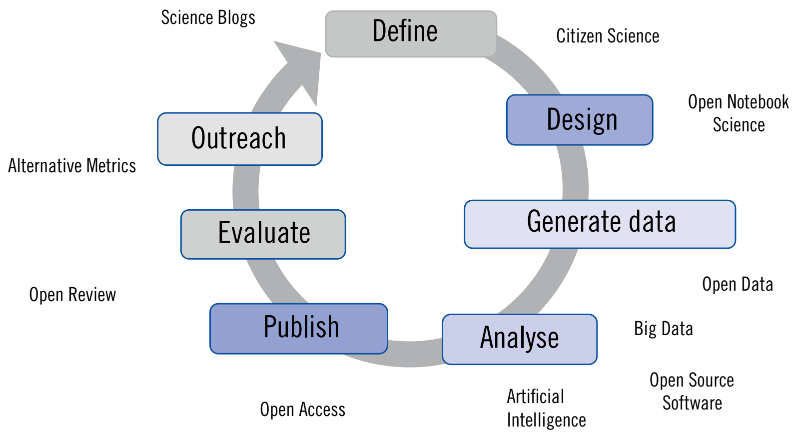
Digitalisation affects all activities of scientific research. Fig. 4-1 shows the typical scientific process and illustrates how various applications made possible by digitalisation are used in the different phases. It is possible, for example, to use digital networks to involve members of the public in defining research questions and narrowing the topic; this is one form of Citizen Science, cat-

3 See Grasberger (2014); Ulrich (2015).

4 See Merton (1973).

5 See Nentwich und König (2012); Schroeder (2008); Breivik et al. (2009); Schaper-Rinkel et al. (2012).

Fig. 4-1: Digitalisation of the scientific process



Source: Based on Kramer and Bosma (2016) and Leitner (2017).

egorised here as part of the Definition phase. Digital technologies likewise play a role in the conception of investigation design and in devising the operational approach to research questions, partly as there are new options to consider when designing research projects, and also to collect prompt feedback in the community or to attract project partners.

Digital technologies create a variety of new opportunities for generating data. Open Data represents an important developmental pathway in this regard and means that researchers can themselves make data freely available, but at the same time they can also access data from third parties. Citizens can also be involved in the generation of data by, for example, sending measured data on their state of health to research teams. Another trend described in the literature is that of Open Notebook Science, which means making the data generated within the scope of research projects directly accessible through the internet. In this context, scientific data is made freely available within a few hours, before the actual publication of scientific papers by the researchers involved – something which can take a few years in the case of peer-reviewed publications. Citizens are also increasingly becoming involved in data generation, a trend, also known as sensor-based participative data collection (Participatory Sensing), which means that individuals and communities collect and store events, patterns and infrastructures in a wide variety of fields using their personal mobile phones and web services.

The large amount of data available also frequently calls for new analytical methods such as artificial intelligence or machine learning and thereby has an influence on the phase of Analysis and Interpretation of results. Data-driven science becomes more successful, the more data are made available on an open basis and without any restrictions in terms of use. Of course the digitalisation of research is not new, as is shown for example by the development of Open Source software, which originated in the sciences and is used widely in many fields, such as Open Source statistics programmes.

Further on in the process, a key activity of scientists is also strongly influenced, namely the way in which their findings are published: here we can take Open Access as a prime example. At the same time, digitalisation opens up new forms of evaluating research: trends such as Open Review and the development of Alternative Metrics can be cited, which have an impact on the Evaluation phase. In the age of Open Science, new measurement concepts are emerging which go beyond the traditional "impact factor", measuring the number of citations of scientific publications: it is increasingly common to attempt to record social dimensions as well. There are after all numerous possibilities for communicating results more quickly, more widely and in a greater variety of ways and so increasing the impact, for example in the form of Science Blogs, as is shown below.

The umbrella term of Open Science is often used as a term for the possibilities opened up by digitalisation and this concept is also being promoted by the European Commission.

In recent years a series of social networks and IT tools have begun to be used in day-to-day scientific work. Platforms and application tools such as Research Gate, Mendeley or Academia.edu play a large role in this within the scientific community, but are also changing the ways in which research results are distributed and represented to a broader public. IT tools and social networks provide support, among other things, in searching for collaborative partners, enabling access to publications and data, offering alerts and the possibility of presenting research profiles, supporting the exchange of videos, enabling comments to be made and offering ways to measure the impact made. Yet social networks such as LinkedIn and XING also provide a place for scientists for networking, discussion and presentation of their research work.

A key distribution channel is offered by the messaging service Twitter, which is not only suitable for the distribution of research results, but above all also provides a "filter function". A large number of journals, research organisations and individuals tweet news about their scientific work. Users receive contributions which are of interest to them via their Twitter account. Instruments and platforms for joint use of data and options for setting up blogs and Wiki articles on the net are relatively easy for scientists and institutions to use and also speed up the application and distribution process. New forms of rapid (pre-) publication and of fast feedback from the community are also growing correspondingly.

The following section examines some selected developmental trends and applications and portrays selected activities and projects in Austria.

4.1.2 Open Access and Open Data

Open Access means having free access to scientific information on the internet and encompasses publications as well as research data. The latter are designated as Open Data. A formal distinction is made between three possible ways of creating Open Access: Green Open Access, Gold Open Access and Hybrid Open Access. Green Open Access means the second publication of scientific articles on institutional or specialist repositories (document servers), Golden Open Access the first publication of scientific articles in Open Access periodicals or books. With the Hybrid Open Access pathway, authors can effectively be paid a fee for Open Access publication of their article.

Austria has a number of organisations contributing to the implementation and further development of Open Access and Open Data. The main stakeholders are the Austrian Science Fund (FWF), Universities Austria (uniko), the University Libraries Forum (the network of all Austrian academic libraries, including the National Library), the österreichische Bibliothekenverbund und Service Ges.m.b.H. (Austrian Library Association, OBVSG), E-Media Austria Cooperation (an association of some universities for consortium purchase of electronic journals) and also the Open Access Network Austria (OANA).

The Austrian Science Fund (FWF) has been intensively involved with Open Access since 2012. As a signatory to the "Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities", the FWF has since 2015 been obliging and encouraging all project directors to make their research results freely accessible in the internet.[6] More than 80% of all peer-reviewed articles resulting from projects funded by the Austrian Science Fund (FWF) are currently assumed to

6 See https://www.fwf.ac.at/de/forschungsfoerderung/open-access-policy/monitoring-open-access/

be published in the Open Access form. The Open Access Policy of the FWF was expanded at the end of 2014 to include the recommendation that research data which are generated within the framework of FWF-funded projects are made available via Open Access, to the extent that this is legally and ethically possible.[7] The target is for almost 100% of the quality-assured publications generated by FWF projects to be on an Open Access basis by 2020 (including free re-use licenses) and that the costs of these are made clear. Furthermore, the FWF plans to have a binding Open Research Data Policy in place by 2018 for all of its funding programmes (with data management plans included in project proposals).

OANA was set up in 2012 as a joint initiative under the organisational umbrella of the FWF and uniko. The key topics it deals with are adopting a joint position towards information providers (usually publishers), coordination between Austrian research institutes, funding donors and research agendas (including consideration of international trends), and acting as a contact point and source of information for scientists, research institutes and political representatives. In 2016, an OANA working group developed 16 recommendations for Open Access implementation in Austria[8], with a view to converting all scientific publication activity in Austria to Open Access by 2025. These implementation steps were also presented to the Austrian Council of Ministers in July 2016 and were noted with approval.

Open Access also has far-reaching consequences for the costs of maintaining full access to scientific journals while simultaneously reducing the cost of creating Open Access publications. The Austrian Academic Consortium (KEMÖ) conducts negotiations to this end with the major international scientific publishing houses on behalf of the Austrian Consortium of Libraries. A new licensing model, "Springer Compact", was agreed in 2015 with the Springer publishing house for a period covering three years from January 2016 onwards. Springer Compact combines the use of content on SpringerLink with the possibility of Open Access publishing. The new model offers scientists the possibility of Open Access publishing their research results in a high quality and wide-ranging portfolio of journals. This represents a first important step in changing the scientific publications system and transforming the nature of subscriptions, with the aim of creating an efficient and largely budget-neutral transition.

In addition to the institutions listed, the national advisory committees have also considered the question of Open Access and Open Data. The Council for Research and Technology Development (RFTE) strategy for 2020 proclaims the goal of all public research results in Austria being freely accessible on the internet by 2020.[9] The European Research Area (ERA) - Portal Austria published a Policy Brief on Open Science in 2015 which also drew up recommendations for promoting Open Access.[10]

Initiatives have also recently been launched to promote the use of Open Data in the field of applied research. The Federal Ministry for Transport, Innovation and Technology (BMVIT) has compiled Open Access guidelines referring to the recommendations of the European Commission (2012/417/EU), according to which results from publicly-financed projects from mission-focused programmes should largely be made available to interested members of the public. It is envisaged in the further development planned that in future Open Data formats should be taken even more strongly into account in the collaborative and open processing of research data. The promotion of Open Data in applied research is moreover also addressed in the Open Innovation strategy of the Austrian Federal government.

7 See http://www.fwf.ac.at/en/research-funding/open-access-policy/

8 See OANA (2016).

9 See RFTE (2009, 31).

10 See ERA Portal Austria (2015).

4.1.3 Infrastructures for Open Access and Open Data

In order to facilitate Open Access and Open Data, appropriate infrastructures are required which to date have primarily been financed from public resources and frequently operated by universities and research institutes.

E-Infrastructures Austria is a project for the coordinated establishment and further development of repository infrastructures in Austria.[11] It was launched in January 2014 and is financed by the Federal Ministry of Science, Research and Economy (BMWFW) within the framework of Higher Education Sector Structural Funding (HRSM). The primary task of the three-year HRSM project was the coordinated establishment and further development of repository infrastructures for research and teaching as well as efficient and sustainable research data management. The participants in the project were 20 universities and five non-university institutions. Its activities are being continued by the successor project of "e-Infrastructures Austria plus" with the objective of constructing a model in the long term for document servers and repositories which are networked with each other.[12]

Beyond this, there are some projects which are creating infrastructures in specific research fields. The Austrian Social Science Data Archive (AuSSDA) is creating an Austria-wide data archive for social science data and services in coordination with CESSDA European Infrastructure (ESFRI Project). PUMA, likewise funded within the framework of an HRSM project, is a platform for surveys, methods and analyses which also deals with Open Data and data-driven research methods in the social sciences.[13] Led by the University of Vienna, cooperation is taking place between the Universities of Linz, Innsbruck, Graz, Salzburg and Klagenfurt, the Academy of Sciences, the MODUL University and Statistics Austria with the aim of establishing an Austrian centre of excellence for quantitative methods of empirical social research and for premium-quality data collections.

The Austrian Centre for Digital Humanities (ACDH) is a joint centre shared between the Universities of Vienna and Graz and the Austrian Academy of Sciences.[14] The CLARIN and DARIAH research infrastructure is jointly operated in order to develop specific basic services, repositories and digital research methods in the Humanities.[15] The HRMS-funded project "Portfolio/Showroom - Making Art Research Accessible" will in future be considering digitalisation in the Fine Arts and establishing a research information system.

"Sentinel National Mirror Austria" is a project run by the Federal Ministry for Transport, Innovation and Technology (BMVIT), Federal Ministry of Science, Research and Economy (BMWFW) and the Central Institute for Meteorology and Geodynamics (ZAMG), which makes current earth observation data from the Sentinel satellites accessible to the public for free.[16]

AT2OA (Austrian Transition to Open Access) is a further project, financed by HRSM funds, which will develop further infrastructures between 2017 and 2019. The 21 Austrian public universities, IST Austria and KEMÖ are participating in the project. Licensing contracts are being re-negotiated with providers and financing and transition models defined in order to bring about an increase in Austrian Open Access publication output. It is also intended to set up

11 See http://e-infrastructures.at/startseite/

12 See http://e-infrastructures.at

13 See http://www.puma-plattform.at/

14 See http://www.digital-humanities.at/de

15 See http://www.clarin-dariah.at

16 See www.sentinel.zamg.ac.at

Open Access Monitoring covering the whole of Austria.

Within the context of the current chapter, which is focused on scientific research, it should be mentioned that digital technologies and online availability are also changing the teaching and learning activities throughout the Austrian educational landscape. The higher education institutions are pioneering in this. A key role is played by open or free educational resources[17] ("Open Educational Resources", OER) – teaching and learning materials which are made freely accessible, to allow them to be used by others. The University of Graz and Graz University of Technology, for example, launched the first Austrian Massive Open Online Course (MOOC) Platform, iMooX[18], which only provides OER content. Another project which is also establishing an important infrastructure and which is being funded by the Federal Ministry of Science, Research and Economy (BMWFW) from HRSM resources, is the Open Education Austria Project[19]: Under the overall responsibility of the University of Vienna, a national OER infrastructure is being developed which for the first time brings together the services of (e-)learning centres, libraries and central information services, provides support for teaching staff creating OER materials and ensures accessibility to these materials for university teaching in Austria.

A final example is the Data Market Austria (DMA) project, funded by the Austrian Research Promotion Agency (FFG) and launched in 2016, which addresses issues including inter-operability and data security. This is intended to lead to circumstances being created which will enable business-relevant stakeholders and firms to provide and make use of data.

In addition to projects at the national level, the European Commission is also helping to promote the establishment of infrastructures for Open Access and Open Data. The European e-infrastructure, OpenAIRE, in which the University of Vienna is involved, can also be mentioned here as an example.[20] The aim of this research infrastructure is to create free-of-charge public access throughout Europe to quality-checked scientific articles via a central electronic portal. Particularly noteworthy is the new Zenodo research data repository which has been created within the framework of OpenAire and in cooperation with CERN.[21]

Some further important directories of repositories are available at an international level. The "Directory of Open Access Repositories" (OpenDOAR)[22] lists over 2,600 Open Access repositories for academic research. It also provides various statistics related to repositories, for example by country, field, institution or in general terms relating to the growth and increase in repositories. Likewise recommended in the EU Guidelines is the "Registry of Open Access Repositories" (ROAR)[23], with 4,173 repositories listed. Re3data.org is a data repository which has been funded by the German Research Community (DFG) since 2012. With 1,600 data repositories listed at present, it currently represents the most comprehensive register of this kind. Also of importance is the Directory of OA Journals (DOAJ) which is not just a directory, but also awards a quality standard mark for OA journals and is also recommended

17 See Recommendations for the integration of Open Educational Resources in universities in Austria, http://www.fnm-austria.at/fileadmin/user_upload/documents/Buecher/2016_fnma-OER-Empfehlungen_final.pdf

18 See http://imoox.at

19 See http://openeducation.at/home/

20 See http://openaire.univie.ac.at/

21 See https://zenodo.org/

22 See The Directory of Open Access Repositories, http://www.opendoar.org/

23 See The Registry of Open Access Repositories: http://roar.eprints.org/

in this regard by uniko and the Austrian Science Fund (FWF).

The objective of the European Commission in the medium term is to create a European Open Science Cloud. This aims to integrate infrastructures which have previously operated for the most part separately. The Open Science Cloud is an open, collaborative platform for the management, sharing, accessing and archiving of research data and other objects and should therefore also serve as a source of ideas and knowledge for firms and other stakeholders aiming to commercialise research results.

The projects listed have helped to build up the Open Access and Open Data infrastructures in Austria and to set up networks at national and international levels. According to the currently available figures, there are now 25 repositories operated by Austrian institutions (as of February 2017).[24]

4.1.4 Big Data

The quantity of data produced in science, society and industry is increasing exponentially. Data collected by sensors in mobile telephones and cars are an example here as well as data saved in social networks or financial transactions. Figures from studies show that, according to the most up-to-date available data (current to 2014), about 4.4 zettabytes of electronic data are in existence and with annual growth rates continuing to rise, 40 zettabytes of data will be generated by 2020.[25] This trend, which is also known as Big Data, is considered to have huge potential in science for addressing new types of research enquiries. Up until now research has been primarily concerned with the issue of how these huge heterogeneous quantities of data can not only be analysed, but also how they can be archived, transferred and used by innovative technologies and applications over the long term.

A series of projects and initiatives can be cited in biosciences and medicine, for example, which attempt to combine data, to administer the results and then to make these available for various applications world-wide.[26] This is linked to innovative shared computer architectures and systems, such as Grid Computing, a form of shared computing in which use is made of several computers at the same time. The use and treatment of these data, e.g. through identification of unexpected correlations in data structures, the interpretation of empirical findings and the formulation of new types of research questions, is considered to be a central challenge for public and private research.[27]

The European Commission is promoting Big Data projects with its Horizon 2020 initiative and has published its own priorities for Big Data in the information and communication technologies programme line. The European Grid Infrastructure Initiative is another example of this.[28] The European Commission is supporting the development of this e-infrastructure, which links European researchers through a shared data and computer structure. While current discussion of Big Data is primarily centred around the analysis of unstructured data, large quantities of structured data are also of importance for research. The Large Hadron Collider (LHC) at CERN is an example of this which, in line with the principle of Open Data, has been providing large quantities of data to the research community since 2009. The LHC Computing Grid (LCG) provides a distributed computer and storage network infrastructure for the experiments on the Large Hadron Collider.

24 See https://www.openaire.eu/oa-austria; Re3data.org

25 See Kahn et al. (2014).

26 See Howe et al. (2008).

27 See Frankel und Reid (2008).

28 See http://www.egi.eu/

Bioinformatics is among the early users of Big and Open Data. One Austrian example is the establishment of the European bio-database at the Medical University of Graz. Due to the increasing importance of Open Data and Big Data, the Medical University of Vienna has recently adopted a policy on the use of Big Data.

Big Data projects have been funded in Austria since 2013 by the Federal Ministry for Transport, Innovation and Technology (BMVIT) under the "ICT of the future" umbrella programme. Big Data is relevant, for example, for mobility applications. At the Austrian Institute of Technology, large quantities of data are processed for the development of mobility applications within the framework of a Real Time Data Analytics project. JOANNEUM RESEARCH has developed an open platform for interoperable services within the framework of a project which enables smart, incident-focused management of very large quantities of data and provides various information streams in crisis situations. Research groups also use it to evaluate satellite images for remote sensing. Data are further processed using modern algorithms and validated selectively ("ICT of the future", key project Data Market Austria[29]). The Prepare4EODC project, coordinated by the University of Vienna in collaboration with further partners from science, the public sector and also private industry, is another project to note, in which earth observation data are made available for the analysis of global water resources. Many different kinds of data are also combined for town planning and development within the framework of ongoing Smart Cities projects, where these are used for innovative applications, funded by the Austrian Research Promotion Agency (FFG) among other organisations.

In response to the increasing importance of the analysis of large quantities of data, the fields of Data Science and Data Analytics are also growing in importance. Some universities in Austria have committed themselves to this topic and offer degree programmes. Examples include a course of studies at the University of Salzburg and specific training programmes at the Technical University of Vienna, the Vienna University of Economics and Business and the Wiener Neustadt University of Applied Sciences. Furthermore, an endowed professorship for Data Science was awarded in 2016 at the Graz University of Technology.

The KNOW Centre at the Graz University of Technology, which is also financed by funds from the COMET programme, has been dealing for many years with the question of how large and complex volumes of data can be analysed and processed for a wide range of applications. An important research priority is the question as to how Big Data can be used for new business models and commercial applications.

4.1.5 Data-driven research methods

Making use of large and complex quantities of data, generated in a dislocated fashion, for scientific research implies a development which is designated in the literature as a "data-driven" research method.[30] Researchers postulate that in future in some areas, classic hypothesis- and theory-driven research will be replaced by data-driven research methods.[31] Against this background the information technology infrastructure, including databases, acquires an increasingly large role, in terms of identifying correlations and patterns in the data, as well as in driving forward experimental research.

Digital technologies are already successfully employed in various branches of medicine. Ophthalmology is a particularly attractive area for the use of new methods of automated data analysis, as standard diagnostic investigations are almost entirely based on digital imaging. The Eye Clinic at the Medical University of Vienna is leading the

29 See https://datamarket.at/

30 See Schaper-Rinkel et al. (2012, 14f).

31 See Burgelman et al. (2010).

world in this area because, as a pioneer in ophthalmological image analysis, it has been developing machine learning methods for optimising diagnoses, establishing prognoses and individualising treatment methods[32] for four years now. This development is based on two key components: on the one hand, the foundation of a Christian Doppler Laboratory for Ophthalmological Image Analysis (OPTIMA) and, on the other hand, the establishment of a central platform for digital image analysis, the Vienna Reading Center (VCR). Ocular coherence tomography provides non-invasive, high resolution and three-dimensional images of the retina which allow any change in the development of an illness and in the course of treatment to be precisely recognised. Methods of computerised image analysis have recently been introduced, in order to provide a comprehensive, targeted and reproducible diagnostic evaluation for any patient at any point in time. In this approach, recourse is made to methods of artificial intelligence where, in particular, machine learning allows biomarkers and patterns of illness activity to be gathered from large data pools without any limitation arising from preliminary hypotheses.

Against the background of the ever larger quantities of data and computing performances required, investments are needed in computers, databases and networks. The Federal Ministry of Science, Research and Economy (BMWFW) has accordingly been investing for some years in the development of High-Performance-Computing facilities, such as the VSC (Vienna Scientific Cluster) or the Austrian Centre for Scientific Computing (ACSC) in Linz. Scientific Computing is also a research priority at the universities of Vienna and Innsbruck.

4.1.6 Digitalisation as an object of research

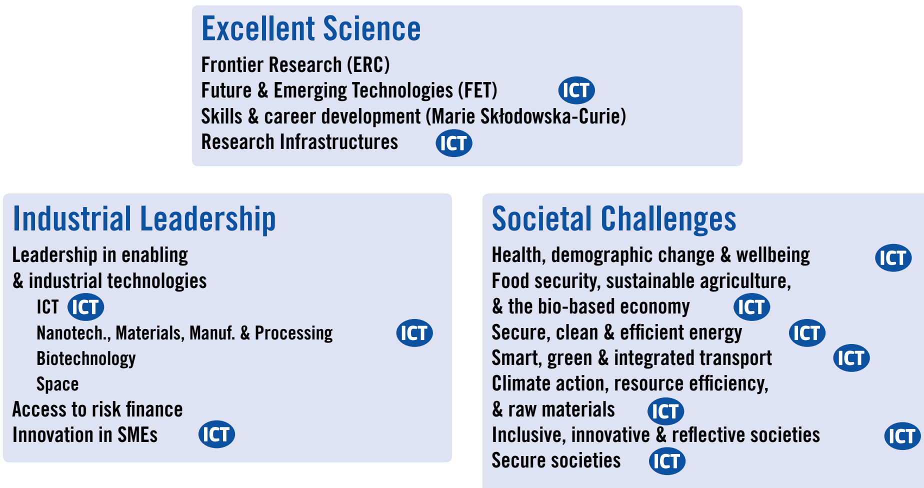
The digitalisation of society and industry also entails changes for research in virtually all fields and topic areas. Trends in digitalisation are increasingly becoming the object of research at universities and research institutes. In this regard, issues stemming from the areas of information and communication technologies (ICT), optical technologies, sensor technology or electrical engineering are also of great relevance for other specialist areas, such as communication and education sciences, medical and health research or the so-called "Digital Humanities". The European Research Framework Programme Horizon 2020 also regards ICT – including digitalisation – as an interdisciplinary issue which affects many different industries (see Fig. 4-2).

Research about and for digitalisation serves to enhance our understanding of digital transformation, examining the effects of digitalisation for individuals and society, and the opportunities it creates; areas such as the Digital Humanities, for instance, also promote self-reflection with regard to the development and application of digital technologies. A wide range of research and development projects are being conducted within this context, stretching from research into formal methods for analysing large quantities of data, to the development of technologies for various application areas (frequently in cooperation with users and citizens), and investigation of the social impacts of digitalisation. Some examples are described here by way of illustration.

- The Institute for Computer Aided Automation at the Vienna University of Technology is involved in some EU-funded projects where digital technologies for ageing (Ambient Assisted Living - AAL) are being developed to promote good health in the work place and to support mobility in people's own homes. JOANNEUM RESEARCH has also developed a bundle of activities focused on the topic of AAL. These include enhancing imaging procedures for recognising falls by additional methods using acoustic sensors. There are also projects exploring new digital technologies for people suffering from dementia, and supporting people with disabilities in finding their way around public buildings.

32 Known under the definition: "The right treatment for the right patient at the right time".

Fig. 4-2: Overview of ICT in Horizon 2020



Source: European Commission (2016c).

- The University of Salzburg, the Vienna University of Applied Sciences, Technikum Wien, the Joanneum University of Applied Sciences and the Austrian Institute of Technology have their own "user labs" where researchers are investigating how the use of digital technologies affects the users themselves, with the help of eye-tracking instruments and screen recording.
- The Institute of Technology Assessment at the Austrian Academy of Sciences, the Institute of Design and Assessment of Technology at the Vienna University of Technology, the research group for Techno-Science and Societal Transformation at the Institute for Advanced Studies (IHS), the Centre for Social Innovation (ZSI), the Working Life Research Centre (FORBA) and JOANNEUM RESEARCH – POLICIES, among other issues, are concerned with the social impacts of digitalisation.

The development of industrial technologies such as robots, assistance systems and software products for various economic sub-sectors is now a key area in virtually all Austrian universities and research institutes. Specialist research groups are also addressing questions about the future of work in a digitalised world, and so contributing to a co-evolutionary development of technology and society. Through these kinds of research projects, insights are also being gained which form a key foundation for politics and society, to help shape the transformation in a responsible manner and to strengthen acceptance and trust in a digitalised world.

Despite digitalisation and the evolution of new topic fields, it is clear that experience, expertise and domain knowledge gained from existing areas of application, for example with regard to telecommunications, the environment or health care, remain essential for the development of this research area.

4.1.7 Summary

National and European RTI policy has in recent years promoted the development of digital technologies and the related applications and opportunities. Examples include the European Commission's policy of funding Open Science and Open Innovation, national strategies for funding Open Access and specific research infrastructures, and the Open Innovation strategy of the Austrian federal government.

Open Science requires new investments in data infrastructures (e-infrastructures) and new capabilities and skills for scientists to enable them to participate successfully in these processes. The growing need for these types of investment must be taken into account by universities and research institutes in their financing and facility decisions.

In Austria to date, both bottom-up and top-down measures have been important in pro-actively shaping digital transformation in universities, higher education and research institutes. The Austrian Science Fund (FWF), the Open Access Network Austria (OANA), the Austrian Academic Consortium (KEMÖ), and e-Infrastructures Austria have established a series of initiatives in close cooperation, which provide a good basis for positioning Austria as an innovation leader in the fields of Open Access and Open Data, both in Europe and across the world.

The many challenges for policy makers also include areas such as security, guarantees, copyright law protection and data protection. The questions of how to store and protect data sustainably, as well as enabling access and increasing user-friendliness are important topics on the development and policy agenda. In this context, however, some researchers warn of a new kind of "digital divide" emerging, characterised by "the big data rich and the big data poor".[33]

There are further challenges regarding the issue of how public access to data and information can be secured for as many stakeholders as possible – including for the proposed Open Science and Open Access principles – if universities and research institutes are at the same time competing for third-party funding and commissioned projects.[34] They could have a short-term advantage in certain cases if they keep data and findings secret or provide them exclusively to the client. This conflict of priorities will become more acute in some cases in future, for instance those involving research projects on contract for industry, where research institutes wish to finance their investments in databases and electronic infrastructures through commercial projects or where scientific publishing houses have to find new business models. In this context, issues around data protection and privacy in particular are a factor that could potentially limit the future spread of the phenomena described here.

There is still little comparable information overall at the international level on the distribution, participation and use of Austrian scientists and institutions in the new research methods and strategies described here. The monitoring which is currently planned by the EU and which will include indicators on the proliferation of Open Access and Open Data also promises to ensure that Austria achieves international recognition in future.

4.2 Digitalisation and innovation in the business enterprise sector

Increasing digitalisation is apparent in the business enterprise sector across both the manufacturing and service industries. These trends are crucial for the overall technological performance of Austria: Knowledge-intensive business services, including the information and communication services which are relevant for digitalisation, typically show high productivity, which has a positive effect on the economy as a whole, both directly and indirectly (i.e. via the customer). Investments in digital production technologies are also expected to result in further productivity gains. New data show that distribution of these technologies among Austrian firms is gathering speed, with large, internationally active firms taking the lead.

The importance of this topic has also been recognised for some years in the RTI funding of the responsible ministries. In addition to specific digitalisation funding programmes, a focus is also being set on digitalisation in existing technolo-

33 See Boyd und Crawford (2012).

34 See Weber und Burgelman (2015).

gy-neutral programmes. Within the framework of the National Cluster Programme, business concerns are being taken into account, while the topic of digitalisation is also embedded in strategic planning by means of the Digital Roadmap which was put forward in January 2017.

4.2.1 Industry 4.0: empirical results for Austria

The digitalisation of industrial production (Industry 4.0) is regarded by many as the key to revitalising European industry. The concept of Industry 4.0 emerged in Germany and was defined as part of the formulation of high-tech strategy in 2012 as a project for the future. An important reference document is the final report of the Industry 4.0 working group, published by the Industry-Science Research Alliance and the German National Academy of Science and Engineering[35] Aichholzer et al, in a study undertaken for the Austrian Parliament, talk of networked, real time-enabled and self-optimising production systems aimed at "raising productivity, resource efficiency, quality and flexibility"[36]. In addition to the term Industry 4.0, other, in part over-lapping concepts, are used, such as Advanced Manufacturing Technologies (AMT), Cyber-physical Systems (CPS) or the Internet of Things (IoT).

This chapter begins by considering the distribution of digital production technologies at industry level and then discusses the drivers, obstacles and Austria's specific skills in industrial digitalisation. The underlying data are derived from the "European Manufacturing Survey" as well as interviews with company representatives and stakeholders in Austria.

The European Manufacturing Survey (EMS)[37] covers process and product innovations and other forms of modernisation in firms engaged in manufacturing. Among other issues, the EMS asks about the deployment of 19 different process technologies in firms, of which eleven technologies are classified as being of relevance for Industry 4.0. These include the following technologies:

- Software systems for production planning and control (e.g. ERP systems)
- Product Life-cycle Management systems (PLM)
- Technologies for ensuring safe human-machine cooperation (e.g. cooperative robots, barrier-free stations etc.)
- Digital techniques for the provision of services (e.g. mobile end-devices, sensor techniques for teleservices, virtual/augmented reality applications)
- Digital exchange of production schedule data with suppliers and customers (Supply Chain Management systems, SCM)
- Technology for automating internal logistics (e.g. warehouse administration systems, RFID)
- Real-time production control systems
- Industrial robots for manufacturing processes (e.g. for caulking or treating surfaces, painting, cleaning)
- Industrial robots for handling processes (e.g. for inlaying/mounting/sorting/packing)
- Additive manufacturing processes for making prototypes (e.g. 3D printing)
- Additive manufacturing processes in series production (also individual/small-run series or spare parts)

A comparative index is calculated using cumulative figures for the use of technologies from of this group of eleven. Index values range from 0 (no Industry 4.0 technologies) to 9 (as there are no firms making use of all eleven technologies). Of the eleven technologies, software systems for production planning and control are clearly the most widely used, while technologies for safe co-operation between humans and machines and generative manufacturing processes in series manufacturing are the least used.

35 See acatech (2013).

36 See Aichholzer et al. (2015, 13).

37 See Zahradnik et al. (2016).

The Index makes it possible to compare the distribution of Industry 4.0 technologies in different types of firms (see Fig. 4-3). Evidently the deployment of Industry 4.0 technologies increases with the size of the firms. This is partly a result of economies of scale and partly because large firms are able to bear the investment costs more easily. Furthermore, large firms often have a wider range of deployment options for these technologies, meaning their incentive to invest is greater. The differences between firms of varying size are certainly clear: In firms with more than 250 employees, there are on average five of these technologies deployed, while firms with 20 to 30 employees only use between one and two of the technologies. In this latter size category, about 40% of firms use no Industry 4.0 technologies at all, while there virtually no firms in the category with more than 250 employees where no Industry 4.0 technology is being deployed. Firms with fewer than 20 employees were not surveyed.

Firms in the mid-range technology segment use Industry 4.0 technologies with greater frequency than firms in the high technology or low technology segments. Automobile construction, the plastics industry and mechanical engineering are leading the way here. It can be concluded from this that Industry 4.0 technologies are particularly in tune with the requirements of Austrian manufacturing, which is focused in the mid-range technology segment. The differences between firms with varying levels of technology intensity are, however, much smaller than between size categories, which indicates that Industry 4.0 technologies are also being used in traditional economic sub-sectors as well, such as foods and beverages, textiles, wood, paper or furniture.

In contrast, marked differences are to be found between suppliers and firms which are not suppliers. It appears that Industry 4.0 technologies help suppliers better meet requirements for quality, flexibility and documentation of the production process as well as improving coordination with their customers' production processes. Customer requirements are evidently one of the key drivers for the use of Industry 4.0.

The data also reveal a clear connection between product innovation and the application of Industry 4.0 technologies. Firms which have launched new products feature a higher number of Industry 4.0 technologies. On the one hand, firms with innovative products may be more receptive to process technologies, but on the other hand, Industry 4.0 technologies may also provide the basis for product innovations.

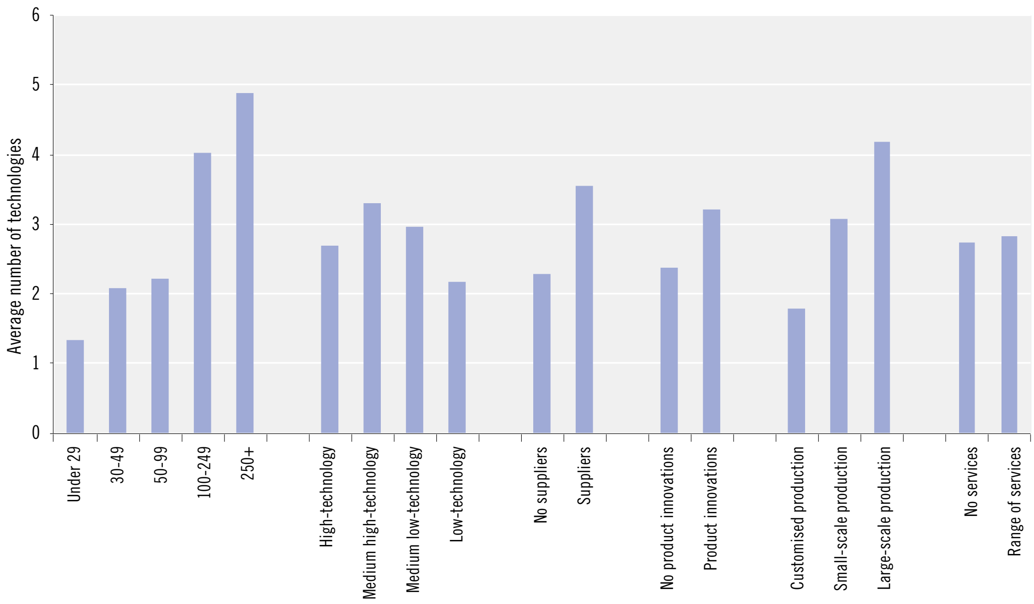
The use of Industry 4.0 technologies is also markedly more common among manufacturers with large-scale production than those with small or customised production runs. The advantages generated by higher levels of flexibility are presumably greatest for large-scale manufacturers, but this finding can also be explained by different firm sizes.

A final point to note is that, the data do not reveal any differences between firms which offer services in addition to their primary products and those which do not offer services. This is surprising as Industry 4.0 is often linked to new industrial services (for example based on Industry 4.0 data); an example of this would be businesses which offer the services of a product by the hour, cubic meter or in other units. In any case, the importance of these new industrial services does not yet appear to be large enough to make a difference here.

Within Industry 4.0, a disruptive effect on existing production structures is particularly associated with additive manufacturing processes (3D printing). According to EMS figures, currently about 16% of the Austrian manufacturing firms with more than 20 employees deploy additive manufacturing processes, usually for the development of prototypes. 3D printing is, however, still a rarity in manufacturing. As with other Industry 4.0 technologies, additive manufacturing processes are also found with greater frequency in large firms and high-/medium-tech firms manufacturing complex systems, components and modules.

In summary, it is clear that Industry 4.0 tech-

Fig. 4-3: Distribution of Industry 4.0 technologies in different types of firms, 2015



Source: EMS 2015. Calculations: AIT.

nologies have begun to spread throughout Austrian industry, although their distribution still seems to be limited to large, internationally active firms and serial manufacturers. One explanation for this pattern is possibly the initial high fixed costs for these technologies and the associated uncertainty, which can be borne more easily by large firms. The figures do not, however, provide any information as to whether by international comparison Austria is a pioneer or a straggler. Further international comparisons are required on this.

4.2.2 Services as drivers of innovation and growth

For decades now, changing employment patterns in the Austrian economy have been characterised by a trend towards higher numbers in the service sector[38]. According to Statistics Austria data, the share of R&D expenditure by the service industries rose between 1998 and 2013 from 22% to 37% of the entire R&D expenditure in the business enterprise sector. Even under the assumption of some under-reporting in the service sector at the beginning of this period, the growth in R&D expenditure in the service sector is considerable: while R&D expenditure in the manufacturing sector grew at an average of 6.5% per year, that of the service sector increased by 11.6% per year. R&D expenditure in the service sector therefore grew continuously more quickly than in the manufacturing sector.

Within the service industries, the sectors of Research and Development (R&D) in biotechnology, service providers (SPs) for information technology, trade and information services show the highest rise in R&D expenditure.

The Research and Development sector includes firms whose task consists of providing R&D services for third parties. Overall, the R&D expenditure of firms in the R&D services sector for 2013 amount to more than € 1 billion or 16% of the entire R&D expenditures of the business enterprise sector. Leading stakeholders in this

38 See Dinges et al. (2017).

sector are, for example, the Austrian Institute of Technology (AIT), JOANNEUM RESEARCH or the Centres of Excellence, but also start-ups whose value creation consists mainly of research services, as they have not yet begun production on their own account. One part of this sector is R&D in biotechnology. R&D expenditure in this area rose from €18 million in 2002 to €366 million in 2013, equating to about 5% of the total R&D expenditure of the business enterprise sector. These sectors include important research institutes of foreign firms engaged in the pharmaceutical industry.

R&D expenditure in the information technology services sector likewise grew at an extraordinarily strong rate. At €272 million, this sector spent almost as much on R&D in 2013 as metal production. Typical tasks in this sector are development, adaptation, testing and software management, or the planning and design of computer systems. This makes this sector one of the core areas for the digitalisation of many other sectors, as it supplies the software infrastructure on which innovations can be developed.

What explanations are there for the rapid growth in R&D expenditure in the services sector? A key developmental driver is the introduction of new technologies, in particular information and communication technologies (ICT). Trade, for example, is considerably more technology-intensive than it was 15 years ago due to new developments in logistics and ICT. New technologies have also significantly increased R&D intensity in many other areas within the service provision sector.

A further explanation stems from changes in the inter-sectoral division of labour. One example is the above-mentioned field of R&D in biotechnology, where research firms have close relationships with the producers of pharmaceutical products through research questions and methods, cooperation agreements, licensing or investment holdings. A new division of labour has evolved between the two sectors over the last decade: Clinical studies are outsourced on a large scale to specialised suppliers, and pharmaceutical firms supplement and replace their own R&D activities by purchasing patents and research results from these biotechnology firms[39]. In the trade sector too, it can be assumed that much of the R&D activity is closely related to manufacturing.

In addition, examples can be found where software development and other IT services are outsourced from industry into the service sector, so that these trends can also be partly attributed to shifts between these two sectors. It would, however, be wrong to regard the growth in R&D expenditures in the service sector primarily as the result of statistical proportional shifts. A category of knowledge-intensive business services has been established within the service sector, for which innovation and R&D form the key factors for growth and employment. Self-employed knowledge-intensive service providers have significantly greater opportunities for specialisation and division of labour than would be the case for in-house departments in manufacturing firms, meaning the trend can also be partly be attributed to dynamic learning effects. Input-output statistics[40] also show that other service providers, rather than manufacturers, are usually the most important customers for these knowledge-intensive business services. In this regard, the term "industry-related services" is misleading. Knowledge-intensive value creation chains have been evolving within the services sector itself for a long time now. The digitalisation of areas of the services sector is therefore also having a significant impact on other areas in this sector.

It is also clear that areas of the services sector which are in the forefront of digitalisation are also among the most active in developing innovations. Analysis of the latest Community Innovation Survey (CIS 14) for Austria (Table 4-1) reveals that there are more innovative firms in

39 See Ramirez (2013).

40 See Statistics Austria (2016).

Table 4-1: Innovation activities in the knowledge-intensive services in Austria, results of the European innovation survey CIS14

	sector (ÖNACE divisions)				
	Information and communication (58-63)	Financial services (64-66)	Freelance/technical services (71-73)	Services Total	Manufacturing (10-33)
	in %				
Innovating firms [1)]	82.1	63.1	64.6	59.5	64.1
Firms with product innovations	54.4	22.4	37.8	30.8	37.9
Firms with process innovations	44.5	25.0	35.0	32.8	39.0
Firms with organisational innovations	53.8	47.1	45.0	37.3	35.8
Firms with marketing innovations	44.5	29.8	25.8	29.8	31.0

1) Firms with product, process, marketing innovations, organisational innovations or ongoing innovation activities that have not been completed or have been suspended for product or process innovations.

Source: Statistics Austria, European Community Innovation Survey (CIS 2014). Graphic: Austrian Institute of Economic Research (WIFO).

three of the knowledge-intensive ÖNACE service industries recorded in the CIS (Information and communication; Financial services; Freelance and technical services) than in the economy as a whole. The industries Information and communication services (82.1%) and Freelance-technical services (64.6%) even show a higher level of innovation activity than the manufacturing sector (64.1%).

Overall, innovative potential in the core areas of domestic knowledge-intensive business services (KIBS) certainly appears to be thoroughly sound and at least on a par to the manufacturing sector. This can be largely attributed to the marked and growing R&D focus of these service providers, as described above, as well as to the advance of digitalisation and the related demand for new ICT solutions.

High levels of focus on innovation also result in corresponding business efficiency. This is illustrated by Table 4-2, which shows productivity (per capita) and how this is changing in individual ÖNACE-industries within KIBS. According to this, the areas of Information and communication, Financial and insurance services and also to some extent Freelance and technical services (2014) achieve higher levels of productivity than the economy as a whole, but also more than the manufacturing of goods. Differences in efficiency within KIBS also result from measuring productivity based on the number of employees, as the proportion of part-time workers varies between different KIBS industries.[41] This is also true for comparisons with manufacturing, where part-time employment plays a significantly smaller role than in the service sector. The statistics therefore turn out more favourably for the secondary compared to the tertiary sector when efficiency is measured on a "per employee" basis.

Although relevant figures show only slight growth in many of the most productive KIBS areas, and the particularly efficient financial services have recently even had to accept falls in productivity, there are still hardly any negative effects on overall productivity resulting from the rise in significance of KIBS. This is even more the case, as shown by recent analyses, since such services not only have direct effects on productivity, via their own productivity and its development, but also have a positive indirect influence on productivity through the effects their use has in the client firms or industries[42]. KIBS are therefore of strategic importance as "local knowledge agents" for other firms and industries and lead to increases in efficiency for them. For this reason providers of knowledge-intensive business services are

41 See Mayerhofer und Firgo (2015).

42 See Mayerhofer und Firgo (2015).

Table 4-2: Labour productivity in the KIBS in detail, gross value added at factor costs per employed worker 2014 and 2008/2014

	2014		2008/2014	
	In €	As a % of the overall economy	% change p.a.	Growth differential to overall (PP)
Information and communication total	102,590	140.4	0.6	0.1
Publishing activities	84,368	115.5	0.2	0.3
Film production/rental, cinemas	73,860	101.1	5.3	4.9
Programming and broadcasting activities	95,697	131.0	4.5	4.0
Telecommunications	165,679	226.8	0.6	0.1
IT services	93,747	128.3	2.2	1.7
Information service activities	89,247	122.2	0.3	– 0.2
Financial and insurance services total	136,032	186.2	– 3.1	– 3.6
Financial services	143,278	196.1	– 4.7	– 5.2
Insurance and pension funds	135,130	185.0	0.1	– 0.4
Other Finance and insurance services	96,298	131.8	4.1	3.6
Freelance/technical services total	81,000	110.9	0.3	– 0.2
Legal advice and auditing	79,513	108.8	1.2	0.7
Company management, consultation	96,607	132.3	1.0	0.5
Architecture and engineering firms	83,646	114.5	– 0.2	– 0.7
Scientific research and development	67,145	91.9	– 0.6	– 1.0
Advertising and market research	61,256	83.9	– 1.6	– 2.1
Other freelance/technical tasks	67,990	93.1	– 1.5	– 2.0
Veterinary activities	58,613	80.2	1.0	0.5
Other industrial services total	51,159	70.0	0.9	0.4
Leasing of moveable items	349,937	479	0.0	– 0.5
Leasing of personnel	39,868	54.6	1.9	1.4
Travel agencies and travel operators	49,932	68.4	4.7	4.2
Private guard and security services	28,294	38.7	2.8	2.3
Building services; gardening	31,218	42.7	2.9	2.4
Industry services otherwise not stated	57,984	79.4	2.3	1.8
Overall economy	73,049	100	0.5	± 0.0
Manufacturing	81,890	112.1	1.2	0.7

Source: Statistics Austria, Performance and structural survey Calculations: Austrian Institute of Economic Research (WIFO).

regularly cited in the Community Innovation Survey (CIS) by innovative firms as essential sources of external information. Their role in innovation processes is admittedly smaller than that played by customers and competitors, but exceeds that of universities and research institutes.[43] At the same time their importance is increasing as external sources of knowledge for business innovations, given the levels of specialist knowledge requirements and the complexity of innovation processes, but also given the ever faster pace of technological and digital change.[44] KIBS in particular facilitate access by SMEs to highly specialised and complex knowledge. The key role played by KIBS in Open Innovation processes has also been empirically confirmed across a wide range of sectors.[45] An investigation[46] for European NUTS-2 regions shows that the increase in KIBS within regional economic structures has a positive net effect on the overall development of economic productivity of a region (see Table 4-3).

43 See Kox und Rubalcaba (2007).

44 See Daniels und Bryson (2002).

45 See Martinez-Fernandez et al. (2011).

46 See Mayerhofer und Firgo (2015).

Tab. 4-3: Regression results for productivity growth and KIBS in NUTS-2 regions of the EU-27, 1991–2012

Dependent variable:	All regions	Regions according to level of industrialisation	
Growth in productivity		**low**	**high**
KIBS Growth	+	0	+
KIBS level	+	+	0
Additional control variables	included	included	included

\+ = significantly positive at least at a 95% level

0 = insignificant

\- = significantly negative at least at a 95% level

Source: Mayerhofer und Firgo (2015).

For Austria and the other EU-27 states, no negative effects on productivity are associated with the structural shift towards the services sector ("tertiarisation"), despite a frequent expectation of such an effect associated with the growth of the services sector.[47] Particularly since tertiarisation in highly developed economies during the last few decades has, with advancing digitalisation, overwhelmingly been led by the growth of KIBS characterized by high R&D and ICT intensity. A further increase in the importance of specialised services is also to be expected in the future.

Overall, this speaks in favour of awarding KIBS a high status when designing innovation policy and in the activities of RTI policy. Forms of market failure as economic arguments for public intervention in the KIBS area, due to virulent information asymmetries to be found here (KIBS as "credence goods"[48]), and the positive externalities described, might in any case be just as significant here as in other economic sectors that have previously dominated the funding system. In addition, neglecting non-technological innovations and intangible investments could have an overall negative effect on innovation activity, as many process and product innovations do not require technology-related investments (for example, in new organisational designs and distribution channels and/or new combinations of product and service elements) in order to achieve market success. The availability of innovative KIBS is therefore also of increasingly critical importance in terms of competitiveness for industrial-commercial activities, as ensuring the ability of the latter to be competitive is above all based on such services (such as R&D, design etc.) together with forms of system integration with a strong service component, including of course the integration of Industry 4.0 or other digital solutions in SMEs engaged in manufacturing (see also Fig. 4-3). The particular importance attached to the ICT sector as a sub-division of KIBS becomes clear upon closer examination. As can be seen from Table 4-1, this sub-division plays a crucial role in innovation-driven structural change due to the advancing digitalisation of society and industry.

Effects on the labour market associated with increasing digitalisation (see Chapter 4.3) include positive employment trends in the ICT sector in particular. These effects can be found not only in sectors producing ICT but also in those profiting from ICT solutions and generating demand for these as intermediate services. A recent study[49] has shown that for Austria, higher ICT intensity in regional economies – measured by the proportions of local employment in industries with high ICT demand – is associated with higher regional employment growth. This positive effect can be identified both in manufacturing and in the service sector. In addition, for Austria as a whole, employment in ICT-intensive industries has also grown more quickly within the observation period of 2004–2015 than employment as a

47 Baumol (1967) anticipated that services would only have little potential for increased efficiency through technological advances in comparison with manufacturing. For quality assurance, however, he suggested that salaries in the services sector would need to keep pace with the general increase in salaries in an economy. The result would be constantly rising costs in the services sector caused by rising salary costs alongside stagnating productivity ("cost disease").

48 See Kox und Rubalcaba (2007).

49 See Firgo (2016).

whole. Even if future developments in the effects of digitalisation and Industry 4.0 on employment cannot be foreseen exactly, the positive development to date of knowledge-intensive service industries is still unmistakeable, in particular in ICT and in R&D services.

4.2.3 Summary

This chapter has examined various aspects of innovation in the business sector more closely, with a particular focus on the role of innovative service providers, including the ICT field, and on the proliferation of Industry 4.0 technologies in Austria. The results of the European Manufacturing Survey (EMS) regarding the use of Industry 4.0 technologies also show that it is predominantly large firms that have begun to deploy these. This reflects a classic distribution pattern in which large firms have advantages in adaptation compared with SMEs, due to the fixed costs associated with introducing new technologies. RTI policy could initiate a process of reflection in this regard on the extent to which diffusion funding (as opposed to research funding) for SMEs in the field of Industry 4.0 requires a separate allocation of resources. Previous examples of this type of support include for instance the FlexCIM programme of the ITF. Specialised ICT service providers, which are developing dynamically in Austria, could play a key role in any such programme to promote the spread of these technologies. The high level of innovation is a strong feature of knowledge-intensive services, while innovative potential, R&D intensity and productivity are in part comparable with manufacturing. Some sectors such as pharmaceuticals and ICT have even overtaken manufacturing in the intensity of their research, although these findings are to be interpreted with caution due to a possible lack of clarity in the statistical classification of sectors. Knowledge-intensive services are generally also highly productive and help increase productivity in sectors with demand for these services. The dynamic development in specialised, innovative knowledge-intensive services is particularly beneficial for small and medium-sized enterprises (SMEs) where company size implies that it is not economically viable to develop such know-how in-house. The successful diffusion of digital technologies is important for the long-term competitiveness of firms both in the secondary sector (Industry-4.0 technologies) and in the services sector (ICT technologies), and may help to limit job losses caused by digitalisation in so far as the continued existence of firms has positive employment effects when compared with what would otherwise be the threat of closure.

4.3 Technological transformation, employment and qualification requirements

As in earlier phases of rapid technological transformation, both very positive and also potentially very negative effects on employment are ascribed to digitalisation. In these debates, the short-term effects of technological transformation are often overestimated, with too little attention being paid to the economic, legal and social preconditions required for the implementation and distribution of the new technologies. In contrast, the long-term effects are frequently underestimated as these only become fully effective after a wide variety of complementary changes have occurred.[50]

Current technology trends are distinguished above all by dramatically reduced "unit costs" in information processing and data communication. The combination of networked computing units with ever greater levels of performance and fully digitised storage of mass data, growing rapidly through networking, opens up new potentials for integrated information processing activities and learning processes. These facilitate the increasing automation and networking of activities over long distances and enable a wide variety of applications for "artificial intelligence" in the form of

50 See Mokyr et al. (2015).

the automation of intelligent behaviour.[51] Electronic business transactions and public services, networked digital manufacturing (Industry 4.0), driverless vehicles, "smart" cities, "smart" living or telemedicine are well-known examples of this.

The following section begins with a general overview – as far as can be empirically observed – of the connection between innovation activities and working conditions (see Chapter 4.3.1), and goes on to describe developments in the effects on employment (see Chapter 4.3.2) and impact in terms of qualification requirements, and the possible effects of technical transformation on incomes and income distribution (see Chapter 4.3.3).

4.3.1 The role of innovation activities in the organisation of work in Austrian firms

The economic situation is characterised by enduring structural and technological change, which is why a high level of innovation activity and flexibility is essential for firms if they are to remain competitive. According to a survey[52] carried out among large Austrian industrial firms, the qualifications and skills of the workforce and the technological content of the products manufactured are two crucial factors in being able to keep ahead of national and international competitors. According to the firms which participated in the survey, the importance of both these factors in ensuring their competitiveness will increase even further in the next five years. In the course of transition towards Industry 4.0, every third firm expects competition based on quality to increase, together with the increased need to invest in human and physical capital. International studies also point to structural change with regard to workforce training levels as a result of technological transformation.[53] In terms of reacting to organisational and technological change, firms have a choice between in-house training or recruiting new qualified employees. The question as to how and in which direction this structural change will take place within the workforce has been investigated for the Austrian context in a current study.[54]

Based on this examination, firms are consolidated into groups that are as homogeneous as possible with respect to the funding received by them, their industry-wide innovation activities and age structure, in order to identify differences in the working conditions. If a structural change becomes apparent in the workforce as a result of increased innovation activities, this should be more obvious for those firms operating in more innovative and knowledge-intensive industries than for firms in more traditional sectors.[55] Moreover, potential differences between firms that have received funding and those that have not received funding within of the clustered groups of firms are discussed. The firms are clustered based on the average age of the firms, firm size (measured by the average number of employees per annum) and the level of innovation in the sector in which the firms operate. The relative innovation activity in a sector is determined by using a standard industrial classification code of the industry:[56] This involves

51 See Peneder et al. (2016).

52 See Hölzl et al. (2016).

53 See Behaghel et al. (2008); Chéron et al. (2007).

54 See Bock-Schappelwein et al. (2016). The study is based on a unique data set that links information on funding received by firms with company and workforce-specific features for the first time. The only funding taken into account here is funding from the Austrian Research Promotion Agency (FFG). Firms that have received advice but no financial support are not included in the analysis. Firms that are characterised by very low funding activities and accordingly receive very small and rare amounts of funds are also not included in the analysis.

55 Disruptive innovations can also be observed in traditional sectors, as shown by the examples of Amazon in the retail sector and Airbnb in tourism. However, industries that are more traditional generally feature lower levels of innovation activity.

56 See Peneder (2010).

(1) Industries that feature high levels of innovation intensity: The proportion of firms that engage in intramural research is particularly high in these industries. The focus is on product innovations and those industries are characterized by high numbers of patent applications. This group of industries consists primarily of sectors in the ICT and research services areas.

(2) Industries that are characterised by medium-high levels of innovation intensity: Many industries in this category focus on process innovations as a priority. The R&D expenditure is below 5% of revenues on average. Industries in this group include, for example, chemical products and telecommunications. The manufacture of goods made from wood and paper can be stated as an example of those industries that are characterised by average levels of innovation intensity.

(3) Industries that feature medium-low levels of innovation intensity and focus primarily on the adaptation of new technologies. This includes, for example, the food industry, publishing and insurance.

(4) Lastly, industries that are characterised by low levels of innovation intensity and focus primarily on the adaptation of new technologies.[57]

Firms are consolidated into groups that are as homogeneous as possible based on these characteristics using cluster analyses: (1) young/highly innovative, (2) young/innovative, (3) young/less innovative, (4) established/innovative, and (5) established/less innovative firms. While older firms dominate in the clusters of established firms, the remaining three groups are characterised by relatively young firms. Annual revenues are higher than average primarily in established/innovative firms, while young/highly innovative firms are classified within highly innovative industries in particular.[58]

These different types of firms provide the basis for examining the structure of workforce, with a further distinction made for each type between firms that receive funding and those that do not. Specific workforce characteristics are identified using a series of indicators. These include the structure of the workforce by gender, age, education, social status (manual workers, white-collar employees, officers), length of employment, and employment turnover. A distinction is made between low, medium and high levels of education with respect to the highest level of education completed. The low levels of education relate to people who only had compulsory schooling. The medium levels of education include those who complete apprenticeships and medium-level technical and vocational schools. The high levels of education include the secondary school leaving certificate (general educational and higher technical and vocational college), graduates from universities or universities of applied sciences along with university-related degrees.

In all, 84,334 of the Austrian firms observed in 2014 were categorised using the above presented firm classification. Around three quarters of these firms are categorised as less innovative (17,006 established/less innovative firms, 46,624 young/less innovative firms), a further fifth are innovative (2,215 established/innovative firms, 13,970 young/innovative firms) and 5.4% of firms examined are classified as highly innovative (and young) (4,519 firms).

30.4% of the young/highly innovative firms and young/innovative firms are active in manufacturing as are a fifth of the established/innovative firms, while hardly any firms in the group of the young/less innovative firms (1.9%) are involved in manufacturing.

57 For those industries which cannot be classified according to the suggested industry classification, average R&D intensities are used instead. All other industries are assigned to their corresponding industry cluster in accordance with Peneder (2010). Only firms for which there is information available regarding the industry to which they belong can be mapped accordingly in this classification.

58 See Bock-Schappelwein et al. (2016).

Table 4-4: Workforce-specific features, broken down into types of firms, 2014

	Established and innovative			Established and less innovative			Young and highly innovative			Young and innovative			Young and less innovative			All types of firms		
	Total	F	NF	Total	F	NF	Total	F	NF	Total	F	NF	Total	F	NF	Total	F	NF
Average share of women [as %]	47.4	25.9	49.0	43.4	28.6	43.8	34.5	26.2	36.4	48.0	32.3	48.9	45.9	36.9	46.0	44.5	29.5	45.1
Average age of the workforce in years	41.1	41.7	41.0	39.5	40.9	39.5	36.5	35.3	36.8	37.9	36.7	38	37.4	37.9	39.5	36.3	36.0	36.3
Share of the workforce that is highly qualified [as %]	30.0	19.9	30.7	19.2	19.3	19.2	30.5	40.8	28.1	29.1	34.2	28.8	16.0	33.3	15.8	20.0	32.8	19.6
Share of the workforce with low level of qualifications [as %]	18.1	13.5	18.5	19.2	14.8	19.3	8.8	6.4	9.4	11.8	11.0	11.8	16.6	7.8	16.7	15.9	9.8	16.1
Proportion of blue-collar workers predominating [as %]	47.8	68.6	46.2	63.5	62.2	63.5	22.5	26.0	21.7	27.6	37.1	27.0	53.8	32.5	54.0	49.6	38.8	49.9
Proportion of white-collar employees predominating [as %]	54.1	30.8	55.9	37.9	38.5	37.9	78.6	76.0	79.3	72.5	63.8	73.0	47.2	69.7	47.0	51.4	62.5	51.0
Symmetrical growth rate in employment [as %]																		
Growing (strongly)	28.6	32.7	28.3	29.4	32.8	29.3	38.6	47.8	36.4	34.0	43.3	33.5	37.1	38.4	37.0	34.9	41.5	34.7
Stagnating	39.4	38.5	39.4	38.2	31.5	38.4	39.5	22.9	43.4	43.4	26.9	44.4	39.2	31.3	39.2	39.7	27.9	40.1
Contracting (heavily)	32.1	28.8	32.3	32.4	35.7	32.3	21.9	29.2	20.2	22.5	29.8	22.1	23.8	30.3	23.7	25.4	30.6	25.2
Turnover rate grouped [as %]																		
<0.5	56.6	62.2	56.2	44.8	53.3	44.5	48.9	49.9	48.6	45.9	41.3	46.2	32.8	42.7	32.7	38.9	47.5	38.6
0.5<=x<=1	22.7	26.9	22.3	22.8	35.2	22.4	24.6	29.9	23.4	24.2	35.6	23.5	18.4	30.9	18.3	20.7	32.4	20.3
1<x<=2	12.4	7.7	12.7	16.1	8.7	16.3	17.2	15.2	17.6	18.0	16.9	18.1	20.5	16.6	20.6	18.8	14.4	19.0
>2.0	8.4	3.2	8.7	16.4	2.8	16.7	9.4	4.9	10.4	11.9	6.3	12.3	28.3	9.8	28.5	21.6	5.7	22.1
Churning rate grouped [as %]																		
<0.5	64.5	69.9	64.1	53.8	64.3	53.5	68.1	65.8	68.6	62.0	55.6	62.3	45.8	56.9	45.6	51.8	61.3	51.4
0.5<=x<=1	18.7	20.5	18.6	18.6	27.6	18.3	17.3	22.6	16.0	18.5	29.9	17.8	15.2	24.1	15.2	16.7	25.7	16.4
1<x<=2	10.2	6.4	10.4	13.5	6.1	13.7	9.6	8.8	9.9	12.2	11.4	12.2	16.5	13.1	16.6	14.7	9.7	14.8
>2.0	6.6	3.2	6.8	14.1	2.0	14.4	5.0	2.8	5.5	7.4	3.1	7.6	22.5	5.9	22.7	16.9	3.3	17.4

Assessments as at reference date 31 Dec. 2014
F = innovation funded
NF = not innovation funded.

Source: Austrian Research Promotion Agency (FFG) AURELIA-HV data record, Calculations: Austrian Institute of Economic Research (WIFO)

Gender

Especially in the group of established firms as well as in the group of young/highly innovative firms comparatively few women are working. Based on the fact that 46.8% of all employed workers in Austria in 2016 were women, the proportion of women is particularly low in young/highly innovative firms and established/innovative firms at around 26% (see Table 4-4), while this proportion is somewhat higher in the young/innovative and the young/less innovative firms.

Age

Differences between the different groups of firms can also be seen in relation to the age structure of the workforce, particularly between established/young firms. While the average age of the workforce in the established/innovative firms (41.7 years of age in the firms receiving funding and 41.0 years of age in those not receiving funding) and in the established/less innovative firms (40.9 and 39.5 years of age respectively) is relatively high, the average age of the workforce in young/highly innovative firms (particularly in those receiving funding) is well below this at approx. 35 years of age.

Education

Measured in terms of the proportion of employees with high levels of education in the top quartile (top 25%)[59], young firms that received funding have comparatively high numbers of highly qualified employees within the workforce (40.8% of young/highly innovative firms with funding). In contrast, the proportion of established/innovative firms with a high proportion of well-educated employees is just 19.9%. In general, it is clear that not only is the proportion of highly qualified employees who form part of the workforce higher in firms with funding, but there is also a greater variety of different educational qualifications mapping the diversity in the task areas at the operational level.[60]

Social status

With respect to social status of the workforce, there are also differences between the types of firms, and additional distinctions between firms with and without funding. Firms that feature less innovation activities also have a particularly high proportion of blue-collar workers. By contrast, the groups of innovative firms include more firms that have a particularly high proportion of white-collar employees.

Within the group of firms with funding, few structural differences based on innovation activities can be identified but rather based on the age of the firms. In established firms, the proportion of blue-collar workers tends to be higher than average, irrespective of the innovation activity in their industry. The proportion of firms that mainly have white-collar employees predominates, in turn, in the group of young/less innovative firms.

Employment

While there is a relatively equal distribution observed between employment that is growing (strongly), stagnating and contracting (heavily) among established firms, young firms are characterised by a particularly high proportion of firms with growing employment (strongly) (38.6% of young/highly innovative firms, 34.0% of young/innovative firms, and 37.1% of young/less innovative firms). This supports the results from other empirical studies on the connection between a firm's age and employment growth.[61] However, the proportion of firms having stagnating employment is highest in all types of firms (between 38.2% of established/less innovative firms and 43.4% of young/innovative firms).

in all categories of firms, the proportion of firms with (strongly) growing employment is higher among firms with funding than it is among firms with no funding. The difference of around ten percentage points is particularly striking in the categories of young/(highly) innovative firms: 47.8% of young/highly innovative firms with funding and 43.3% of young/innovative firms with funding demonstrate (strongly) growing employment.

Firms with funding also tend to have lower turnover rates[62] than those with no funding, irrespective of the category of firm. Unlike 22.1% of firms with no funding only around 5.7% of all firms with funding have turnover rates larger than two. The largest group of firms features very low turnover rates across all categories of firms. However, a difference with respect to very high turnover rates can be observed between innovative and less innovative types of firms. The pro-

59 The top quartile is characterised by a proportion of highly educated white-collar employees of more than 14.3%. Only 25% of firms have a proportion of white-collar employees with a lower level of education of more than 15.4%.

60 See Bock-Schappelwein et al. (2016).

61 See Evans (1987); Geroski (2005); Haltiwanger et al. (2013).

62 The turnover rate measures the total number of flows in relation to the stock of employees on a yearly average.

portions of firms with high turnover rates in the less innovative types of firms are in some cases multiples of the proportions observed in innovative categories of firms. A total of 28.3% of young/less innovative and 16.4% of established/less innovative firms have turnover rates of more than two, while the same applies for 11.9% (9.4%) of young/(highly) innovative and 8.4% of established/innovative firms.

The churning rates[63] are generally lower at innovative types of firms than at less innovative types of firms. Young/less innovative firms in particular have higher churning rates. Distinguishing between firms with funding and with no funding reveals a similar picture to the turnover rates; only a small proportion of firms with funding have very high churning rates across all categories of firm. The difference is especially pronounced within the group of young/less innovative firms: while 22.7% of young/less innovative firms with no funding have very high churning rates, the same only applies to 5.9% of young/less innovative firms that have received funding.

With respect to the working conditions and workforce in different categories of firms and differentiating between firms with funding and with no funding, the extended analysis shows that the proportion of women in funded firms which was already low in any case is particularly low in young/innovative and established/innovative firms. This highlights the importance of long-term measures that provide targeted support for recruiting women in innovative industries, but which are not at the focus of the funding and promotion of innovation activities considered in this analysis. The workforce at young firms is also comparatively young. These young companies also have comparatively high numbers of highly qualified employees in the workforce, particularly in the young/highly innovative firms with funding, while they barely have any lower qualified employees. Skills and abilities, together with formal education are key factors for labour market integration, particularly given the increased digitalisation of work. Formal qualifications, skills and abilities are required that makes a clear distinction between the human workforce and robots or programmed algorithms.[64] Labour turnover with no effect on employment stock take place especially in young/less innovative firms that receive no funding for innovation. In all categories of firms, the group of firms with funding has a higher proportion of firms with (strongly) growing employment than the group of firms with no funding. Employment tends to demonstrate a higher level of stability as a result.

4.3.2 Is work drying up for us? – The impact of new technologies on employment

While Chapter 4.3.1 examined the effects of innovation activities and funding on the organisation and growth of employment, this chapter looks specifically at the impact of new digital automation technologies and outlines the trend for work volumes over time. The current discussion is characterised by "digital fears" of replacing human work with increased automation. The question arises (again), therefore, whether work will emanate from the labour society in future. This is based on a series of studies that identify a large number of tasks that could potentially be automated (Table 4-5). It includes Frey and Osborne (2013), who have calculated based on expert assessments that 47% of employees in the US are in jobs that have a high probability of being automated within the next one or two decades (jobs at risk). Bowles (2014) transferred this approach to research to the European Union and came to a similar result, with around 50% of all jobs in Austria and Germany affected by automation. Brzeski and Burk (2015) also estimate that around 59% of jobs would be affected in Germa-

63 The churning rate provides information on the size of the company's employee turnover (inflows and outflows) with no effects on stock of employment.

64 See Bock-Schappelwein und Huemer (2017).

Table 4-5: Examinations of the automation potential for job roles and/or tasks

Authors	Country	Automation potential related to	Key results: potentially affected …
Frey and Osborne (2013)	USA	Job roles	47%
Bowles (2014)	EU nations	Job roles	AT: 54%
			DE: 51%
Brzeski and Burk (2015)	Germany	Job roles	59%
Pajarinen and Rouvinen (2014)	Finland	Job roles	36%
Bonin et al. (2015).	Germany	Tasks	12%
Dengler and Matthes (2015)	Germany	Tasks	15%
Arntz et al. 2016	OECD countries	Tasks	AT: 12%
			DE: 12%

Source: WIFO chart.

ny. According to estimates by Pajarinen and Rouvinen (2014), this affects around one third of jobs in Finland.

By contrast, studies focused on an analysis of the tasks (rather than on entire professions)[65] provide a more complex picture. According to these, automation should not result in professions being lost in their entirety, but task profiles will change within job roles. Overall, they expect significantly fewer job losses from automation on a scale of around 12%. These will affect primarily lesser-qualified employees. Dengler and Matthes (2015) come to a similar conclusion, i.e. that around 15% of employees in Germany are currently affected, as more than 70% of the content of their work could be completed by computers. Arntz et al. (2016) calculated the probability of automation for 21 OECD countries given the heterogeneity of work content within job roles. According to them, 9% of jobs could potentially be automated in the countries examined, with this figure at 12% each in Austria and Germany.[66]

Despite the low figures compared with other studies (the figures here are gross variables, i.e. without taking into account the positive effects on employment from digitalisation), the results still made headlines last year, primarily because Austria (together with Germany) features the highest risk potential of all comparison countries. The comparatively high proportion of employees with low qualifications is the reason for this. Tichy (2016, 861) on the other hand points out that above-average numbers of low to medium qualified employees carry out tasks in Austria that are difficult to automate as a result of a production structure often based on short runs. In this case, the potential threat to Austria would be overestimated.

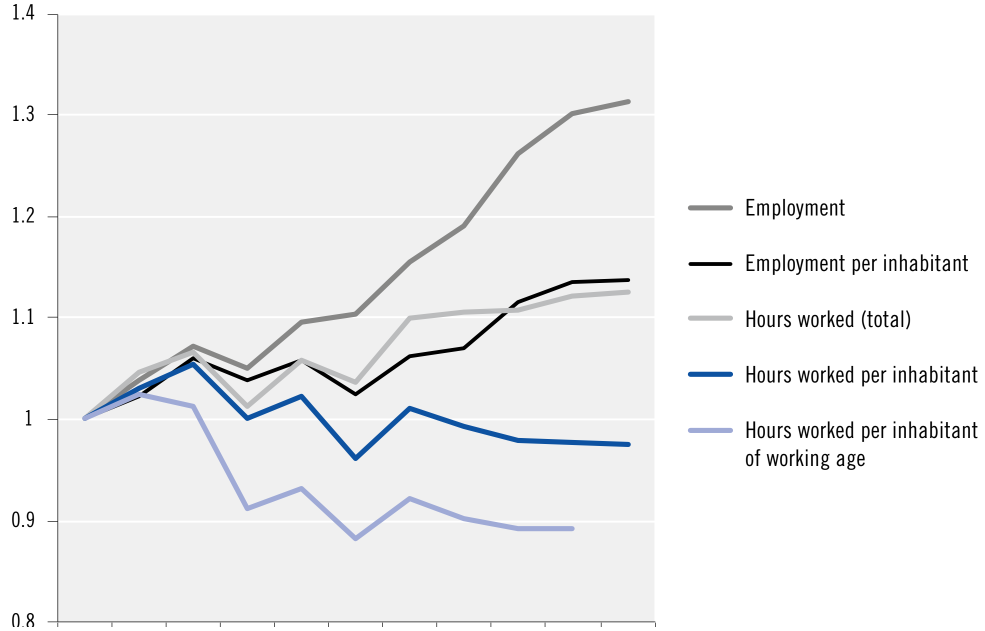
Assessments on the potential for rationalisation centred on technology are countered with the argument that the hypothetical technical potential for redundancy will never be fully exploited in practise. Aside from legal, ethical and emotional ("working climate") obstacles, the situation is also dependent on economic profitability. The human workforce continues in many situations to be characterised by major flexibility and by its ability to react quickly to unexpected events and circumstances. Finally, the deployment of new technologies generally also requires high levels of investment as well as longer and, at times, expensive learning processes in firms, which will in any case slow down the technological change expected.

A look at the longer-term trends in overall economic work volumes in Austria shows the extent to which technological change has re-

65 See Bonin et al. (2015) for Germany.

66 A recent study by Nagl et al. (2017) determines a comparable loss in employment of 9% for Austria.

Fig. 4-4: Work volume trends in Austria (Index, 1970=100)



Source: The Conference Board, OECD. Calculations: Austrian Institute of Economic Research (WIFO).

duced labour demand or to which other economic mechanisms, such as the demand for new goods and services improved with digital processes and properties, has been able to counteract the reduction in labour demand.

A look at the trends in unemployment alone, on the other hand, would not suggest that work is drying up as a result of technological change. This is because, in the short term at least, unemployment is affected more by crisis management, economic fluctuations and growth in the labour supply. The latter has contributed to persistent growth in employment of around 30% since 1970 (Fig. 4-4). A look at population growth, for instance, shows that the rise in employment per inhabitant has been around 14% since 1970. However, this key figure does not yet account for the fact that the average working hours per employee are also declining continuously.

The crucial issue, therefore, in terms of whether work is drying up over the long term relates to working hours actually provided rather than employment.[67] These working hours grew by around 13% from 1970 to 2014. If one also takes population growth into account, then the working hours per inhabitant have remained virtually constant at –2% over the course of more than four decades. It is only when demographic change is taken into account, and the hours worked per inhabitant of working age are calculated, that a substantial fall of around 11% can be seen in working volumes. This key figure represents a lower limit, since on the one hand the structural increase in those years that young people use for their education is not taken into account, and on the other the end of the data series in 2013 also falls within a period that is still characterised by efforts to overcome the major financial and economic crisis. There is also the fact that the data available shows the biggest fall in the first half of the 1980s, while the trend after this is relatively stable, i.e. contrary to the hypothesis of growing "technological unemployment" in recent years.

67 See Peneder et al. (2016).

The arguments on the impact on employment or on work processes of deploying digital technologies in firms are controversial. Analysing the change in the focus of tasks in the last few decades is useful for the purposes of assessing potential future trends for the labour market.[68] This provides an indication of the technological changes that have already taken place in firms. The focus of the tasks can be distinguished by whether they relate primarily to routine or non-routine tasks. Routine tasks follow recurring rules that are potentially programmable, while the procedures for non-routine tasks are too complex and variable to be translated into programmable code and executed by machines. A distinction can also be made between analytical, interactive and manual non-routine tasks on the one hand and cognitive and manual routine tasks on the other. A longer-term comparison between the mid-1990s and 2015 has shown that employment is increasing proportionally in analytical and interactive non-routine tasks, while employment that is characterised by manual non-routine tasks is gradually becoming less important in relative terms. Employment focused on analytical and interactive non-routine tasks has predominated since the early 2000s. Within employment that is characterised by non-routine tasks there is a gradual shift taking place from manual to analytical and interactive non-routine tasks. A similar trend can be seen within employment focused on routine tasks, in which cognitive routine tasks are becoming increasingly important at the expense of manual ones.

The heavy fall in manual routine tasks over the last few years shows that the automation process is already very advanced in many industries. Assuming similar employment trends in the near future, additional employment opportunities will be derived in analytical and interactive non-routine tasks as well as cognitive routine tasks, while jobs that generally consist of manual routine tasks should continue to become less significant. The extent to which cognitive routine tasks will be replaced by technology remains an open issue. Cognitive routine tasks are predominantly (at around 80%) exercised in Austria by men and women with a medium formal qualification profile. Up until now, many technological innovations have complemented employees' qualification profiles rather than replaced them.

It is also particularly difficult assessing the impact that digital technologies will have through the creation of new business models and markets on employment trends over the next few years. Jobs or tasks will emerge as a result of new products and business areas, while existing jobs will be replaced to some extent as a result of this.

4.3.3 Working and qualification conditions

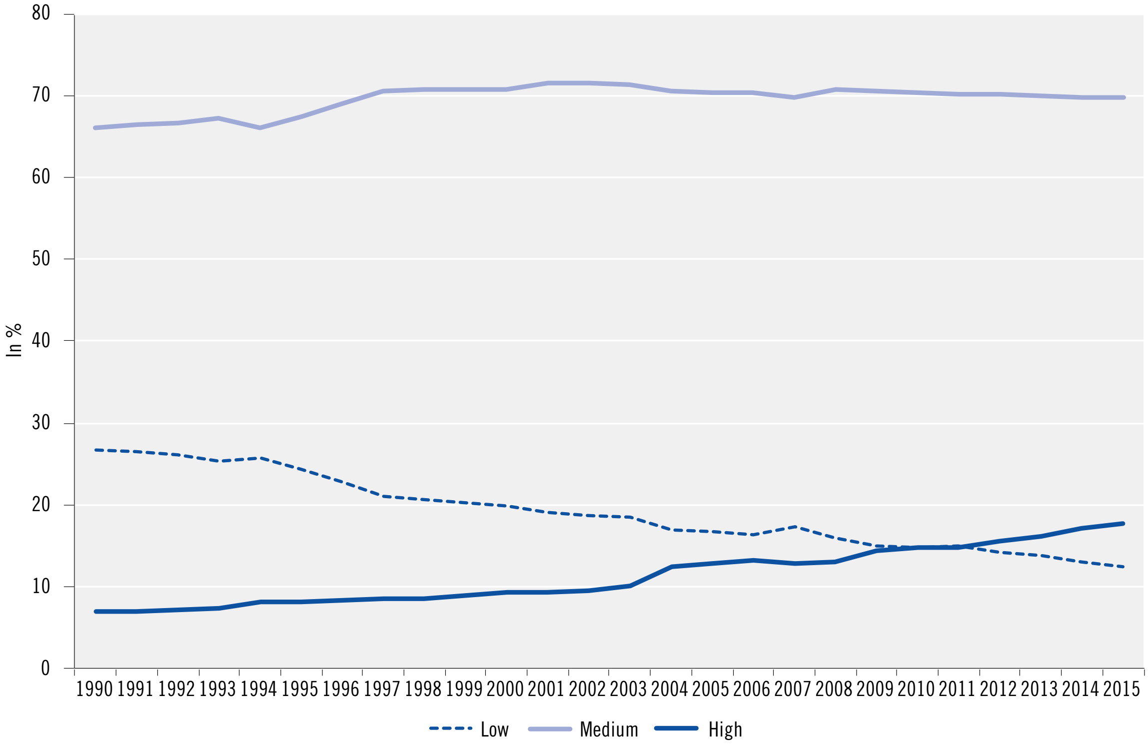
Digital technologies will require skills that distinguish individuals from robots or programmed algorithms, such as understanding and communicating information, solving unstructured problems and carrying out manual non-routine tasks. Specific skills and formal qualifications along with experience and digital skills are also crucial in terms of labour market integration, while social skills, communication skills and problem solving are equally indispensable.[69]

By task, Austria has had a relatively stable ratio of employed workers for the last 20 years (see Fig. 4-5). The proportion of jobs with routine tasks is relatively stable with this at 40%. Shifts can be seen on the other hand over the observation period along the line separating manual and non-manual tasks. While employed workers were still roughly equally distributed between manual and non-manual tasks in the mid-1990s, the proportion of non-manual tasks has risen since then to around 60% now, while manual tasks has fallen to around 40%. Manual routine tasks are exercised by workers with low levels of

68 See Bock-Schappelwein (2016).

69 See Peneder et al. (2016); Bock-Schappelwein and Huemer (2017).

Fig. 4-5: Employed workers by highest level of education completed in Austria, 1990–2015



Employed workers (in accordance with Labour Force concept) with at least 12 working hours per week, prior to 1994 (in accordance with subsistence concept) at least 13 hours per week.
"Low" includes all individuals who are statutory school leavers at most, "medium" all individuals with completion of vocational training, occupational medium or higher training and general education higher training and completed graduate school, "high" all individuals with an academic education.

Source: Statistics Austria: Labour force survey micro census Calculations: Austrian Institute of Economic Research (WIFO).

education with particular frequency within manual tasks.[70]

In terms of the formal qualification, there is also a relatively stable proportion at around 70% of workers with medium levels of education identified in the last 25 years among employed workers.[71] Workers with low levels of formal qualifications have come under pressure. Their employment share is gradually falling while the proportion of highly qualified employees is rising. There have been more highly qualified employees in Austria since 2012 for the first time than workers with low levels of formal qualifications. In 2015, 17.8% of all employed workers had a university or similar degree, while the share of employees with low levels of formal qualifications fell to 12.5%. A gradual rise in qualification levels can be observed in Austria, with no indication of job polarisation in the sense of rising demand for low and high qualifications but falling demand for medium level qualifications.

4.3.4 Summary

Society's attention is currently focused on the impact of the technological change and automation on the future of work. This chapter discusses examinations of the potential for automation for job roles and/or tasks and looks at the issues

70 See Bock-Schappelwein (2016).

71 See Dinges et al. (2017).

related to future demand for workers and changes to the qualification requirements in a highly dynamic digitised economy, in order to estimate the changes associated with this more effectively and in an attempt to contribute to the factual debate. While the process of automation is already at a very advanced stage in many areas, the picture differs greatly between the individual sectors. Additional employment opportunities are seen in particular for jobs featuring predominantly analytical and interactive non-routine activities as well as cognitive routine activities. Jobs in the manufacturing sector featuring generally manual routine activities are expected to become less significant. The penetration level for new technologies in services firms is still very low and is only expected to experience a moderate rise over the next few years. New requirements also arise from digitalisation in the area of qualifications and further education and training. Employees will be required in future to have abilities that machines are not (yet) able to develop, such as skilled manual or creative design skills, combined with digital skills and highly developed soft skills.

5 Austria in the European Research Area

The European context is important for Austria's national research landscape and research policy in many ways. The creation of a joint European Research Area will improve framework conditions and networking for European research, thereby contributing more generally to Europe's competitiveness. An integral component of these efforts is the recognition that significant societal challenges, such as climate change and demographic trends, require collaborative solutions that can no longer be delivered at the level of individual nations. The European Research Framework Programme is an important instrument in the communitarisation of research in Europe. In addition to the goals of networking stakeholders from various member countries and encouraging projects in the interest of Europe as a collective whole, the performance in the European Framework Programmes is an important indicator of the competitiveness of respective national research systems.

In addition to competitive proposals for R&D and innovation projects within the framework programme, transnational collaborative R&D efforts 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 are becoming increasingly significant. Besides bundling national resources to achieve "critical mass" in particular topic areas, they are an important instrument in anchoring bottom-up topics and focuses at the EU-wide level. Examples of this include Joint Programming Initiatives, ERA Nets and Joint Technology Initiatives.

With this in mind, the following chapter will discuss the ERA Roadmap, approved by the Austrian Council of Ministers in 2016, as the key strategic framework for positioning national initiatives in the European research area as well as Austria's performance in the associated monitoring system, the so-called ERA Dashboard. This is followed by an halftime overview of national stakeholders' performance thus far in the current Research Framework Programme, Horizon 2020. Finally, the importance of transnational European R&D collaboration for the Austrian research landscape will be described and discussed.

5.1 The Austrian ERA Roadmap

The creation of a joint European research area (the European Research Area – ERA) featured in the Treaty of Lisbon with the aim of improving coordination and cooperation amongst EU member states in terms of R&D policies and R&D funding. The intention is in accordance with Article 179 of the Treaty on the Functioning of the European Union (TFEU), to establish an important foundation for future knowledge-based and innovative economic and societal development in Europe.[1] Central components include promoting the mobility of researchers and the exchange of scientific and technological know-how within the EU. In addition to the European Research Framework Programmes, pertinent coordinated activities by member states as well as private and public research stakeholders are important instruments in the implementation of the ERA.

The "European Research Area Roadmap 2015–2020" was presented in spring 2015 within the

1 See European Commission (2000).

context of the "European Research and Innovation Area Committee (ERAC).[2] Based on experiences thus far, a total of seven key fields of action in six prioritised areas have been identified as essential for the further expansion of the ERA:

1. Effective national research systems
2.a. Joint tackling of "grand societal challenges"
   b. Optimisation of the use of public investments in research infrastructure
3. Open labour market for researchers
4. Gender equality and "gender mainstreaming" in research
5. Optimised circulation of, access to and transfer of scientific knowledge
6. International cooperation

These shared priorities, however, exist in a context of heterogeneous national research and innovation systems within the EU and member states' various strategic processes and objectives. The RTI Strategy put forward by the federal government in 2011[3] represents the central frame of reference in Austria for activities related to implementing the ERA. The guidance provided by these transnational priorities may at the same time serve to set national initiatives in motion.

It was in this context that in May 2015 the EU Competitiveness Council adopted the ERA Roadmap 2015–2020, in which each member state is encouraged to move towards national implementation of the European ERA Roadmap by means of national action plans or strategies.[4] This call was met in Austria with the development of an "Austrian ERA Roadmap".[5] It set its objectives in line with the six ERA priorities and was approved by the Austrian federal government's Council of Ministers in April 2016.

Key milestones include the assessment related to setting up an "Austrian Research, Technology and Innovation Hub" (ARTIH) in Brussels as an information and communications hub for Austrian RTI stakeholders at the EU-wide level and the initiation of an OECD review of the Austrian innovation system, the results of which are expected by the end of 2018. Additional milestones, in particular those related to scientific mobility, gender equity and diversity as well as open access and open data, address universities as stakeholders and incorporate focuses that have already been implemented in current performance agreements or are planned for the future,. The key reference document is the Austrian University Development Plan 2016–2021[6], of which central objectives already coincide with numerous initiatives from the "Austrian ERA Roadmap" (e.g. strengthening basic research, promoting young researchers' careers, expanding knowledge and innovation transfers and locational advantages, and promoting a cultural change in favour of social inclusion, gender equality and diversity at the university).

The implementation of measures contained in the Austrian ERA Roadmap are subject in principle to the availability of funding and requires coordination with the Federal Ministry of Finance (BMF) within the framework of the budgetary agreement. Progress in the implementation of the measures contained in the ERA Roadmap and developments in performance in terms of the individual indicators should be reported and discussed in the progress reports that are released every two years, the first of which is to be released in early summer 2017.

5.1.1 ERA cockpit indicators: the ERA Dashboard

To accompany the implementation of the ERA Roadmap, a national working group developed the ERA Dashboard, a condensed set of indicators that assigns one high-level indicator and one

2 See ERAC (2015).

3 See BKA et al. (2011).

4 See Council conclusions on the European Research Area Roadmap 2015–2020, document 9351/15 RECH 181 COMPET 286 MI 354 TELECOM 133, 29 May 2015.

5 See BMWFW (2016); https://era.gv.at/object/document/2581

6 See Federal Ministry of Science, Research and Economy (BMWFW) (2015).

or to two sub-indicators to each of the ERA's six priorities (Table 5-1). Whilst sub-indicators are meant to represent developments of national interest, the high-level indicators can be traced back to the respective EU Commission guidelines and allow for the comparative assessment of the implementation of the ERA across all EU member states. Data to this end is supplied by the EU Commission. To a certain extent, data specific to Austria is used in the sub-indicators. Table 5-1 shows Austria's performance with respect to the ERA Dashboard's individual indicators. Current values and, when available, most recent past values are provided to illustrate development over time. In addition, an international comparative value is provided for each indicator, when possible, in the form of the EU-28 average and the top 3 values for each individual indicator.[7] Aside from the six priorities, additional indicators have been chosen to measure the direct effect of ERA activities on scientific and technological performance (ERC grants, patents) and the indirect effect on economic performance.

The high-level indicator for Priority 1 (Effective Research Systems) is composed of indicators for frequently cited publications, PCT applications, Marie Curie fellowships and ERC Grants. Austria ranks slightly above the EU average, but clearly behind the category's top 3 countries (Sweden, Denmark, the Netherlands), which have excellent science systems and large patent-intensive firms. The first sub-indicator shows the share of project applications for the Horizon 2020 programme that have been rated very good, but does not include ERC and Marie Curie activities. Here Austria is a leading country, with nearly one third of project applications rated as very good. This indicates a good support infrastructure around the submission of projects in addition to the high quality of application-oriented research. The second sub-indicator is identical to Austria's rank in the European Innovation Scoreboard (EIS) as of the latest available EIS report. Last year, Austria moved up in rank from 11 to 10.[8]

Budgeted R&D expenditures (GBARD, Government Budget Allocations for R&D) for i) Europe-wide, transnational research programmes and ii) bilateral or multilateral coordinated research programmes relative to the number of researchers in the public sector and at universities were chosen as a high-level indicator for priority 2a, managing societal challenges. Austria did well in this area, well above the EU average and just behind the leading three countries in this indicator (Belgium, Italy, Latvia). In addition to the two expenditure categories in the high-level indicator, the single sub-indicator for this priority measures expenditures for transnationally financed research institutes, such as CERN[9] and relates the expenditures to the total R&D expenditures as budgeted (in % GBARD). In this area, Austria performs slightly under average.

Priority 2b encourages countries to use the research infrastructure in an optimal manner and uses the availability of national implementation plans for the ERA, including those for ESFRI projects (European Strategy Forum on Research Infrastructures) as a qualitative high-level category with the possible values 0/1. Austria put its implementation plan into action in 2014. The first sub-indicator measures a country's authorised investments in the area of research infrastructure relative to population. In this respect, Austria comes ahead of the UK, Germany and France in the midfield. The second sub-indicator measures investment based on the number of researchers, access to research infrastructure with support received from Horizon 2020 in terms of researchers in the public and higher education sectors. Austria came in fourth place.

7 The two sub-indicators on research infrastructure and the ERC indicator on direct effects were set, differently than in the original version of the ERA Dashboard, on the basis of population in relation to the size of the country. The EU-28 average is calculated as the mean of all of the countries' values.

8 According to the 2015 and 2016 reports from the EIS. If one were to apply the adjusted 2016 EIS methodology to 2015, Austria would have fared worse, falling from 9 to 10.

9 European Organisation for Nuclear Research, https://home.cern/

Table 5-1: ERA Dashboard – implementing the ERA Roadmap on the basis of indicators, Austria compared with the EU-28 and Top 3

	Current	Latest values	EU-28	Top 3
Priority 1: More effective national research systems				
High-level indicator: Excellence in research (corrected)	48.6	45.0	44.4	80.1
Sub-indicator: Quality of the project consortia in H2020	30.8%	32.0%	22.8%	32.4%
Sub-indicator: European Innovation Scoreboard (country ranking)	10	11	-	-
Priority 2a: Jointly managing societal challenges				
High-level indicator: National budgeted expenditures for R&D in Europe-wide, bilateral or multilateral transnational R&D funding programmes	6,958	6,032	2,507	8,201
Sub-indicator: Public financing of transnationally coordinated R&D in % of total budgeted expenditures for R&D	5.0%	4.5%	3.9%	8.8%
Priority 2b: Public investments in research infrastructure optimal use				
High-level indicator: Availability of national implementation plans including ESFRI projects and their funding requirements	2014	N/A	-	-
Sub-indicator: Approved participation in European research infrastructures	2.44	1.99	2.62	8.52
Sub-indicator: Number of researchers who accessed research infrastructure with the help of H2020 support	40.54	N/A	29.93	47.64
Priority 3: Open labour market for researchers				
High-level indicator: Transparent staffing: Number of research positions filled annually via the EURAXESS Jobs Portal per 1,000 researchers in the public sector	71.3	72.30	47.04	221.58
Sub-indicator: Number of professors appointed at universities from EU and non-member states	228	238	-	-
Sub-indicator: Number of research stays abroad by scientific/arts staff /[per university]	4102	4146	-	-
Priority 4: Gender equality and gender mainstreaming in research				
High-level indicator: Number of women appointed professors in the higher education sector	21.5%	20.3%	23.5%	31.6%
Sub-indicator: Number of female researchers in all sectors of performance	23.0%	22.8%	35.6%	50.3%
Sub-indicator: Glass ceiling index	1.76	2.04	1.82	1.08
Priority 5: Best possible diffusion and transfer of results of basic research				
High-level indicator: Number of firms with product or process innovations that cooperated in innovation activities with universities or public-sector research institutes 1	24.6%	-	7.3%	24.1%
Sub-indicator: Number of public-private co-publications per million people	59.0	54.2	33.9	156.30
Sub-indicator: Universities' licencing contracts	395	372	-	-
Priority 6: International collaboration				
High-level indicator: Scientific co-publications with international authors per 1,000 researchers in the public sector	57.7	55.8	50.71	87.04
Sub-indicator: EPO patent applications with national inventor and foreign owner as % of the total national EPO applications	30.4%	29.9%	38.3%	68.5%
Sub-indicator: Number of bilateral and multilateral joint calls with non-member states (acc. to Austria's Beyond Europe target countries)	15	21	-	-
Direct effects				
Sub-indicator: ERC funding received by country	5.80	3.09	3.11	11.46
Sub-indicator: PCT patent applications in challenges in relevant technological fields per billion GDP (in PPS€)	1.07	1.20	0.63	1.96
Sub-indicator: Patent applications per €10 million in funding from the framework programme	169.55	247.11	95.13	241.35
Indirect effects				
Sub-indicator: Employment share in high growth firms	19.4%	17.2%	17.8%	22.9%
Sub-indicator: Economic effects of innovation	0.47	0.49	0.48	0.76

1) Value for the EU for 2012

Source: European Commission, FFG, Data retrieved July 2016. Calculations: Austrian Institute of Economic Research (WIFO).

Priority 3 addresses an open labour market for researchers in Europe and uses the number of research positions occupied via the EURAXESS Jobs portal per 1,000 researchers in the public sector per year. Austria ranks in the middle of the group of countries; top-performing countries are Sweden, Poland and Croatia. The two sub-indicators for this priority are restricted to Austrian data alone and therefore subject to interpretation only over time, but not in international comparison. The number of appointments at universities of academic staff from EU and third-party countries as well as the number of stays abroad by scientific and arts staff (per university) remained stable in the past two years.

Priority 4 is concerned with gender equality and gender mainstreaming in research and uses the proportion of female professors in the higher education sector as a high-level indicator (She-Figures Indicator). Austria performs significantly under the EU average in this area, with just over one fifth. The first sub-indicator calculates the proportion of women in research positions in all sectors (business, universities, public research institutes, private non-profit institutions). With just under one fourth, Austria is again below the EU average of one third. This is related particularly to the low representation of women in corporate research. The second sub-indicator is the glass ceiling index, which is captured in the figures for the high-level indicator, but which relates the proportion of women professors to the proportion of women in research overall to assess opportunities for advancement for women in comparison to men. A value of 1 indicates that women are underrepresented relative to their share among all researchers. This is the case in all countries except Malta. Austria improved markedly last year and surpassed the EU average, but it is still far from achieving a value of 1, which would indicate equal opportunities for advancement for women and men.

The proportion of firms that cooperate with universities or public sector research institutes in developing product or process innovations serves as the high-level indicator for the best possible diffusion and transfer of results from basic research in industry and society (Priority 5).[10] Austria is again the top country in Europe in this indicator, which reflects the intense and long-term supportive efforts Austria has made (e.g. not least by means of the Kplus and, now, the COMET Centres). The first sub-indicator takes the form of a bibliometric calculation of the number of co-publications between public and private research institutes or firms. Here too Austria performs above average, but does not lead. This may indicate that research collaboration in Austria is more often located in applied research, with any publications more likely to be written by university researchers, whilst industry researchers are more actively engaged in product development. The second sub-indicator is related to data on Austrian universities alone and measures signed licensing agreements for technologies they have developed. This figure has experienced positive development since the previous years.

Finally, Priority 6 is related to international research collaboration, in both the research and industry sectors. The high-level indicator measures co-publications with authors from non-EU member countries. Austria achieved above-average values without reaching the top. The first sub-indicator shows the share of a country's patents with national inventors but international applicants. Austria performed below average in this respect. However, it should be noted with respect to this indicator that more innovative countries such as Denmark, Finland, Germany and Sweden performed even "worse", whereas countries that are catching up, such as Slovakia, Romania and Hungary, are top performers. This indicates that much research in these countries takes place in branches of multinational firms, whilst national innovative firms in their own right are still lacking. The second sub-indicator measures the number of bilateral and multilater-

10 The EU-28 average is available only for 2012, whilst the Austrian data are for 2014.

al joint calls with non-member states according to Austria's Beyond-Europe target countries, which declined in the last year.

With respect to direct effects, the indicators on ERC grants and patents altogether show an above-average position in the upper midfield, though not a leading position. The same is true for the first indicator of indirect effects, the share of investment in high-growth firms in innovative sectors. The economic effects of innovation indicator is a subgroup of indicators from the EIS, which reflects, for example, the contribution of knowledge-intensive sectors to employment figures and percentage of sales with innovations. Austria is average in this respect, though Austria's strengths in innovation, which are specialised in sectors with mid-level technology, are insufficiently measured. The economic effects in the EIS instead focus quite strongly on high-tech sectors.[11]

5.1.2 Summary

Results from the first ERA Dashboard, which is intended to accompany the implementation of the ERA Roadmap, provides a mixed picture with several areas in which Austria leads Europe-wide (quality of project applications to Horizon 2020 without ERC and MSCA, collaboration between science and industry in innovation), but other areas in which Austria demonstrates a need to catch up in comparison to the EU average (investment in European research infrastructure, gender equality, with the exception of the glass ceiling index). In most areas, however, Austria demonstrated above-average performance that, whilst not leading, was comfortably situated in upper midfield, similar to its scope of performance in research, technology and innovation one recognises from other areas, such as Austria's position in the EIS. However, the successful implementation of the ERA Roadmap requires additional efforts that specifically address known weaknesses.

5.2 Austria's performance in Horizon 2020

In this section, Austria's performance in the European research framework programme Horizon 2020 will be discussed with reference to data collected by the Austrian Research Promotion Agency (FFG).[12] As of September 2016, nearly a quarter of the entire Horizon 2020 budget of €77.2 billion has been disbursed. The three large pillars of Horizon 2020 are scientific excellence and infrastructure (share of total budget: 31%), industrial competitiveness (share of total budget: 21%) and societal challenges (share of total budget: 37%), followed by a series of individual programmes (see Table 5-2). The two largest programme lines are the ERC (European Research Council), which supports pioneering research purely on the basis of scientific excellence, and the more application-oriented programme lines more closely affiliated with industry that support the EU's leading role in cross-sectional and industrial technologies. Together, these make up 34% of the Horizon 2020 budget (see Table 5-2).

Most rates of implementation for individual programmes hover around one quarter, with just some significantly lower (innovation in SME: 11%) or higher (leading role in cross-sectional and industrial technologies: 34%), which means that around one quarter of the total available budget has been disbursed thus far. The success rate for all projects, investments and support mechanisms, i.e. the number of approved projects amongst the projects submitted, tends to be between 12% and 14%. The success rate for investments is 14.1% for the EU-28. This rate declined in comparison to the seventh framework programme by 7.6 percentage points, somewhat more than in Austria (from 22.4% to 16.3%).

11 See Austrian Research and Technology Report 2014, BMWF, BMVIT and BMWFJ (2014); http://www.bmwfw.gv.at/ftb, Janger et al. (2017).

12 See EU Performance Monitoring; https://eupm.ffg.at/

Table 5-2: Budget allocation by Horizon 2020 pillar, 2014–2020

	in % of the H2020 budget		in % of the H2020 budget
EXCELLENT SCIENCE	**31**	**LEADING ROLE IN INDUSTRY**	**21**
European Research Council	17	Leadership in enabling and industrial technologies	17
Future and emerging technologies	3	Access to venture capital	4
Marie Skłodowska-Curie funding	8	Innovation in small and medium enterprises	1
Research infrastructures	3	Industrial Leadership – Cross-theme	0
SOCIETAL CHALLENGES.	**37**	**ADDITIONAL TOPICS AND PROGRAMMES**	
Health, demographic trends and well-being	9	Spreading excellence and expanding participation	1
Challenges in the bioeconomy	5	Science with and for society	1
Secure, clean and efficient energy	7	Non-nuclear direct actions of the JRC	2
Intelligent, environmentally friendly and integrated transport	8	European Institute of Innovation and Technology (EIT)	3
Climate protection, environment, resource efficiency and raw materials	4	EURATOM	3
Europe in a changing world – Integrative, innovative and reflexive societies	2		
Secure societies – Protecting Europe's and its citizens' freedom and security	2		

Source: European Commission and the Austrian Research Promotion Agency (FFG).

Table 5-3: Distribution of approved funding to the Horizon 2020 pillars, Austria compared to the EU

	Funding distribution in AT	AT relative to IL	AT vs. CH	AT vs. EU28
Excellent Science	31%	91	36	95
Industrial Leadership	26%	120	565	109
Societal Challenges	40%	100	549	106
Other	2%	60	131	48

AT = Austria

IL = Innovation Leaders (Denmark, Germany, Finland, the Netherlands, Sweden)

CH = Switzerland

Source: European Commission, EU Performance Monitoring FFG. Calculations: Austrian Institute of Economic Research (WIFO).

This value is quite low and indicates that generally only one out of seven proposals is successful. The chance of failure is great, and the relationship between the work put into the application and the funds received is disproportionate. In comparison, the rate of success – whilst still low – is over 20% at the Austrian Science Fund (FWF), whereas the success rate for the Austrian Research Promotion Agency (FFG), which is much more heterogeneous in its programme lines, lies between 13% for BRIDGE-early phase financing, 35% in the BRIDGE programmes, 20-50% in thematic programmes and 65% in general programmes. Applications therefore have in general a greater chance of success in Austria, a factor that can have an impact on performance in Horizon 2020 if the costs for applications relative to the funding possibilities in Austria are too great and the advantages provided by EU projects can no longer outweigh these disadvantages in cost.

The following will first provide an overview of the distribution of Austrian research activities across Horizon 2020's three pillars before presenting success rates for applications according to the type of research actor compared with the EU average and the leading innovation countries. The distribution of funding by Horizon 2020 pillar (Table 5-3) paints a picture that is not fundamentally different from the EU-28 average and the leading innovation countries. Austria received somewhat less funding for excellent science, but a higher share for supporting its leading role in the EU when it comes to industrial technologies. Only under the category "Other" did

Table 5-4: Approved projects, participations, funding and collaborations, Austria compared to the EU

	Projects	Participations	Funding (millions €)	Coordinations
All countries	10,460	47,123	19,595.6	10,460
Austria	948	1,340	563.8	259
Austria's share in all countries	9.1%	2.8%	2.9%	2.5%
		per million people		
Austria	110	156	65	30
Innovation Leaders	103	151	71	35
Denmark	146	193	87	56
Germany	38	72	41	15
Netherlands	111	173	88	43
Finland	117	168	72	35
Sweden	104	146	68	28
Switzerland	106	135	45	27

AT = Austria

IL = Innovation Leaders (Denmark, Germany, Finland, the Netherlands, Sweden)

CH = Switzerland

Source: European Commission, EU Performance Monitoring FFG. Calculations: Austrian Institute of Economic Research (WIFO).

substantially less money flow to Austria. This includes the Euratom nuclear research programme, for which Austria contributes significantly fewer funds than did other countries. Switzerland is only partly comparable, given that it concentrates on funding in the area of excellent science and was not part of Horizon 2020 for the years 2014–2016. Swiss stakeholders could therefore only take part with self-financing. Caution should therefore be exercised in interpreting values for Switzerland, particularly in those pillars aside from support for excellent research.

A total of €564 million has been distributed to Austria through the Horizon 2020 programme thus far (Table 5-4). This amount can only be roughly compared to total public expenditures for R&D in Austria as funds have also been disbursed from precursor programmes since the start of Horizon 2020 and the most recent national R&D survey dates back to 2013. In that year, €180 million, or just 5.5% of the total Austrian public expenditures on R&D, were disbursed from the EU. Thus EU funding plays a relatively minor role in entire innovation system. On the other hand, these funds are for the most part awarded on the basis of strict evaluation criteria. The EU research programme additionally provides the possibility for international networking and reaching a critical mass in research, which can in turn be of further use within the national context. EU funding is therefore comparable to the funding awarded by the large Austrian funding agencies, the Austrian Science Fund (FWF) and Austrian Research Promotion Agency (FFG) and is, from this vantage point, a relevant extension of the funding available in Austria, especially considering that the FWF budget tends to be around €200 million and the FFG budget is currently around €450 million. Austria's participation in all of the participations, funding and coordinations approved thus far fluctuates between 2.5% and 2.9%. Austria achieves a larger share, of 9.1%, only when it comes to projects.[13] Relative to its population size, Austria lies somewhat below the average of the leading innovation countries in approved funding and coordi-

13 The high figure is a result of the manner in which projects are counted and an Austrian participation is sufficient. This means that the sum of participations by country frequently exceeds 100% since a number of researchers in large projects participate from various countries.

Table 5-5: Distribution of evaluated participations by organisation type, Austria compared to EU

		Higher education	Firms	Non-uni research	Publ. institutions	Other
Evaluated participations	**All countries**	12.4639	12.1813	60,428	11,216	12,395
	EU-28	108,886	111,483	55,639	9,752	11,443
	AT	2967	2981	1721	178	362
	IL	4288	4279	2690	560	444
Success rate of participations (in %)	**All countries**	12.5	12.9	17.3	26.6	19.6
	EU-28	12.1	13.1	17.1	26.1	19.3
	AT	12.7	17.3	16.7	46.6	20.7
	IL	12.7	14.8	18.2	27.4	20.2

AT = Austria
IL = Innovation Leaders (Denmark, Germany, Finland, the Netherlands, Sweden)
CH = Switzerland

Source: European Commission, EU Performance Monitoring FFG.

Table 5-6: Austria's success rate in the area of excellent science, compared to EU

	Approved participants	Thereof in coordinating roles	Approved funding	Success rate of participations	Share AT	AT relative to IL (IL=100)	AT relative to Switzerland (CH=100)	AT relative to EU-28 (EU-28=100)
Excellent science	320	131	175,624,158	14.4%	2.6%	112	97	111
European Research Council	60	56	100,523,906	16.9%	2.9%	127	74	136
Future and newly emerging technologies	34	5	16,197,823	7.0%	2.8%	112	92	115
Marie Skłodowska-Curie funding	192	65	47,336,933	15.6%	2.4%	129	126	122
Research infrastructures	34	5	115,65,496	23.3%	1.6%	66	61	67

AT = Austria
IL = Innovation Leaders (Denmark, Germany, Finland, the Netherlands, Sweden)
CH = Switzerland
Share AT = Austria's share in all funding

Source: European Commission, EU-Performance Monitoring FFG, Calculations: Austrian Institute of Economic Research (WIFO).

nations. Denmark and the Netherlands are leaders in this respect, whilst Germany lies markedly below Austria.

The distribution of the success rate (approved participations relative to applications) by organisation type is similar in the case of Austrian universities compared to EU-28 and leading innovation countries, whilst the figures for firms and non-university research institutes show the opposite image of those for the EU and innovation leaders. This could be due to classifying COMET centres as firms in statistics and in the R&D survey, but requires further investigation. Austria exhibits a significantly higher rate of success when it comes to public institutions, though the sample size here is limited and, at least in part, relates not to research, but to support services (e.g. "coordination support actions") provided to research institutes by the Austrian Research Promotion Agency (FFG) or federal ministries.

The following section presents Austria's success rate in the individual pillars and individual programmes that comprise the respective pillars of Horizon 2020. In the area of excellent science, Austria has thus far achieved a rate of 2.6% for all funding, 0.3 percentage points below the Austria's rate for total Horizon 2020 funding. This is particularly due to the limited use of the research infrastructure programme, in which the Austrian rate is only 1.6%, having an impact on the success rate. In the area of science, Austria achieved success rates higher than those of the EU-28 and the leading innovation countries, with the exception of the European Research In-

Table 5-7: Austria's success rate in leading role in industrial technologies, Comparison with EU

	Approved participants	Thereof in coordinating role	Approved funding	Success rate of participations	Share AT	AT relative to IL (IL=100)	AT relative to Switzerland (CH=100)	AT relative to EU-28 (EU-28=100)
Industrial Leadership	351	47	146,020,385	16.7%	3.2%	109	89	115
Basic and industrial technologies	329	45	144,521,643	16.1%	3.2%	107	86	115
Information and Communication Technologies	211	37	91,976,543	15.9%	3.4%	106	87	121
Nanotechnologies, Advanced Materials and Production	28	2	13,829,427	21.4%	4.0%	172	113	190
Advanced materials	16	2	10,120,169	21.6%	2.9%	89	80	89
Biotechnology	7	0	3,656,311	21.9%	3.1%	171	84	155
Advanced manufacturing and processing	45	3	19,885,488	14.2%	3.2%	103	84	103
Space	22	1	5,053,705	12.9%	1.5%	73	60	69
Access to venture capital	0	0	0	0.0%	0.0%	0	0	0
Innovation in small and medium enterprises	22	2	1,498,742	43.1%	2.3%	123	216	92

AT = Austria
IL = Innovation Leaders (Denmark, Germany, Finland, the Netherlands, Sweden)
CH = Switzerland
Share AT = Austria's share in all funding

Source: European Commission, EU Performance Monitoring FFG. Calculations: Austrian Institute of Economic Research (WIFO).

Table 5-8: Austria's success rate in the area of societal challenges, Comparison with EU-28

	Approved participants	Thereof in coordinating role	Approved funding	Success rate of participations	Share AT	AT relative to IL (IL=100)	AT relative to Switzerland (CH=100)	AT relative to EU28 (EU28=100)
Societal challenges.	614	76	228,308,858	18.1%	3.1%	106	94	119
Health, demographic trends and well-being	86	12	37,557,247	11.7%	2.3%	96	91	106
Challenges in the bioeconomy	47	4	9,503,605	16.3%	1.1%	76	75	86
Secure, clean and efficient energy	155	22	72,148,943	19.5%	4.3%	114	72	126
Intelligent, environmentally friendly and integrated transport	170	24	60,921,720	42.4%	3.8%	124	110	138
Climate protection, environment, resource efficiency and raw materials	72	5	21,368,899	20.1%	2.4%	88	76	101
Europe in a changing world – Integrative, innovative and reflexive societies	46	3	12,987,186	9.3%	3.9%	112	92	137
Secure societies – Protecting Europe's and its citizens' freedom and security	38	6	13,821,258	11.8%	3.3%	104	90	111

AT = Austria
IL = Innovation Leaders (Denmark, Germany, Finland, the Netherlands, Sweden)
CH = Switzerland
Share AT = Austria's share in all funding

Source: European Commission, EU Performance Monitoring FFG. Calculations: Austrian Institute of Economic Research (WIFO).

frastructure Programme (see Chapter 5.1.1 on Priority 2b).

Austrian applications to the ERC have a success rate of 16.9%, which lies only below those of Switzerland (22.7%), the Netherlands (18.8%) and Germany (17.6%). However, Austria's portion of funding disbursed by the ERC, of 2.9% is right on average with the Austrian share of all Horizon 2020 funding. This indicates that relatively few applications come from Austria, but that these perform relatively well. The number of Austrian applications submitted to and evaluated by the ERC relative to population represent just 73% of the average of the innovation leaders and Switzerland, excluding Germany, which represents just 64%. The innovation leaders and

Switzerland, excluding Germany, occupy places 1 through 5 with respect to the number of applications relative to population. The UK's success rate, at 14.2%, is lower than Austria's, though its portion of ERC-disbursed funding is 21.3%, 7 percentage points above its total share in Horizon 2020.

At 3.2%, Austria achieves a higher share of funding in the area "Industrial Leadership" than the total average (2.9%). The by far largest sub-program, "Leadership in Enabling and Industrial Technologies", consists of several thematic tracks, success in which can be read as an indication of technological strengths in application-oriented research. Austria has achieved higher success rates than the leading innovation countries almost across the board, with the exception of "Advanced Materials" and "Space". Austria achieved particularly high success rates in the areas "Nanotechnologies, Advanced Materials and Production" and "Biotechnology".

Austria's performance was more mixed with respect to the "Societal Challenges" pillar. Whilst the 3.1% share of funding lies slightly above the total Austrian share in Horizon 2020, significant differences are apparent amongst the individual funding schemes. There were high rates of success in particular in the areas of energy and transport, which also generate significant funding sums. In contrast, success rates were below average in the areas of Food and Water and below those of leading innovation countries in the areas of Climate Change, Health and Ageing Populations.

Highlights among the remaining areas include Austria's above-average success rate in the areas "Prevalence of Excellence and Expanding Participation" and "Science with and for Society".

In sum, it is evident that Horizon 2020 is characterised by lower success rates than the RP7, which leads to increased effort and expense in the application process making participation more difficult. Austria's success rate has fallen slightly less than the EU average. Given its size, EU funding might be seen as an additional "agency pillar" in research next to the Austrian Science Fund (FWF) and Austrian Research Promotion Agency (FFG), which is as quality-driven as FWF and FFG funding and additionally works to build international networks and creates critical mass, e.g. in infrastructure projects. Success rates by organisation type hardly differ from those of other countries, with the exception of the superior performance of firms as compared to non-university research institutes. This could well be a result of statistics.

Below-average funding shares were achieved in the area of excellent science in the individual pillars as a result of the limited disbursements within the framework of the research infrastructure programme, which also shows a limited rate of success. Despite a very high success rate in the ERC, the share of funding gained in this area was not above average. The number of applications relative to population is markedly lower than the average among leading innovation countries. Success at the EU-level is predicated on a solid national foundation, as is evident in the example of Switzerland, where an excellently endowed science fund is matched by marked success in the ERC.

The importance of a strong national foundation in Austria is evident in its success in application-oriented and industrial research. Research in the area of societal challenges receives a slightly above-average share of funding, whereby certain areas such as energy and transport perform very well whilst others, such as food and water, show room for improvement. Overall, success rates in the areas of societal challenges and industrial research demonstrate Austria's technological strengths.

5.3 Austria's engagement in transnational R&D collaborations

In addition to competitive proposals for R&D and innovation projects within the European Framework Programmes, transnational R&D collaborations in the form of bilateral and multilateral partnership initiatives (dubbed MULLAT in Austria[14]) among EU member states, funding agencies, business associations and individual stakeholders, such as universities and research institutes, form an important cornerstone of European research agendas. Whilst proposals submitted as part of the framework programme are meant, first and foremost, to address topics of Europe-wide interest, the diverse forms of bilateral and multilateral partnerships contribute to the communitisation of R&D activities in Europe through their subject discovery and implementation processes, which are primarily driven in a bottom-up style by the respective stakeholders. The aim is to contribute to the creation of an internationally competitive critical mass in selected focus areas through the bundling of national resources in the areas of R&D and innovation funding and the networking of related activities in the public and private sectors. These initiatives thereby represent the central instruments in the so-called alignment, i.e. the strategic demand made on member states to improve the coordination of national research programmes, priorities and activities in the interest of further developing the *European Research Area* (ERA).[15] At the same time, these forms of networking and collaboration are increasingly seen to be decisive for the national stakeholders' performance in calls for proposals through the framework programme, as they contribute not only to possibilities for expanding transnational networks, but also in promoting European topics in national funding schemes and, therefore, respective gains in know-how by national stakeholders.[16] On the other hand, these initiatives are important instruments for anchoring national areas of strength and focuses in European R&D and innovation programmes and strategic processes.

One important milestone for the increasing importance of transnational networking in European R&D and innovation policy is the 6th European Research Framework Programme (RP 6)[17], with the implementation of the so-called ERA Nets and initiatives in accordance with Article 169 of the Treaty on the Functioning of the European Union[18] (now Article 185) as an individual pillar in addition to the direct financing of collaborative R&D projects. Whereas ERA Nets are an instrument for promoting coordination among existing national R&D funding programmes, the Article 169/185 initiatives are targeted towards developing and implementing a strategic programme shared by the member states, including carrying out joint calls for proposals. The Commission has made co-financing funds available for creating and conducting joint proposals. In addition to the renaming of the now Article 185 initiatives, the ERA Net instrument has undergone a series of further developments. With the introduction of the so-called ERA Net Plus as part of the 7th Framework Programme, the instrument's focus is now on conducting joint proposals through national funding agencies instead of financing network activities. The current Horizon 2020 Framework Programme has made a supplementary funding mechanism available for joint proposals, in addition to national funding, named ERA Net Cofund activities (a fusion of the previously existing ERA Net and ERA Net Plus activities).[19]

Parallel to these developments, the EU Commission developed the concept of Joint Programming in 2008.[20] The goal is to stimulate the development of joint strategic research agendas

14 See Austrian Research Promotion Agency (FFG) (2014).

15 See GPC ERA-LEARN-Project (2015): Deliverable 4.1.

16 See Polt et al. (2016, 8).

17 See European Commission (2014).

18 Cf. http://eur-lex.europa.eu/legal-content/DE/TXT/HTML/?uri=CELEX:12012E/TXT&from=DE

19 See European Commission (2015a).

20 See European Commission (2008); European Commission (2008, 468).

(SRA) by member states. The so-called Joint Programming Initiatives (JPI) form the strategic superstructure for joint programme financing and coordination of R&D activities by member states in commonly defined subject areas. This is meant to lead to the bundling of multiple Member States' resources and capacities in research funding. The focus of research activities should be on contributing to solving grand societal challenges, such as climate change, demographic trends, health or the design of urban environments. This new logic of mission-oriented R&D planning is also embedded in the current Horizon 2020 framework programme, which supports the establishment of JPIs through so-called Coordination and Support Actions (CSA). Joint proposals can also be supported through Horizon 2020 or take place via ERA Net activities, which represent a key financing instrument for implementing the JPIs' objectives.

Joint Technology Initiatives (JTI according to Article 187) were created in the course of the RP7 as an instrument for establishing public-private partnerships between business associations and the EU Commission, for financing R&D projects in areas that are particularly relevant for European industry and therefore in terms of competitiveness.[21]

The work programmes in Horizon 2020 are much more heavily founded on content-based input and coordination activities among diverse multilateral initiatives (MULLAT) than were previous framework programmes. With the new instrument called contractual Public-Private Partnerships (cPPPs), a mechanism has been created to anchor proposals related to subject areas that are of interest to industry directly in the framework programme. This corresponds to the underlying logic of Horizon 2020, which aims to more intensively network and coordinate various research, technology and innovation platforms that already exist or are being developed in bilateral or multilateral form at the European level with each other and in terms of focuses and activities connected to the Framework Programme.[22] In addition to the instruments described above that are aimed at networking and coordinating various public or public and private interests and resources in R&D and innovation, there are a series of other instruments, the majority of which operate under the aegis of the European Commission, that aim to network stakeholders from industry and/or the scientific sector, including the Knowledge and Innovation Communities (KIC) of the European Innovation and Technology Institute (EIT). The EUREKA Network, in existence since 1985 and involving 40 partner countries (Canada, South Korea and South Africa are additional associated members), represents an international-European network for implementing cross-border collaboration in the area of application-oriented R&D. The European Commission is likewise a member and acts as a funding partner of the Article 185 Eurostars initiative, created within the framework of EUREKA and dedicated to supporting R&D in SME. The diverse arrays of transnational R&D collaborations, as they exist in the context of multilateral initiatives, can be roughly divided into three groups[23]:

- Public-public initiatives with the objective of bundling member states' R&D funding sources in defined bottom-up focus areas; these include JPIs, Article 185 initiatives and ERA Net activities (ERA Net, ERA Plus and ERA Net Cofund).
- Public-private initiatives with the aim of networking business interests, focuses and re-

21 With the exception of the JTI ECSEL, which is also financed through national funds and is coordinated in Austria through the Federal Ministry for Transport, Innovation and Technology (BMVIT) programme "ICT of the Future", which is administered by the Austrian Research Promotion Agency (FFG).

22 See Polt et al. (2016, 25).

23 Section 8-2 in Appendix I contains a glossary.

sources with public interests and resources (whereby public includes the EU Commission); these include JTI, cPPPs and the EIT KICs.
- Other multilateral forms of collaboration, with a focus on networking and forms of collaboration, differing from the communitarisation of financing, such as the European Technology Platform (ETP), COST or EUREKA.

5.3.1 Austrian involvement in transnational R&D collaborations

Austria and Austrian stakeholders have been represented in nearly all forms of these transnational European initiatives from the start. The Coordination and Support Action ERA LEARN 2020, funded through Horizon 2020, allows for analysis of participation in public-public initiatives in cross-EU comparison.[24] Since the 6th Research Framework Programme, Austria has participated in a total of 162 of these initiatives.[25] It is therefore currently in seventh place behind Germany (225), France (221), Spain (199), the Netherlands (195), the UK (183) and Belgium (170) (See Fig. 5-1). Austria is currently engaged in 64 out of 108 active initiatives, which corresponds to a share of 59% (see Table 5-9). A large part of these participations were in activities related to the ERA Net scheme. Austria is thus currently involved in 43 of the 80 active ERA Net initiatives, which corresponds to a share of 54%. In addition, national institutions function in coordinative roles in five of these networks. The Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) coordinates the ERA Net SUMFOREST[26]. The Federal Ministry for Transport, Innovation and Technology (BMVIT) coordinates the two ERA Net Cofund activities Smart Cities and Communities (ENSCC)[27] und Smart Grids Plus[28]. The Austrian Research Promotion Agency (FFG) is in turn responsible for the ERA Net Cofund Materials Research and Innovation (M-ERA.NET 2)[29] and PhotonicSensing[30]. In some cases, ERA Nets are continued even after EU funding has run out. One example is the CEDR transnational research programme (Conference of the European Directors of the Road).[31] These types of activities are included under "Other" in Table 5-9.

In addition to diverse activities as part of the ERA Net scheme, Austria is involved in Article 185 initiatives on Active and Assisted Living

Table 5-9: Active public-public initiatives

	Total active	Active AT	Share AT	Coordination AT
ERA Net activities (ERA Net, ERA Net Plus, ERA Net Cofund)	80	43	54%	5
Art. 169/185	5	4	80%	–
JPI	10	8	80%	1
Other	13	9	69%	–
Total	**108**	**64**	**59%**	**6**

Source: ERA LEARN 2020, https://www.era-learn.eu/network-information/countries; status of 3rd January 2017.

24 Cf. https://www.era-learn.eu/

25 Assessment of ERA LEARN 2020: https://www.era-learn.eu/network-information/countries; As at 03.01.2017.

26 Cf. https://www.sumforest.org/

27 Cf. http://www.smartcities.at/europa/transnationale-kooperationen/era-net-cofund-smart-cities-and-communities/

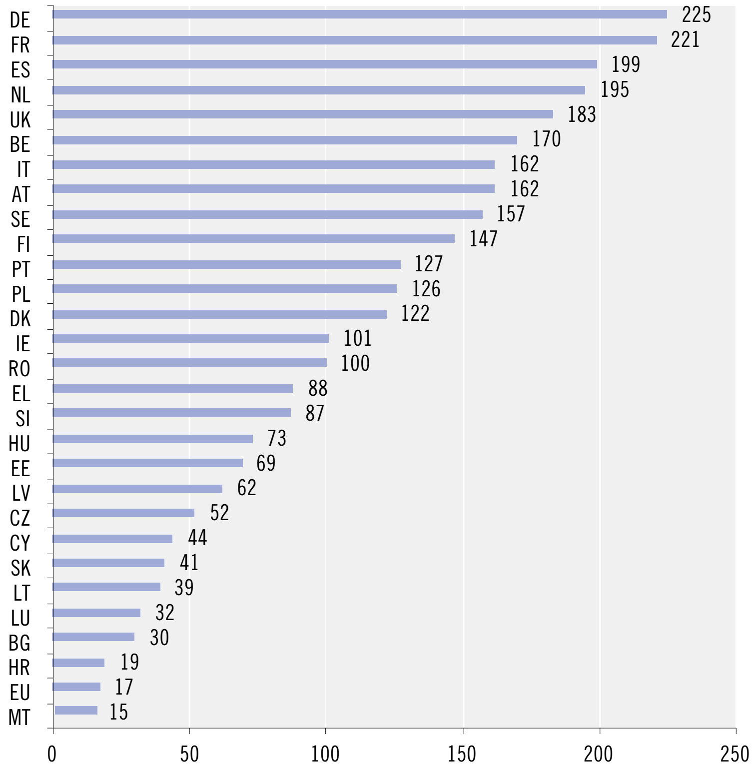
28 Cf. http://www.eranet-smartgridsplus.eu/

29 Cf. http://cordis.europa.eu/project/rcn/200084_en.html

30 Cf. https://www.ffg.at/photonicsensing

31 See BMVIT (2015):

Figure 5-1: Number of public-public initiatives with national participation since RP 6



Source: ERA LEARN 2020, https://www.era-learn.eu/network-information/countries; As at 3 January 2017.

(AAL)[32], European & Developing Countries Clinical Trials Partnership (EDCTP2)[33], European Metrology Programme for Innovation and Research (EMPIR)[34] and on Eurostars[35]. Austria is additionally currently involved in eight out of ten active JPIs, and furthermore, the Federal Ministry for Transport, Innovation and Technology (BMVIT) acts as a coordinator for the JPI Urban Europe[36].

The other seven are JPI Neurodegenerative Disease Research (JPND)[37], JPI Agriculture, Food Security and Climate Change (FACCE)[38], JPI A Healthy Diet for a Healthy Life (HDHL)[39], JPI Connecting Climate Knowledge for Europe (CLIMATE)[40], JPI More Years, Better Lives – The Potentials and Challenges of Demographic Change (MYBL)[41], JPI Water Challenges for a Changing

32 Cf. http://www.aal-europe.eu/

33 Cf. http://www.edctp.org/

34 Cf. https://www.euramet.org/research-innovation/empir

35 Cf. https://www.eurostars-eureka.eu/

36 Cf. http://jpi-urbaneurope.eu/

37 Cf. http://www.neurodegenerationresearch.eu/

38 Cf. https://www.faccejpi.com/

39 Cf. http://www.healthydietforhealthylife.eu/

40 Cf. http://www.jpi-climate.eu/home

41 Cf. http://www.jp-demographic.eu/

World[42] and JPI Cultural Heritage and Global Change: A New Challenge for Europe[43]

A large part of the funds for the country's participation in these public-public initiatives are provided by the Austrian Research Promotion Agency's and the Austrian Science Fund's national funding programmes, as is described in the following section.

In contrast to the public-public partnerships, participation in public-private partnerships and their activities, i.e. the resources used for example, for funding, are not determined in the same fashion, at a European level, which precludes European comparisons here. This is because these are cases in which firms, special interest groups and autonomous institutions such as universities are involved and it is not necessarily required that national public funds are provided.

A national survey of these participations was conducted for the first time in 2014 by the Austrian Research Promotion Agency (FFG), which has regularly updated this data in a database.[44] As of October 2016, Austrian stakeholders are represented in six Joint Technology Initiatives (Art. 187). These cover a broad array of subject focuses. The JTI Shift2Rail[45] and JTI Clean Sky 2[46] are focused on transport. The JTI Electronic Components and Systems for European Leadership (ECSEL)[47] is specialised in research on nano-, micro- and semiconductor electronics. The JTI Biobased Industries (BBI)[48] and JTI Fuel Cells and Hydrogen (FCH)[49] are focused on sustainable and renewable production methods and on the development of fuel cells. The focus of the JTI Innovative Medicines Initiative (IMI2)[50] is the development of innovative treatment methods. The JTIs' R&D activities are supported by funds from the European Commission and the business stakeholders involved in the respective initiatives, and in the case of ECSEL with additional funds from the Austrian R&D programmes funded by the Federal Ministry for Transport, Innovation and Technology (BMVIT). To date, Austrian stakeholders have been additionally represented in a total of ten cPPPs for developing proposals within the framework of Horizon 2020 with a clear focus on ICT topics, such as big data and robotics.

Additional multilateral initiatives include participations in five European Innovation Partnerships (EIP) and EUREKA. The EIT KIC RawMaterials, started in 2014, is an example of the participation of Austrian stakeholders in an initiative of the European Institute of Technology (EIT). In addition to University of Leoben, the so-called core partner, and the Universities of Vienna and Graz along with the Graz University of Technology, the Bundesanstalt für Geologie (Federal Geological Agency) and two firms are also members of this initiative, which focuses on researching the acquisition, recycling and substitution of raw materials.[51]

5.3.2 Financing transnational R&D collaborations

Since 2007, the national public funds for transnational R&D cooperation in European as well as bilateral and multilateral collaborations between

42 Cf. http://www.waterjpi.eu/

43 Cf. http://www.jpi-culturalheritage.eu/

44 See Austrian Research Promotion Agency (FFG) (2014).

45 Cf. http://shift2rail.org/

46 Cf. http://www.cleansky.eu/

47 Cf. http://www.ecsel-ju.eu/web/index.php

48 Cf. http://www.bbi-europe.eu/

49 Cf. http://www.fch.europa.eu/

50 Cf. https://www.imi.europa.eu/content/imi-2

51 See Austrian Research Promotion Agency (FFG) (2015):

member states have been consistently surveyed by Eurostat. Data is collected by national statistical offices, based on government expenditures for R&D and funds that are disbursed through public intermediaries (funding agencies, funds). Statistics Austria is the responsible body in Austria. This allows for a comparative overview of financial engagement by EU member states and associated countries. National funding towards transnationally coordinated R&D[52] is therefore a key indicator of national and European monitoring of the ERA. It is provided in three categories:

- *National funds for transnational public R&D performers* : covers public expenditures for the European Organization for Nuclear Research (CERN), the Institut Laue-Langevin (ILL), the European Synchrotron Radiation Facility (ESRF), the European Molecular Biology Laboratory (EMBL), the European Southern Observatory (ESO) and the European Commission's Joint Research Centre (JRC).
- *National funds for Europe-wide transnational public R&D programmes*: covers public expenditures for ERA Nets, ERA Net Plus, ERA Net Cofund, the European Fusion Development Agreement (EFDA), EUREKA, COST, EUROCORES, the European Space Agency (ESA), the European Molecular Biology Organisation (EMBO), the European Molecular Biology Conference (EMBC) and Article 185 Initiatives and public funding contributions to JTIs.
- *National funds for bilateral or multilateral transnational public R&D programmes*: covers bilateral collaborations between Member States without the participation of the EU Commission as, for example, the Austrian Science Fund's lead agency procedure.

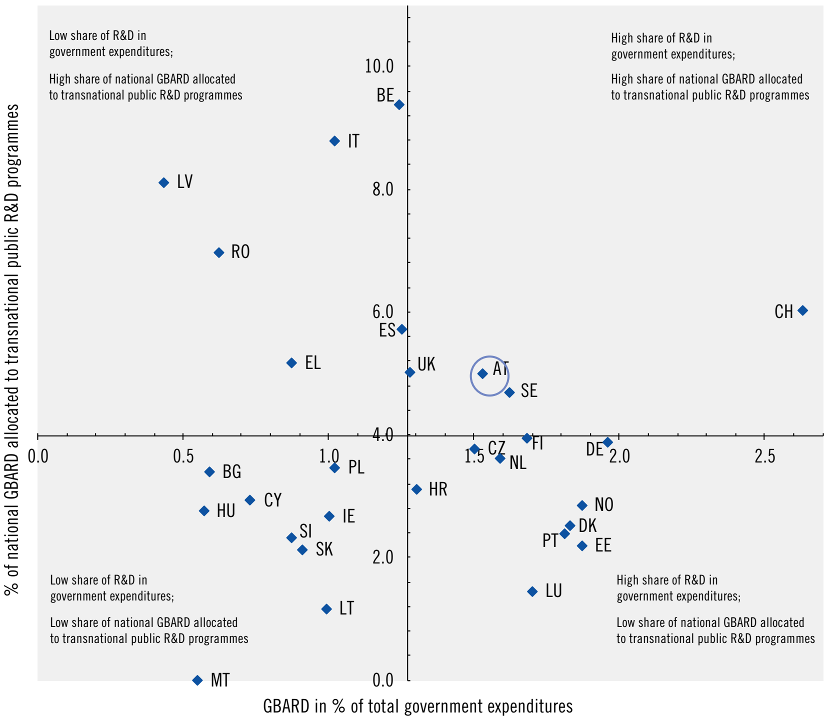
The focus here is on types of public-public partnership initiatives. These include, alongside funding for transnational research stakeholders, national financial contributions to transnational R&D projects as well as bilateral and multilateral collaborations in EU-wide programmes, ERA Nets and Article 185 initiatives. Not included are institutional resources for the initiation, participation and coordination of these types of collaborations in government ministries, funding institutions and research institutes. This also concerns institutional funds, such as those used by universities. Public-private partnerships without direct participation of member states, such as the JTIs or KICs, are likewise not included in these statistics. One exception is the JTI ECSEL, which is also financed via public programmes – through the Federal Ministry for Transport, Innovation and Technology's (BMVIT) "ICT of the Future" programme in Austria.

Fig. 5-2 shows the share of expenditures for transnational R&D in government expenditures for R&D of all EU member and associated states compared to the R&D share in total government expenditures. Among those countries with similar R&D shares in government expenditures (i.e. above the mean of 1.22%), Austria lies just behind the UK (average: 3.61%) as the EU member country with the largest share in expenditures for transnationally coordinated R&D with 4.99% in 2014. Amounting to €132.22 million in 2014, however, the absolute figure remains relatively small. The ability to fund national participations in bilateral and multilateral R&D activities, on the transnational level or as a part of European initiatives, depends on the national availability of R&D funding in the context of the size of the respective country's economy. Differences in the availability of resources result in difference conditions for each individual Member State.[53] In a comparison of absolute figures of contributions, Austria comes in ninth position, behind Germany, with €987 million, as well as Italy and the UK, with €742 million and €634 million, which occupy first through third place. In nearly all EU member and associated states (for which data for

52 Eurostat Indicator: gba_tncoor.

53 See Polt et al. (2016).

Figure 5-2: National funding for transnational R&D and R&D share in government expenditures, 2014



Source: Eurostat (2016): Presentation by JOANNEUM RESEARCH. See Polt et al. (2016) for a comparison with the year 2013.

the period 2007–2014 is available)[54] expenditures for transnational R&D have partly increased substantially over the past several years. Austria's has doubled from its starting figure of €65.12 million in 2007 (see Figure 5-3). In comparison to total expenditures for R&D in all sectors in Austria (2014: €10.1 billion)[55], the direct financial expenditures for transnational R&D activities – 1.3% in 2014 – are relatively small.

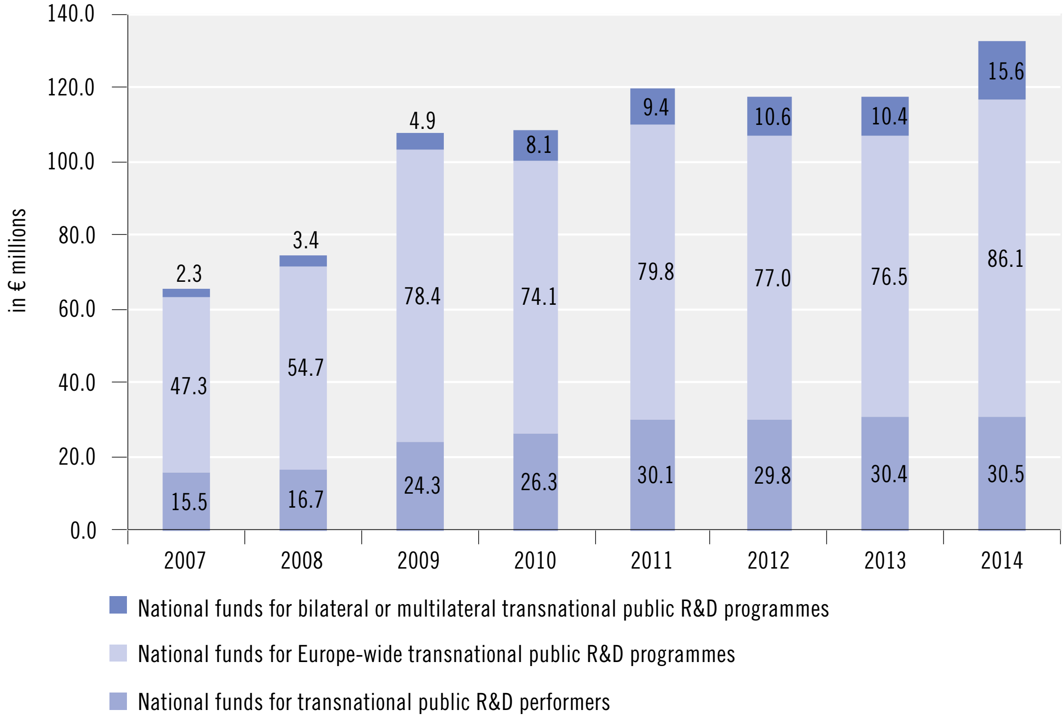
The distribution of funds across various categories has remained relatively stable since the start. Nearly a fourth (2014: 23.1%) are contributions to European research infrastructure or stakeholders, such as CERN. The largest share is taken by funding of transnational R&D projects. Around two thirds (2014: 65.1%) are for Europe-wide programmes such as ERA Nets and finally, around 12% are dedicated to bilateral and multilateral programmes. A significant amount of funding is disbursed by national funding schemes that are administered by the Austrian Research Promotion Agency (FFG), and some by the Austrian Science Fund (FWF). Overall, Austrian Research Promotion Agency (FFG) programme lines co-funded multinational projects within the context of transnational R&D projects to the amount of nearly €24 million in 2014 (see Table 5-10). Given the Austrian Research Promotion Agency's total funding volume of €478.16 million (cash equivalent funding) in 2014[56], this comes to around 5% of the funding activities. Nearly a third (31%) of this

54 No data was provided for France at any time.

55 According to Statistics Austria, Globalschätzung 2016 ("Global Ratings").

56 See Austrian Research and Technology Report 2014, BMWF, BMVIT and BMWFJ (2014); http://www.bmwfw.gv.at/ftb

Figure 5-3: Development of Austrian expenditures for transnational R&D according to expenditure type, 2007–2014



Source: Eurostat (2016): Graphic: JOANNEUM RESEARCH.

consisted of funding within the context of "ICT of the Future" programme lines, which went to the JTI ECSEL. Additional thematic focuses were energy research and ambient assisted living, insofar as these fit within the programme lines' parameters.

In comparison, the Austrian Science Fund (FWF) funded transnational R&D collaborations in the amount of €24 million in 2014, which represented just under 12% of the total volume of newly awarded funding for 2014 (211.4%)[57]. The bulk (€15.65 million) went towards the funding of bilateral and multilateral projects organised in accordance with the lead agency procedure[58] and not towards EU initiatives. The lead agency procedure was developed in 2008 by the Austrian Science Fund (FWF), Germany's Deutsche Forschungsgemeinschaft (DFG) and the Swiss National Science Foundation (SNF) and allows the submission of bilateral and trilateral proposals to just one funding organisation (the "lead agency") in accordance with the respective national regulations. Funding by the project partners is processed separately and according to general national circumstances. Since 2008 the lead agency procedure has been expanded beyond the original three founding countries to include nowadays 13 European and three non-European funding organisations. In 2014 the Austrian Science Fund (FWF) was the lead agency in funding a total of 75 projects with partner organisations from seven European countries.

Furthermore, the Austrian Science Fund (FWF) funded a total of 40 project participations by na-

57 See Austrian Research and Technology Report 2014, BMWF, BMVIT and BMWFJ (2014); http://www.bmwfw.gv.at/ftb

58 https://www.fwf.ac.at/fileadmin/files/Dokumente/Antragstellung/Internationale_Programme/i_infoblatt-dach.pdf

Table 5-10: Commitments fixed by amount/contract in context of the Austrian Research Promotion Agency's European multilateral initiatives (in thousand €), 2014

Multilateral initiative	Programme (national)	Programme line (national)	Number of projects	Total funding including all sources	Support from AT funds	Estimated support from EU funds (paid and not paid)
Article 185	Benefit	Ambient Assisted Living Joint Programme	10	2,707	1,446	1,262
EUREKA Article 185	EUROSTARS	EUROSTARS-2	8	1,384	1,038	346
ERA Net activities	BASIS	General programme	10	1,969	1,954	14
	COIN	Cooperation and networks	6	1,844	1,844	0
	Energy Research (e!MISSION)	Energy research	1	390	390	0
	KIRAS	Collaborative R&D projects	5	1,864	1,864	0
	Mobilität der Zukunft (Mobility of the Future)	Mobilität der Zukunft (Mobility of the Future)	3	1,149	1,149	0
	NANO-EHS	NANO-EHS	3	451	451	0
	Produktion der Zukunft (Production for the future)	Produktion der Zukunft (Production for the future)	3	1,299	1,299	0
	TAKE OFF	TAKE OFF	2	1,058	1,058	0
JPI	ENERGIE DER ZUKUNFT (Energy for the Future)	JPI Urban Europe	6	2,025	2,025	0
JTI	IKT der Zukunft (ICT of the Future)	ARTEMIS	15	7,509	4,531	2,978
		ENIAC	14	5,468	2,932	2,535
EUREKA	BASIS	General programme	6	2,035	1,985	50
Total result			**92**	**31,151**	**23,966**	**7,185**

Source: Statistics Austria, FFG data reports.

tional partners within the framework of ERA Net activities in the amount of €9.3 million, which primarily involved participations in new ERA Net Cofund instruments (see also 8-2 in Appendix I).

5.3.3 Summary

In comparison to other EU member states, Austria is relatively strong involved in transnational R&D activities, measured in participations in these types of initiatives as well as in the share of the national public R&D budget dedicated to these activities. Participation by national stakeholders in these types of networks are assessed extremely favourably by the Austrian R&D community and, not least, are considered to be an important determining factor of performance in Framework Programmes.[59] At the same time, these kinds of initiatives cannot replace national funding mechanisms, which are decisive in building up national areas of expertise. One example of this is ICT, in which a mix of national programmes (e.g. BENEFIT, ICT of the Future) and participation in transnational partnerships such as the JTI ECSEL, the Article 185 initiative AAL or assorted cPPPs are considered important reasons for the particular success of Austrian stakeholders in this area's framework programme.[60]

At the same time, the intensity of the participation, which essentially means the funds made available for this purpose, is a key factor in these measures' effect on the national research land-

59 See Polt et al. (2015); Polt et al. (2016).

60 See Polt et al. (2016).

Table 5-11: Contractually fixed financing of multilateral initiatives by the Austrian Science Fund (FWF) (in thousand €), 2014

Multilateral initiative (ERA Net)	Programme national	Number of projects	Promotion AT partial projects	EU Cofunding
BioDivERsA	FWF International Programmes	7	1,174	no
ChistERA	FWF International Programmes	1	332	no
ERA CAPS	FWF International Programmes	6	1,722	no
SynBio	FWF International Programmes	2	393	no
E-RARE	FWF International Programmes	2	452	no
Infect-ERA	FWF International Programmes	4	1,034	no
NEURON	FWF International Programmes	2	558	no
NORFACE	FWF International Programmes	5	1,167	yes
TRANSCAN	FWF International Programmes	11	2,489	no
Total		**40**	**9,313**	

Source: FWF area International Programmes, in Polt et al. (2016).

scape. Thus Austria, viewed as a whole, gives relatively little in absolute terms for these types of projects, as measured in the number of its participations. Germany, for example, is the leading country in terms of number and intensity of participation in transnational partnerships. Whilst to date Germany participated in just 1.4 times more initiatives than Austria, it dedicated nearly 9 times the amount of funds in total to such initiatives up to 2014 (the last available data). Belgium, which with 170 participations in public-public partnerships to date ranks similarly to Austria, invested double the amount of funds up to 2014. In future, greater attention should be paid to the appropriate prioritisation and coordination of national funds for transnational collaborations so as to more effectively make use of Austria's good starting position in this area. The implementation of a dedicated working group within the framework of the RTI Task Force is a first step in this direction. Strategic positioning within the European Research Area and, concomitantly, in corresponding transnational networks is a key component in the current performance agreements with the universities (for the 2016–2018 period), which aim to strengthen institutional engagement in this area and simultaneously improve visibility.

6 Evaluation Culture and Practice

In order to create stronger incentives for research and innovation, the range of RTI-related measures and initiatives has been continuously expanded in recent years. Although they started out with somewhat broad-based measures for supporting R&D, many countries are now expanding and supplementing them with systematic approaches, strategic objectives and setting research priorities ("mission orientation"). The most common argument to legitimize programmes, policies and institutions is that they can help overcome a market or system failure. Inspired by the "Grand Challenges" and the prioritisation of research agendas, more recent articles[1] also point to the major political challenges involved in supporting transformative processes in large innovation systems (e.g. transport, energy and health systems).

As RTI policy instruments expanded, the interest as to whether corresponding investments would also be used sensibly and efficiently also grew. As a result, evaluations have become more and more important as an instrument for assessing the performance of programmes and initiatives. The goal of evaluations is to provide information about the performance of RTI-related measures, to assess the expediency of expenditures funds on specific measures, and to promote policy learning in the sense of improving these measures.

A mature "evaluation culture" is a key component of a research, technology and innovation policy that is transparent, strategic and facilitates learning. In light of growing expenditure on RTI and increased public interest, steps have also been taken in Austria in recent years to enable more efficient and evidence-based policy formulation and policy making. The following chapter gives a detailed overview of the development and status quo of the Austrian RTI evaluation culture, discusses the usefulness and use of evaluation results on the basis of current findings[2] and presents the challenges facing evaluations in terms of content and methodological aspects.

6.1 RTI evaluation in Austria

There has been a continuous development and expansion of evaluation competences and capacities as well as the creation of responsibilities in ministerial departments and agencies in Austria since the mid-1990s. Key drivers, apart from the EU accession, which provided new regulations and standards for evaluations and had a decisive influence on the still dominant programme orientation, were the growing use of New Public Management approaches, the establishment of task-specific organisations ("agencification") as well as the creation and implementation of corresponding laws and regulations, such as the stipulations for impact-oriented budgeting and administration. In addition, the Austrian Council for Research and Technology Development (RFTE) has contributed to a stronger perception of the role and relevance of evaluations through its publications and related recommendations in recent years.

The relevant statutory foundations are provid-

1 See Weber and Rohracher (2012).

2 The chapter is mainly based on works by Streicher (2017), Warta and Philipp (2016), Landsteiner (2015), Reiner and Smoliner (2012), and Dinges and Schmidmayer (2010).

ed by a series of laws in Austria,including 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 so-called RTI guidelines (guidelines on the promotion of research based upon these laws[3] and of commercial-technical research, technology development and innovation).[4] 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".[5] An appropriate monitoring system must be created to collect the necessary information that provides standardised basic information for the duration of the project.

Thus evaluations are used to varying extents in many research and technology programmes either for programme planning (ex-ante evaluations), programme implementation (monitoring and interim evaluations) or when programmes end (ex-post evaluation), or are used for the strategic further development of Austria's research funding portfolio. Following the revision of the RTI guidelines in 2015, the focus was shifted to substantive targets and indicators in line with the implementation of impact-orientated budget and administration management.

In addition to the legal and administrative circumstances, an active discourse has also developed in Austria over the role, use, possibilities and handling of evaluations. Activities surrounding the research and technology policy evaluation platform (fteval)[6] have made important contributions to this development. Since its foundation in 1996, the fteval platform has aimed to support the improvement of evaluation practice. Members of the platform are ministries, agencies, research institutes and consultancy firms. Activities and offers of the platform encompass supporting the dialogue between the respective stakeholders, providing discussion fora, issuing publications (e.g. the fteval journal[7]) as well as holding training courses and workshops. The platform collects and regularly publishes relevant studies and evaluation results on its website and plays a leading role in the organisation of several international conferences[8] in Vienna. As the broker between clients of evaluations, evaluation service providers and R&D institutions affected by the evaluations, the fteval platform is an important and unique forum by international standards.

A central component of the fteval platform's activities is the formulation and publication of standards of evaluation in research and technolo-

---

3 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.

4 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 Funding Act (FTFG) from the Federal Minister for Transport, Innovation and Technology (GZ BMVIT-609.986/0011-III/I2/2014), and the Federal Minister of Economics and Labour (GZ BMWFW-97.005/0003-C1/9/2014).

5 See RTI theme guidelines, RTI structure guidelines, RTI human resources guidelines, Chapter 3.3.

6 Cf. http://www.fteval.at

7 Cf. http://www.fteval.at/de/newsletter/archive/

8 The "Open Evaluation" conference was most recently held from 24–25 November 2016 in Vienna, with around 250 participants from 35 countries.

gy policy[9]. The standards are currently undergoing revision, which should be finalised in the course of 2017.

Against this backdrop, there has been a significant rise in RTI evaluation activities in the last 15 years. Evaluations are provided at frequent intervals on different levels, from programmes to institutions and organisations. Austria is among the top countries in Europe with regard to the number of RTI evaluations.

The central features of the RTI evaluation practice in Austria include:

- Evaluations have a predominantly formative (shaping) character. Evaluations and impact analyses with a summative (concluding) focus as well as ex-ante considerations are less common. However, the latter are increasingly used in the relevant reviews with names such as "Trend scenarios" and "Roadmaps".
- Due to the greater focus on impact, evaluation criteria based on economic aspects are increasingly being taken into consideration. Broader approaches to the measurement of socio-economic impact dimensions (e.g. health or sustainability aspects) have found little use to date.
- Typically, RTI evaluations use a mix of different investigative methods, with qualitative and descriptive procedures predominating. Quantitative methods, in particular those that can be applied to estimate causal effects, and experimental approaches, are used seldomly.
- The low proportion of final ex-post observations and (quantitative) impact analyses can, aside from the purpose of the evaluation and related requirements, often be traced to the limited availability and quality of data. Access to official, company-related microdata is currently tightly restricted compared to other countries, due to the legal situation in Austria.
- A large number of evaluation reports are collected in Austria and published on ministry websites, the fteval platform and elsewhere. The annual Austrian Research and Technology Report published by the Federal Government also presents a selection of recent evaluation results to Parliament and subsequently to the wider public.

6.1.1 Usefulness and use of evaluations

As international comparative studies[10] show, the quality of Austrian RTI evaluations is perceived as being largely satisfactory and professional by clients and policymakers alike. The way the evaluations are designed and the method sets applied are deemed appropriate, recommendations for further developments are considered relevant. Possible improvements are viewed in terms of the usefulness of evaluation reports and evaluation processes. These include writing the reports in clear language that can be understood by stakeholders who are unfamiliar with RTI policy, a compact presentation of the overall approach of the evaluation, as well as a (more detailed) discussion of the applied assessment criteria. Evaluation processes have a clear potential to spark discussions and learning processes which has not yet been fully exploited. They would also benefit from a better interlinking with the evaluations' purpose and use as well as the inclusion of potential users.

The rise in the number and quality of evaluations went hand in hand with the question at international level as to the consequences of evaluations and their contribution to policy and the development of initiatives. Recent studies[11] suggest that RTI evaluations in Austria certainly are used, to different extents and on different levels. The use of evaluations is mostly limited to the measure in question and the stakeholders who are directly involved (such as the programme administration in the agencies). Decisions concern mostly the adaptation and further development

9 Cf. http://www.fteval.at/upload/Standards_Plattform_Fteval.pdf

10 See Tsipouri and Sidiropolous (2014); Dinges and Schmidmayer (2010); see also Reiner and Smoliner (2012).

11 See Streicher (2017); Landsteiner (2015).

of existing programmes, meaning that evaluations are primarily used for the purposes of on-going programme development. Evaluations, even if only to a modest extent, also generate new insight into specific features of the instrument and how it is managed. Growth in knowledge outside of the respective areas of control is less clearly visible, although efforts have recently been fostered to initiate discussion processes by using evaluation results beyond the limits of specific organisations.

When considering the usefulness and use of evaluations, some studies[12] in evaluation research emphasise the need for a comprehensive perspective in order to better understand causal connections and effects of evaluations that can occur on different levels and in different manifestations. Hence, context-related factors and mechanisms, institutionalised rules as well as the role of stakeholders and their interaction in the evaluation process receive more attention.[13] For Austria, it is suggested that programme evaluations generate a wide range of different effects and have a clear and traceable influence on the development of programmes. However, changes to programmes cannot usually be ascribed to specific evaluation activities. It is more often a combination of different impulses, for instance other evaluations, which bring about cumulative (trickle-down) effects, the consequences of which may extend to identifiable changes.

The factors and mechanisms that may condition the effects of evaluations include the statutory and political circumstances, such as budgeting guidelines and prioritisations in RTI policy, as well as the prevalent evaluation culture and programme features such as its age or continuity. At the actor level, the individual interest and preferences, in particular those of the organisations that are being represented, are considered to be important. The professionalism and credibility of the evaluator is also an important factor for increasing the effects of evaluations, while the frequent, rather limited interaction with stakeholders in evaluations is a factor that limits the use of and learning from evaluations[14]

6.1.2 Challenges and trends

The increasingly required, systematic check on the impact of government funding initiatives and the greater interest in socio-economic relationships raises requirements with regards to evaluation methodology and data availability/analysis. At the same time, the use of corresponding measurement indicators, counterfactual analyses or control group comparisons and quasi-experimental methods is gaining in importance. Also, the need for a more systemic perspective is also growing, e.g. focusing on the position, role and interactions of a measure in the context of different funding and control instruments of a national innovation system. Such portfolio evaluations with the goal of embedding the program that is evaluated in the existing funding landscape, and increasing the coherence between the measures have been used only to a small extent in Austria and elsewhere. Findings from this could, for example, also reveal potentials for dealing with the "Grand Challenges".

Due to the increased tendency to measure effectiveness and present results, the purpose and relevance – especially for longer-running measures – should continue to be a focal point in evaluations, as current research[15] for Austria shows. Collaborative or participative approaches with a possible inclusion of stakeholders may allow, for example, a closer examination of the potential operating principles of programmes. At the same time, feedback loops can be used across the entire evaluation process and developments communicated in a prompt and concise form.

12 See Johnson et al. (2009); Henry and Mark (2003); Mark and Henry (2004); Alkin and Taut (2003); Kirkhart (2000).

13 See Streicher (2017); Højlund (2015, 2014); Burr (2009); Boswell (2008); Lethonen (2005).

14 See Johnson et al. (2009).

15 See Streicher (2017).

In order to identify the operating principles of complex research and innovation in the best way possible, especially in terms of an appropriate cost-benefit relationship, the actual requirements, information needs and expectations of relevant decision-makers must be clarified right from the start. Alongside a definition of the evaluation's addressees, this particularly concerns the question of data availability, which is often a prerequisite for the use of certain method sets in an evaluation. The clarification of requirements and issues can also contribute to the more concise formulation and thus more transparent design of the Terms of Reference, which play a central role in improving the quality and use of evaluations. Another method already found more frequently in other countries involves a so-called "Inception Phase" which gives evaluators the opportunity to deal with the available data situation, the methodological possibilities and the ability to answer the intended evaluation questions.

6.1.3 Summary

Today, evaluations represent an integral part of the process for introducing and implementing measures aimed at supporting research and technology policy in Austria, both from a legal perspective and in actual practice. Although there are gaps in the area of impact evaluation and in the access to or linking of statistical data, as can be seen in a recent investigation (see Chapter 6.2.5), the activities and discourse in RTI policy are marked by efforts to further strengthen the evaluation culture to improve the design of research and technology programmes as well as evaluation methods. It is noted that evaluations are typically carried out tailored to the instrument and may therefore, depending on the phase in the policy life-cycle, come with different requirements and goals.

In line with the international trend, RTI evaluations have to expand their set of methods in conceptual terms to be better able to meet the requirements for impact measurement. This includes, for example, the use of counterfactual and quasi-experimental methods. In the evaluation literature,[16] the participation of stakeholders, e.g. in the course of participative evaluation approaches, is seen as being a key factor for the improved use of and learning from evaluations, in addition to the role of the evaluators.

An institutionalisation and routinisation of RTI evaluations is increasingly evident. While routines offer control, stability and security, they may also reduce the possibilities of learning processes and changes. Additional learning opportunities could be created through participative evaluation approaches, with an early and on-going involvement of relevant stakeholders in the evaluation process. Other considerations which could improve the usefulness and use of evaluations are an intensification of the planning phase by means of an "Inception Phase", the setting of evaluation priorities as well as promoting the dissemination and discussion of evaluation results.

6.2 Results of selected evaluations

This chapter will provide an overview of recent evaluations of Austrian research funding programmes. They have been selected according to the following criteria: (1) The evaluations are primarily relevant to federal policy, (2) an approved report of the evaluation is available and (3) the evaluation report is publicly accessible. This essentially means that the report has been approved and has been published on the website of the fteval[17] platform.

The results of the following evaluations are presented in brief: the evaluation of the Institute of Science and Technology Austria (on behalf of the board of trustees of IST Austria), the pro-

16 See Johnson et al. (2009).

17 Cf. www.fteval.at

gramme evaluation Building of Tomorrow 1999–2013 (on behalf of the Federal Ministry for Transport, Innovation and Technology – BMVIT), the evaluation of the Creative Industries Voucher (on behalf of the Federal Ministry of Science, Research and Economy – BMWFW), the evaluation of the Innovation Voucher programme (on behalf of the Federal Ministry of Science, Research and Economy – BMWFW) and the Federal Ministry for Transport, Innovation and Technology – BMVIT) and the evaluation of the research tax premium in accordance with Section 108c of the Austrian Income Tax Act on behalf of the Federal Ministry of Finance – BMF).

6.2.1 The evaluation of the Institute of Science and Technology Austria (IST Austria) – Report of the international evaluation committee

Objective of the evaluation

An evaluation of IST Austria must be performed every four years in accordance with the Act on Establishment and is commissioned by the board of trustees of IST Austria[18]. In this second evaluation, a high-ranking international evaluation panel focused on the scientific work, the international collaboration and the appointment of professors.

Objectives of the institute and key information

The Institute of Science and Technology Austria (IST Austria) is an international institute based in Klosterneuburg near Vienna, whose mission is to produce scientific excellence with the main focus on international competitiveness in selected fields of research (life sciences, physical sciences, formal sciences). IST Austria was jointly founded in 2006 by the Austrian Federal Government and the province of Lower Austria. The institute has grown continuously since its founding in 2009. At the time of the evaluation, around 500 employees were recruited, the target was set at 1,000 employees and 90 research groups (by 2026). Anchored in the mission statement of IST Austria are the following principles which reflect the objectives of the institute[19]:

- pursuit of basic research in the natural and mathematical sciences, as well as the education of future researchers
- promotion of interdisciplinary interaction between scientists
- provision of a world-class environment for science and an attractive destination for doctoral students, post-docs, and professors from all countries
- commitment to the highest international academic standards, integrity, equality and diversity on campus, as well as respect and recognition for all
- effective and efficient use of the entrusted public and private funds
- pursuit of an active policy of exploiting intellectual property when possible
- making a successful contribution to the international scientific community, research in Europe, higher education in Austria, and society at large

Results of the evaluation

The evaluation took place in line with the objective pursued at the time of the founding of IST Austria, which the evaluation committee puts as follows: "To create a first-class institute for basic research, which can be measured against the world's leading institutions,"[20] i.e. the aim was to build up an institute of not only national but also international stature.

The evaluation establishes that IST Austria

18 See Kornberg et al. (2016, 21).

19 Cf. https://ist.ac.at/en/ueber-ist-austria/leitbild/

20 See Kornberg et al. (2016, 23).

renders good services measured by key performance indicators. Particular mention is made of the fact that 20 out of 40 professors secured research funding from the European Research Council – ERC. The success rate of the IST Austria professorial graduate school in the competition for this funding is 44%, which puts it in the leading group in Europe and thus even ahead of Oxford University, ETH Zurich and other renowned institutions. According to the evaluation, a further pleasing development in the scope and term of these sought-after funding commitments can be expected, as they enable research groups to perform their work on the highest level.

The evaluation also paints a very positive picture with regard to the institute's international orientation and in doing so makes reference to the trend regarding the appointment of professors. Of the 40 candidates who accepted an academic position offered at IST Austria, 35 are foreign citizens. With one exception, all relocated to IST Austria from institutions abroad. As further proof of the international profile of IST Austria, the evaluation indicates the number of joint publications with external scientists: Accordingly, foreign co-authors are jointly responsible for over 80% of the publications of IST Austria.

According to the evaluation, the development of research groups, which on average consist of ten scientists, most of whom are post-docs, is rated as outstanding. In particular, no professors left for other institutions, and the success rate at securing funds from external sources is described as highly impressive. A total of €55 million in funds and €17.5 million in donations was raised. The PhD programme is also characterised by steady growth and has developed into a popular destination for students from Europe and the rest of the world. Critically, it was noted that while the location, campus and building of IST Austria are appealing, the physical separation from other academic institutions in Vienna makes it more difficult to interact with them. Furthermore, the need for public relations work continues to be expressed, while public transport links and local accommodation options are described as showing room for improvement.

In summary, the evaluation finds that IST Austria had an excellent start, has so far mastered the main challenges that the creation of a new institution entails, and thus laid a sound foundation for future developments. However, the evaluation report also suggests that the next step, the rise to the top, will be an even greater challenge, even though sufficient grounds for optimism remain given the impressive achievements of IST Austria to date. Identified as key tasks and targets for IST Austria are the creation of a Chemistry-Biochemistry-Molecular Biology Department (CBMB) including cryoelectron microscopy, the recruitment of still young but already established scientists with a world class reputation, as well as an affirmation of the long-term support of Austria.

6.2.2 The programme evaluation Building of Tomorrow 1999–2013

Objective of the evaluation

The main objective of the ex-post programme evaluation was to present the overall impact of the programme. The evaluation should not only focus on the immediate results of the programme in terms of research and innovation projects but also the indirect effects of strategic supporting measures[21].

Programme objectives and key information

The programme conceived in the mid-1990s pursued the goal of supporting the research and development of marketable components, elements

21 See Lefenda and Pöchhacker-Tröscher (2016).

and construction concepts for residential, office and utility buildings. The goal was to strengthen the Austrian construction industry amidst international competition and to achieve a leading position with regard to innovative technologies for sustainable construction. R&D and demonstration projects were to achieve a degree of compliance with the following criteria:

- clear reduction in the use of energy and materials
- increased use of renewable sources of energy, in particular solar energy
- increased and efficient use of renewable and ecological materials
- consideration of social aspects and improving the quality of life
- comparable costs to conventional construction and thus high market potential

The programme was implemented in two phases: In the first phase between 1999 and 2005, the programme mainly focused on the above objectives. The programme continued with essentially the same general thrust under the title "Building of Tomorrow Plus" (2008–2012), which was supposed to create the technological prerequisites for the creation of Plus-Energy buildings. These are buildings that generate more energy than they consume over their entire life-cycle. Important new objectives were the development and preparation or support of the market launch or market penetration of economically viable, innovative technical and organisational solutions that make a key contribution in the context of a CO2-neutral construction sector.

Since 1999, projects with a total volume in excess of €1 billion have been applied for, with funding amounting to a total of €306 million. This enabled approx. 450 projects[22] at a total volume of €138 million to be supported with funding worth almost €80 million. The first programme phase involved 220 stakeholders, the second phase a total of 696 stakeholders from industry and science.

Results of the evaluation

The evaluation report paints a positive picture of the programme effects and emphasises how it has contributed to awareness-raising and early sensitisation for the importance and potentials of sustainable construction, as well as highlighting market opportunities for Austrian providers. According to evaluators, the programme also established technical principles for development building standards and further improved the anchoring of these standards in regulatory works such as the housing subsidy.

The long-term approach and focus also gained attention internationally and advanced the technology and innovation leadership of Austrian industry. The international positioning of Austria as key player in the area of Sustainable Construction was strengthened and the programme frequently presented as an example of best practice, including within the context of a survey in the European Parliament. In addition, many buildings that emerged from this were awarded international prizes. Due to the very positive evaluation results, the evaluation stimulates a continuation of the activities for supporting research and innovation in the field of Sustainable Construction, which could take place within the scope of existing initiatives and programmes as well as through activities involving networking and cooperation.

6.2.3 Evaluation of the Creative Industries Voucher

Objective of the evaluation

The Creative Industries Voucher (CIV) launched at the beginning of 2013 is a low-threshold, demand-based instrument for funding cooperation in innovation projects between representatives of the creative industries and other economic sectors.[23] In particular, the evaluation analyses and

22 The report identifies 425 projects from the fourth call for tenders.

23 See Radauer and Warta (2015).

assesses the design and implementation, goal attainment and effects determined to date. Building on this, recommendations and proposed measures were derived for continuation and any adaptation/further development of the funding measures.

Programme objectives and key information

The CIV, which is run by the Austria Wirtschaftsservice (aws) on behalf of the Federal Ministry of Science, Research and Economy (BMWFW), aims at encouraging small and medium-sized firms (SMEs) to utilise the services provided for the creative industries and thus intensify and stimulate innovation projects. According to the Austria Wirtschaftsservice (aws), the voucher is intended for SMEs of all industries that make use of creative industries services in the course of their innovation work. These creative industries services are the object of the funding, which are supported with up to €5,000.[24] The core areas of the potential funding recipients include design, architecture, multimedia/games, fashion, music business/utilisation of music, audio-visual and film/film utilisation, media and publishing, graphics, advertising and the art market.

The CIV was launched in the context of the "evolve" strategy. The goal of evolve was to fully exploit the high innovation potential of the increasingly important creative sector in order to not only secure but also further expand the development of innovation in Austria compared to the rest of Europe.[25] In spring 2016, based on the positive experiences of evolve, the Austrian creative industries strategy was elaborated under the management of the Federal Ministry of Science, Research and Economy (BMWFW), in cooperation with Kreativwirtschaft Austria, the Federal Economic Chambers and the Austria Wirtschaftsservice Gesellschaft mbh (see Chapter 1.3 "Creative industries strategy"). The CIV is an important instrument for implementing the new creative industries strategy. According to the evaluation report, the funding measure pursues the following goals:

- increasing the innovation activity of SMEs
- increasing the utilisation of creative services by SMEs
- strengthening the providers of services in the creative industries
- stimulating and enabling cooperative efforts of firms of the creative industries along the value added chains and of firms of the creative industries with companies from sectors that have little if anything to do with the creative industries.

Since the measure was launched, two rounds of proposal have been held. In 2013, there were 934 applications and 611 approvals. In 2014, the number of applications rose sharply to 2,042. However, the number of funded projects remained constant with 612 approvals. It is noted that applications in 2013 were accepted on a first-come-first-served basis until the budget was used up. In 2014, a cut-off date was set, after which the applications were drawn by a notary.

Results of the evaluation

The evaluation paints a very positive picture of the CIV, which was primarily utilised by young SMEs and sole proprietors. It was established that the measure has a stimulating and supporting effect on the creative industries in conjunction with service providers and – to a lesser extent or more indirectly – with manufacturing companies as well. While a considerable portion of the CIV projects represents cooperations between the creative industries and service providers, it is evident that there are also interesting projects deserving of funding within the creative industries. The evaluation also highlights that the programme has comparatively high additionality values and low spill-over effects. According to the evaluation report, subsequent orders over

24 Cf. https://www.aws.at/fileadmin/user_upload/Downloads/Kurzinformation/aws_Kreativwirtschaftsscheck.pdf

25 Cf. http://www.bmwfw.gv.at/Innovation/Foerderungen/Documents/Kurzinformation%20evolve.pdf

and above CIV projects allow the conclusion that the CIV is in a position to sustainably encourage SMEs to use creative industries-related services.

It should be noted that while the surveys paint a very positive picture about the content of the innovation, the analysis of the project completion reports and applications nevertheless shows that it was occasionally difficult to tell the projects apart from the usual standard services that the creative industries render for their customers. According to the evaluation, the actual degree of innovation appears too low in many projects. In summary, the evaluation sees much of the CIV as a form of sales support, especially in core areas of the creative industries such as advertising and design.

According to the evaluation, the key challenges lie in handling the large number of applications, not all of which will receive funding due to the limited budget available, and in the task of ensuring a minimum level of innovation amongst the projects in the programme. In principle, the evaluation recommends retaining the CIV, but suggests the following measures for improvement: 1) optimised and prompt communication of the funding process, 2) focus on the participation of first utilisations, i.e. the CIV should explicitly address only those SMEs that have never or only rarely worked with a creative industries business, and 3) increased attention to ensuring the innovation content of the CIV projects.

6.2.4 Evaluation of the Innovation Voucher programme

Objective of the evaluation

In the course of the evaluation,[26] the concept and implementation of both existing Innovation Voucher programmes were analysed and their goal attainment assessed. Potentials for optimising the future development of the programmes were also identified and discussed within the scope of the investigation.

Programme objectives and key information

The Innovation Voucher programmes (I-Voucher programmes) provide funding for small and medium-sized firms (SMEs) with the goal of involving them in regular research and innovation activities (broadening the research, development and innovation base), to advance the transfer of knowledge between SMEs and the knowledge sector (activating knowledge transfer), to support the efficiency and effectiveness of R&I projects and to get them ready for the market faster (encouragement and improvement of R&I projects). The I-Voucher programmes are specifically aimed at smaller, as yet not regularly innovating firms that do not have their own R&I staff and are therefore often reliant on transfer of knowledge from research institutes.

The I-Voucher programmes are administered by the Austrian Research Promotion Agency (FFG) as part of a package of R&I funding measures (SME package) specially tailored to SMEs. Applications may be submitted at any time. Two I-Voucher formats are offered:

- The **Innovation Voucher (I-Voucher)** was launched in November 2007 and offers maximum funding of €5,000 without excess for a term of twelve months.
- The **Innovation Voucher plus (I-Voucher plus)** was launched in June 2011 and offers maximum funding of €10,000 (funding ratio 80%) with an excess of 20% of fundable costs of €12,500 and a term of twelve months.

Results of the evaluation

The evaluation states that a large group of new firms was acquired for R&I funding with the assistance of the I-Voucher (68% of applicants are so-called 'newcomers'[27]) and that the I-Vouchers

26 See Jud et al. (2017).

27 The term 'newcomer' describes firms whose first approved Austrian Research Promotion Agency (FFG) project is an I-Voucher or I-Voucher plus.

were also associated with a lever effect for the research and innovation expenditure of the newcomers.

In order to obtain the most comprehensive picture possible of the R&D activities of Innovation Voucher users, the data of these firms were blended with the data of the R&D survey of Statistics Austria. It was found that 452 I-Voucher firms (35% of the I-Voucher firms recorded in the R&D survey) appear in the R&D survey of Statistics Austria as R&D newcomers. The R&D expenditures of these firms are well above the funding level of the I-Voucher. These firms make up a high proportion of the total newcomers in the R&D survey. About one quarter of the newcomers also carried out Austrian Research Promotion Agency (FFG) follow-on projects, which suggests a sustainable increase in R&I activities.

The I-Voucher programmes reach both R&I newcomers and SMEs with R&I experience, with the funding having generated added value for all voucher users. While the I-Voucher projects for R&I newcomers primarily fund the entry into R&I and cooperations, experienced R&I firms use the instruments for experimenting with new ideas.

The evaluation also found that some of the research and innovation projects of the participating SMEs would have been implemented only more slowly or not at all without the support of I-Voucher (plus) and that the results elaborated in the projects could increase the quality of the planned innovations.

According to the evaluation, the I-Voucher programmes are seen as being suitable instruments for developing R&I activities. However, relative to the entire target group, only a portion of the newcomers (10%) appears in more complex Austrian Research Promotion Agency (FFG) programmes. Reasons are seen in the administrative effort for the application, the high quality requirements placed on the projects and the high excess required. However, against the background of the evaluation, this result cannot be traced back to the design of the I-Voucher programmes, but rather indicates the lack of similar low-threshold programmes with which R&I activities of the newcomers could be continued.

To summarise, the evaluation notes that the I-Voucher programme is well embedded into the RTI strategy of the Federal Government and addresses its objectives. The I-Voucher programme does help firms get into R&I, remain in contact with the research institutes and carry out projects together. On the basis of the evaluation results, continuation of the I-Voucher programmes is recommended, although any adjustments to the programme should be checked.

6.2.5 Evaluation of the research tax premium in accordance with Section 108c of the Austrian Income Tax Act

Objective of the evaluation

The research tax premium has been evaluated for the first time since its inception.[28] The objective of the evaluation was to identify effects on the company level that could be allocated to the research tax premium in the period from 2009 to 2015.

Development and key information

The research tax premium was introduced in 2002 and increased continuously over the years, most recently from 10% to 12% in 2016. The tax shortfalls due to the increase to 12% will come into effect only from 2017 and are therefore not taken into consideration. In 2015, R&D expenditures in the amount of almost €502 million were claimed within the scope of the research tax premium. To claim the research tax premium, an

28 See Ecker et al. (2017).

annual assessment report carried out by the Austrian Research Promotion Agency (FFG) is required since financial year 2012.

Results of the evaluation

The importance of indirect R&D funding has recently increased, both nationally and internationally. Tax incentives, such as the Austrian tax premium for research and development, are found in most innovation-based economies around the world. Within the countries of the EU, this instrument is absent only in Bulgaria, Germany, Estonia, Finland, Luxembourg and Cyprus as well as in the non-EU country Switzerland. In the OECD, 29 out of 35 countries provide this instrument, with expenditures for indirect research funding having risen sharply in most countries in recent years; France and Canada lead the way in this regard. In an OECD comparison (based on data as of 2014 – i.e. before the increase to 12%) Austria is in midfield position with expenditure for indirect R&D funding with 0.13% of GDP, and was ranked tenth out of 28 OECD countries in 2014. Overall – for direct and indirect funding together – Austria was in sixth place in 2014.

The research tax premium is used by around 75% of those firms that carry out research in Austria. The evaluation confirms that the research tax premium benefits research-intensive industries. The biggest firms with turnover of more than €50 million drew more than two thirds of the tax premium in all financial years. With regard to the number of applicants for the tax premium, however, the overwhelming share is accounted for by SMEs. Thus an average of about 85% of all assessment reports completed by the Austrian Research Promotion Agency (FFG) addressed SMEs since 2013.

Since financial year 2012, it has been the task of the Austrian Research Promotion Agency (FFG) to check whether the prerequisites concerning content are in place with regard to the presented in-house R&D activities for which a research tax premium was applied. The number of firms was reduced as a result of this assessment. About 1,500 firms per financial year have ceased to apply for the research tax premium since the introduction of the check by the Austrian Research Promotion Agency (FFG). This mainly concerns small firms and firms that operate in industries with a lower R&D intensity (e.g. wholesale). One reason is that those firms whose R&D activity is evidently too low to claim the research tax premium no longer apply for it. The assessment by the Austrian Research Promotion Agency (FFG) thus contributes to the reduction of spill-over effects. Overall, satisfaction levels amongst firms are relatively high, both as regards the procedure for claiming the tax premium and its design.

According to the firms surveyed in the evaluation, the research tax premium contributes both to securing Austria as a business location and to off-shoring R&D activities to Austria, above all for internationally active, research-intensive firms. This must also be seen in the context of the location and funding conditions of other countries. In particular, the situation in Germany, where there are currently no tax breaks for firms pursuing R&D, has an impact on whether and to what extent (additional) R&D activities are performed in Austria. Numerous firms indicated in the survey that they had off-shored some of their R&D activities to Austria – and claimed that the research tax premium was a decisive factor for doing so. The international orientation of these firms is worth noting in this context. The majority of firms that in recent years have expanded competences in Austria, increased R&D responsibility and made additional investments, also has research competences outside of Austria.

In additionally held interviews, some firms indicated that the research tax premium, in conjunction with available, highly qualified human capital in the locational competition within the firm group, certainly was and is decisive for further expanding the R&D location in Austria. In their own words, the firms that have based additional R&D responsibility in Austria also created additional jobs in the years 2010 to 2015. According to them, a total of 14,300 new employees were recruited. These new employees are above all highly qualified scientific personnel as well as technicians and equivalent staff.

The relatively broad range of attributable cost types and fundable expenditures represents an asset of the research tax premium. The thematic openness corresponds to the needs of the firms. According to statements made by the firms, the research tax premium helps them make investments in infrastructure and undertake riskier research projects. Moreover, the evaluation shows that the research tax premium has a supporting effect, especially at research-intensive firms and those that are already pursuing R&D on a regular basis. In contrast, the research tax premium hardly provides an incentive effect for expanding R&D at firms with little or no R&D to date. These firms are better targeted by direct research funding. Direct funding tends to address small and medium-sized firms, which also better supports them with topics that are closer to basic research and thus technologically risky. This means that direct and indirect research funding are not mutually exclusive, but rather complement each other. In order to get a comprehensive picture of this complementary effect, the study recommends carrying out an impact analysis of Austria's entire funding system as soon as the data of direct and indirect research funding are both available and are made accessible.

According to the evaluation, the goal must be to increase the accuracy of research funding even further in the future. For this purpose, it is suggested to more proactively design the communication and consulting between the Federal Ministry of Finance (BMF), the Austrian Research Promotion Agency (FFG) and interest groups with regards to the eligibility for funding of projects. In addition, process support should be provided by financial administration for all firms drawing the tax premium following the concept of "Horizontal Monitoring". The latter should contribute to a further improvement in legal certainty for the firms, also allowing them better planning with regards to the research tax premium.

7 Literature

Acatech (2013): Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0, Frankfurt/Main.

Acatech and BDI (Eds.) (2017): Innovationsindikator 2016/17. Berlin: German National Academy of Science and Engineering and the Federation of German Industries (BDI).

Aghion, P., Dewatripont, M. and Stein, J. C. (2008): Academic freedom, private-sector focus, and the process of innovation, The RAND Journal of Economics, 39(3), 617–635.

Aichholzer, G., Gudowsky, N., Saurwein, F., Rhomberg, W., Weber, M. and Wepner, B. (2015): Industrie 4.0: Foresight & Technikfolgenabschätzung zur gesellschaftlichen Dimension der nächsten industriellen Revolution. Study commissioned by the Austrian Parliament, Vienna.

Alkin, M. C. und Taut, S. M. (2003): Unbundling Evaluation Use, Studies in Educational Evaluation, 29(1), 1–12.

Arntz, M., Gregory, T. and Zierhahn, U. (2016): The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis, OECD Social, Employment and Migration Working Papers 189, Paris.

Austrian FP9 Think Tank (2016): Theses Paper for the next (9th) EU-RTD Framework Programme. By the Austrian FP9 Think Tank. https://era.gv.at/object/document/2826

Aws (2015): Life Science Report Austria 2015

Baumol, W. J. (1967): Macroeconomic of unbalanced Growth: the Anatomy of Urban Crisis, American Economic Review, 57(3), 415–426.

Behaghel, L., Caroli, E. and Walkowiak, E. (2008): Innovation and skill upgrading: The role of external vs internal labour markets, PSE Working Papers no. 2007-04.

Biegelbauer, P. (2013): Wie lernt die Politik: Lernen aus Erfahrung in Politik und Verwaltung, Wiesbaden.

Biegelbauer, P. and Hansen, J. (2011): Democratic Theory and Citizen Participation: democracy models in the evaluation of public participation in science and technology, Science and Public Policy, 38(8), 589–598.

BKA, BMF, BMUKK, BMVIT, BMWFJ and BMWF (2011): Der Weg zum Innovation Leader: Potenziale ausschöpfen, Dynamik steigern, Zukunft schaffen, Strategie der Bundesregierung für Forschung, Technologie und Innovation (Federal government's strategy for research, technology and innovation), Vienna. https://www.bka.gv.at/DocView.axd?CobId=42655

BMVIT (2015): Verkehrsinfrastruktur Forschung und Entwicklung in Österreich: Investitionen in Forschung und Entwicklung. Ein Überblick über das Engagement des BMVIT in transnationalen Maßnahmen und Kooperationen, Vienna.

BMWF, BMVIT, and BMWFJ (2014): Austrian Research and Technology Report 2014. Report under Section 8(1) of the Research Organisation Act on federally subsidised research, technology and innovation in Austria http://www.bmwfw.gv.at/ftb

BMWF, BMVIT, and BMWFJ (2016): Austrian Research and Technology Report 2016. Report under Section 8(1) of the Research Organisation Act on federally subsidised research, technology and innovation in Austria http://www.bmwfw.gv.at/ftb

BMWFW (2015): Austrian University Development Plan 2016–2021, Vienna.

BMWFW (2016): The Austrian ERA Roadmap, Vienna, April 2016.

BMWFW and BMVIT (2016): Presentation to the Council of Ministers on 8 November 2016 concerning a comprehensive package of measures suggested by Working Group 5: Research, Technology, Startups, Vienna.

Bock-Schappelwein, J. (2016): Digitalisierung und Arbeit, in: Peneder, M. (coordination), Bock-Schappelwein, J., Firgo, M., Fritz, O., Streicher, G.: Volkswirtschaftliche Effekte der Digitalisierung, WIFO Study commissioned by A1 Telekom Austria AG, Vienna, 110–126.

Bock-Schappelwein, J., Eppel, R., Famira-Mühlberger, U., Kügler, A., Mahringer, H., Unterlass, F. and Zulehner, C. (2016): Die Wirkung von Innovationsaktivitäten geförderter österreichischer Unternehmen auf die Belegschaft, WIFO Study commissioned by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Vienna Chamber of Labour.

Bock-Schappelwein, J. and Huemer, U. (2017): Österreich 2025: Die Rolle ausreichender Basiskompetenzen in einer digitalisierten Arbeitswelt, WIFO-Monatsberichte 2/2017.

Bonin, H., Gregory, T. and Zierahn, U. (2015): Übertragung der Studie von Frey/Osborne (2013) auf Deutschland, Endbericht, ZEW Kurzexpertise Nr. 57, Mannheim.

Boswell, C. (2008): The political functions of expert knowledge: Knowledge and legitimation in European Union immigration policy, Journal of European Public Policy, 15(4), 471–488.

Bowles, J. (2014): The computerization of European Jobs, Bruegel, Brussels, http://bruegel.org/2014/07/chart-of-the-week-54-of-eu-jobs-at-risk-of-computerisation

Boyd, D. and Crawford, K. (2012): Critical Questions for Big Data. Provocations for a cultural, technological, and scholarly phenomenon, Information Communication & Society, 15, 662–679.

Breivik, M., Hovland, G. and From, P. J. (2009): Trends in Research and Publication: Science 2.0 and Open Access, Modeling Identification and Control, 30, 181–190.

Brzeski, C. and Burk, I. (2015): Die Roboter kommen: Folgen der Automatisierung für den deutschen Arbeitsmarkt, ING DiBa Economic Research 30, Frankfurt/Main.

Burgelman, J. C., Osimo, D. and Bogdanowicz, M. (2010): Science 2.0 (Change will happen…), First Monday, 15(7), http://firstmonday.org/ojs/index.php/fm/article/view/2961/2573

Burr, E. M. (2009): Evaluation use and influence among project directors of state GEAR UP grants. PhD thesis, University of Tennessee, Knoxville.

Chéron, A., Langot, F. and Moreno-Galbis, E. (2007): The 'Dynamic' of Job Competition During the ICT; IZA Discussion Paper No. 2671.

Chesbrough, H. (2003): Open Innovation. The New Imperative for Creating and Profiting From Technology, Harvard University Press: Boston.

Christensen, C. M. (1997): The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Boston.

Cornell University, Insead, WIPO (2016): The Global Innovation Index 2016: Effective Innovation Policies for Development, Ithaca, Fontainebleau, Geneva.

Dahlander, L. and Gann, D. (2010): How open is innovation?, Research Policy, 39(6), 699–709.

Daniels, P. W. and Bryson, J. R. (2002): Manufacturing Services and servicing Manufacturing: Knowledge-based Cities and changing Forms of Production, Urban Studies, 39(5–6), 977–991.

Degelsegger, A. and Torgersen H. (2011): Participatory paternalism: Citizens' conferences in Austrian technology governance, Science and Public Policy, 38(5), 391–402.

Del Savio, L., Prainsack, B. and Buyx, A. (2016): Crowdsourcing the Human Gut: is crowdsourcing also 'citizen science'?, Journal of Science Communication, 15(3), A03. http://jcom.sissa.it/sites/default/files/ documents/JCOM_1503_2016_A03.pdf

Dengler, K. and Matthes, B. (2015): Folgen der Digitalisierung für die Arbeitswelt: Substituierbarkeitspotenziale von Berufen in Deutschland, IAB-Forschungsbericht 11/2015, Institut für Arbeitsmarkt- und Berufsforschung, Nürnberg.

Dinges, M. and Schmidmayer, J. (2010): Country report: Austria., in: Edler, J., Cunningham, P., Gök, A., Rigby, J., Amanatidou, E., Garefi, I., Bührer, S., Dinges, M., Berger, M., Schmidmayer, J. and Guy, K. (2010): Understanding evaluation of innovation policy in Europe, in: INNO-Appraisal final report, Manchester, 243–264.

Dinges, M., Bock-Schappelwein, J., Dachs, B., Fuchs, S., Horvath T. and Rhomberg, W. (2017): Beschäftigung und Industrie 4.0: Technologischer Wandel und die Zukunft des Arbeitsmarkts, Report for the Austrian Research Promotion Agency (FFG), Vienna.

Doudna, J. and Charpentier, E. (2014): The new frontier of genome engineering with CRISPR-Cas9, Science, 346(6213), 1258096.

Ecker, B., Brandl, B., Fink, N., Kaufmann, P., Loretz, S., Sardadvar, S., Sellner, R., Sheikh, S. and Wolf, L. (2017): Evaluierung der Forschungsprämie gem. § 108c EStG, WPZ Research, KMU Forschung Austria and the Institute for Advanced Studies, Vienna.

Engelhart, J. (2016): Qualitative Untersuchung von Angeboten für Wissensvermittlung für Kinder und Jugendliche im Rahmen der Initiative Science Pool, Study commissioned by the Council for Research and Technology Development, RFTE.

Enkel, E. (2011): Open Innovation: Wie machen es die Besten?, Zeitschrift für Führung und Organisation (zfo) 6, 415–421.

Enkel, E., Gassmann, O. and Chesbrough, H. (2009): Open R&D and open innovation: exploring the phenomenon, R&D Management, 39(4), 311–316.

ERA Portal Austria (2015): Open Science, Policy Brief, December 2015.

European Commission (2000): Making a reality of the European Research Area: Guidelines for EU research, COM(2000) 612 final, Brussels.

European Commission (2008): Towards Joint Programming in Research; Communication COM(2008) 468, Brussels.

European Commission (2013): Responsible Research and Innovation (RRI), Science and Technology: Special Eurobarometer 401, Brussels.

European Commission (2014): The Sixth Framework Programme in Brief, Brussels.

European Commission (2015): Indicators for promoting and monitoring Responsible Research and Innovation, Report from the Expert Group on Policy Indicators for Responsible Research and Innovation. http://ec.europa.eu/research/swafs/pdf/pub_rri/rri_indicators_final_version.pdf

European Commission (2015a): HORIZON 2020 Work Programme 2016-17, General Annexes D; Brussels.

European Commission (2016): Study on Knowledge Transfer and Open Innovation. Final Report, Brussels.

European Commission (2016a). The contribution of the Framework Programmes to Major Innovations, Brussels.

European Commission (2016b). Open innovation, open science, open to the world: A vision for Europe, Brussels.

European Commission (2016c): A guide to ICT-related activities in WP2016-17. Brussels.

European Research Area and Innovation Committee – ERAC (2015): Opinion on the European Research Area Roadmap 2015–2020. Brussels, April 2015.

Evans, D. S. (1987): The relationship between firm growth, size, and age: Estimates for 100 manufacturing industries, The Journal of Industrial Economics, 35(4), 567–581.

FFG (Austrian Research Promotion Agency) (2014): Österreichische Vertretung in multilateralen Initiativen – MULLAT Governancestrukturen; Austrian Research Promotion Agency (FFG), 08/2014.

FFG (Austrian Research Promotion Agency) (2015): „EIT RawMaterials" mit starker österreichischer Beteiligung; In Brief: EU Forschung und Innovation; https://www.ffg.at/sites/default/files/downloads/inbrief_eit_rawmaterial.pdf.

Firgo, M. (2016): Digitalisierung und regionales Beschäftigungswachstum in Österreich: Eine ökonometrische Analyse, in: Peneder, M. (coordination), Bock-Schappelwein, J., Firgo, M., Fritz, O., Streicher, G., Volkswirtschaftliche Effekte der Digitalisierung, WIFO Study commissioned by A1 Telekom Austria AG, Vienna, 84–109.

Frankel, F. and Reid, R. (2008): Big data: Distilling meaning from data, Nature, 455(7209), 30–30.

Frey, C. B. and Osborne, M. A. (2013): The Future of Employment: How Susceptible are Jobs to Computerisation?, Oxford Martin Programme on the Impacts of Future Technology, Oxford.

Friesenbichler, K. S. and Leo, H. (2006): WIFO White Paper: Der Rahmen für die Innovationspolitik, WIFO-Monatsberichte 6, 527–536.

Funtowicz, S.O. and Ravetz, J. R. (1993): Science for the post normal age, Futures, 25(7), 739–755.

Gallouj, F. (2002): Knowledge-intensive Business Services: processing Knowledge and producing Innovation, in: Gadrey, J. and Gallouj, F. (eds.), Productivity, Innovation and Knowledge in Services, Edward Elgar, 256–284.

Gallouj, F. and Savona, M. (2009): Innovation in Services: a Review of the Debate and Research Agenda, Journal of Evolutionary Economics, 19(2), 149–172.

Geroski, P. A. (2005): Understanding the implications of empirical work on corporate growth rates, Managerial and Decision Economics, 26, 129–138.

Godin, B. (2007): Science, accounting and statistics: The input-output framework, Research Policy, 36(9), 1388–1403.

Goldman, J., Shilton, K., Burke, J., Estrin, D., Hansen, M., Ramanthan, N., Reddy, S., Samanta, V., Srivastava, M., and West, R. (2009): Participatory Sensing. A citizen-powered approach to illuminating the patterns that shape our world. Woodrow Wilson International Center: Washington D.C.

GPC ERA-LEARN-Project (2015): Deliverable 4.1 – Report on the Definition and Typology of Alignment.

Grasberger, L. (2014): Zeitenwende für die Wissenschaft, Stifterverband, W&W 2-2014, 10–21, http://www.stifterverband.de/pdf/wuw_2014-02_schwerpunkt.pdf

Grupp, H. (1994): The measurement of technical performance of innovations by technometrics and its impact on established technology indicators, Research Policy, 23(2), 175–193.

Guerrieri, P. and Meliciani, V. (2005): Technology and international Competitiveness: the Interdependence between Manufacturing and Producer Services, Structural Change and Economic Dynamics, 16(4), 489–502.

Haltiwanger, J., Jarmin, R. S. and Miranda, J. (2013): Who creates jobs? Small versus large versus young, Review of Economics and Statistics, 95(2), 347–361.

Helpman, E. (Ed.) (1998): General Purpose Technologies and Economic Growth, Cambridge.

Henry, G. T. and Mark, M. M. (2003): Beyond Use: Understanding Evaluation's Influence on Attitudes and Actions, American Journal of Evaluation, 24(3), 293–314.

Højlund, S. (2014): Evaluation use in the organizational context. Changing focus to improve theory, Evaluation 20(1): 26–43.

Højlund, S. (2015): Evaluation use in evaluation systems. The case of the European commission. PhD thesis, Copenhagen Business School, Copenhagen.

Hölzl, W., Friesenbichler, K., Kügler, A., Peneder, M. and Reinstaller, A. (2016): Industrie 2025: Wettbewerbsfähigkeit, Standortfaktoren, Markt- und Produktstrategien und die Positionierung österreichischer Unternehmen in der internationalen Wertschöpfungskette, Austrian Institute of Economic Research (WIFO), Vienna.

Howe, D., Costanzo, M., Fey, P., Gojobori, T., Hannick, L. et al. (2008): Big data: The future of biocuration, Nature 455, 47–50.

Janger, J., Kügler, A., Reinstaller, A. and Unterlass, F. (2017): Österreich 2025: Die „Frontier" in Wissenschaft, Technologie, Innovationen und Wirtschaft: Messung und Bestimmungsfaktoren, WIFO-Monatsberichte, 90(2), 141–151.

Janger, J., Nowotny, K. (2016): Job choice in academia, Research Policy, 45(8), 1672–1683.

Janger, J., Schubert, T., Andries, P., Rammer, C. and Hoskens, M. (2017): The EU 2020 innovation indicator: A step forward in measuring innovation outputs and outcomes?, Research Policy, 46(1), 30–42.

Johnson, K., Greenside, L. O., Toal, S. A., King, J. A., Lawrenz, F., and Volkov, B. (2009): Research on Evaluation Use: A Review of the Empirical Literature from 1986 to 2005, American Journal of Evaluation, 30(3), 377–410.

Jud, T., Handler, R., Kupsa, S. and Pohn-Weidinger, S. (2017): Evaluierung der Innovationsscheck-Programme. (Evaluation of the Innovation Voucher programmes). Convelop, Graz and Vienna.

Kahn, N., Yaqoob, I., Abaker, T., et al. (2014): Big Data: Survey, Technologies, Opportunities, and Challenges, The Scientific World Journal, 24, https://www.hindawi.com/journals/tswj/2014/712826/

Kirkhart, E. K. (2000): Reconceptualizing evaluation use: An integrated theory of influence, New Directions for Evaluation, Special Issue: The Expanding Scope of Evaluation Use, 88, 5–23.

Kline, S. J. and Rosenberg, N. (1986): An overview of innovation: The positive sum strategy: Harnessing technology for economic growth.

Kornberg, R., Ball, J., Eichler R., Liskov, B., Neher, E. and Schekman, R. (2016): Evaluierung des Institute of Science and Technology Austria (IST Austria). Bericht des internationalen Evaluierungskomitees. Klosterneuburg.

Kox, H. L. M. and Rubalcaba, L., (2003): Analysing the Contribution of Business Services to European Economic Growth, MPRA Paper, 2007, München.

Kramer, B. and Bosman, J. (2016): Swiss army knives of scholarly communication. ResearchGate, Academia, Mendeley and others, Presentation at the STM Innovations Seminar, December 7, London.

Landsteiner, G. (2015): Nützlichkeit und Nutzen der Programmevaluationen im Bereich der österreichischen FTI-Politik. Metaevaluation der Programmevaluationen 2003–2014. www.rat-fte.at/tl_files/uploads/Studien/Metaevaluation-FTI-Endbericht-final-web.pdf

Lefenda, J. and Pöchhacker-Tröscher, G. (2016): Programmevaluierung Haus der Zukunft 1999–2013 (Evaluation of the Building of Tomorrow programme 1999–2013). Pöchhacker Innovation Consulting GmbH, Vienna.

Leitner, K.-H. (2003): Von der Idee zum Markt: die 50 besten Innovationen Österreichs: Erfolgsgeschichten der österreichischen Industrie zwischen 1975 und 2000, Vienna.

Leitner, K.-H. (2017): Past, Present and Future of Universities: A Comparison of different National University Systems, Kick-of-Speech at the Alumni Event of the Department of International Management, Johannes Kepler University, Linz.

Leitner, K.-H., Felder, C., Kasztler, A. and Rhomberg, W. (2015): Neue Innovationsmodelle: Potenziale und Herausforderungen für die österreichische Wirtschaft und Innovationspolitik, Study commissioned by Austria Wirtschaftsservice GmbH, AIT-IS-Report 117, Vienna.

Lethonen, M. (2005): Environmental policy evaluation in the service of sustainable development: Influence of the OECD environmental performance reviews from the perspective of institutional economics. PhD thesis, University of Versailles, Saint-Quentin-en-Yvelines.

Lundvall, B.-Å. (2010): National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning.

Mark, M. M. and Henry, G. T. (2004): The Mechanisms and Outcomes of Evaluation Influence, Evaluation, 10(1), 35–57.

Martinez-Fernandez, C., Miles, I. and Weyman, T. (Eds.) (2011): The Knowledge Economy at work: Skills and Innovation in Knowledge intensive Service Activities, Edward Elgar, Cheltenham, 2011.

Mayerhofer, P. and Firgo, M. (2015): Wissensintensive Unternehmensdienste, Wissens-Spillovers und regionales Wachstum. Sub-project 2: Strukturwandel und regionales Wachstum – Wissensintensive Unternehmensdienste als „Wachstumsmotor“?, WIFO Study commissioned by the Vienna Chamber of Labour and the City of Vienna.

McLaughlin, J. A. and Jordan, G. B. (1999): Logic models: a tool for telling your programs performance story, Evaluation and Program Planning, 22(1), 65–72.

Merton, R. K. (1973): The Sociology of Science: Theoretical and Empirical Investigations. University of Chicago Press: Chicago.

Mokyr, J., Vickers, C., and Ziebarth, N. L. (2015): The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?, Journal of Economic Perspectives, 29(3), 31–50.

Nagl, W., Titelbach, G. and Valkova, K. (2017): Digitalisierung der Arbeit: Substituierbarkeit von Berufen im Zuge der Automatisierung durch Industrie 4.0, IHS-Projektbericht Januar 2017, Study commissioned by the Federal Ministry of Labour, Social Affairs and Consumer Protection.

Nentwich, M. and König, R. (2012): Cyberscience 2.0: Research in the Age of Digital Social Networks, Frankfurt and New York.

OECD (2009): OECD Patent Statistics Manual, Paris.

OECD (2015): STI Scoreboard 2015, Paris.

OECD and Eurostat (2005): Oslo Manual. Guidelines for collecting and interpreting innovation data.

OECD and SCImago (2016): Compendium of Bibliometric Science Indicators, Paris.

Open Access Network Austria (OANA) (2016): Empfehlungen für die Umsetzung von Open Access in Österreich, OANA, May, Vienna.

Pajarinen, M. and Rouvinen, P. (2014): Computerization Threatens One Third of Finnish Employment, ETLA Brief 22. http://pub.etla.fi/ETLA-Muistio-Brief-22.pdf

Pakes, A. and Griliches, Z. (1984): Patents and R&D at the firm Level: A First Look, in: Z. Griliches (ed.), R&D, Patents and Productivity, Chicago, 55–72.

Palander, T. (1935): Beiträge zur Standorttheorie, Uppsala.

Palfinger, T. (2017): From Using the Crowd to Empowering the Citizen: The Framing of Citizen Science in Austria, Presentation at the Workshop Critical Studies of Citizen Science in Biomedical Research, King's College London.

Peneder, M. (2010): Technological regimes and the variety of innovation behaviour: Creating integrated taxonomies of firms and sectors, Research Policy, 39(3), 323–334.

Peneder, M., Bock-Schappelwein, J., Firgo, M., Fritz, O. and Streicher, G. (2016): Österreich im Wandel der Digitalisierung, WIFO Study commissioned by A1 Telekom Austria AG, Vienna.

Pinto, H., Fernandez-Esquinas, M. and Uyarra, E. (2015): Universities and Knowledge-intensive Business Services (KIBS) as Sources of Knowledge for innovative Firms in Peripheral Regions, Regional Studies, 49(11), 1873–1891.

Polt, W., Unger, M., Ploder, M., Wagner-Schuster, D., Bundgard Vad, T., Palmquist, S. and Barslund Fosse, H. (2015): The Leverage Potential of the European Research Area for Austria's Ambition to become one of the Innovation Leaders in Europe – A comparative study of Austria, Sweden and Denmark; Study commissioned by the ERA Council Forum Austria.

Polt, W., Unger, M., Winkler, C. and Streicher, J. (2016): Entwicklung einer österreichischen Position zu Alignment – Grundlagenpapier für die Entwicklung einer österreichischen Position zu Alignment; Study commissioned by the Federal Ministry of Transport, Innovation and Technology (BMVIT).

Radauer, A. and Warta, K. (2015): Evaluierung des Kreativwirtschaftsschecks (KWS) (Evaluation of the Creative industries voucher), Technopolis, Vienna.

Ramirez, P. (2013): The new modes and geography of pharmaceutical R&D: Implications for policy, SERVICEGAP Discussion Paper 49, Birmingham.

Reidl, S., Kulmer, V. and Hafellner, S. (2015): Landkarten der Wissenschaftskommunikation: Bestandsaufnahme unterschiedlicher Formate der gesellschaftlichen Vermittlung von Wissenschaft, Forschung und Innovation, Commissioned by the Council for Research and Technology Development (RFTE). http://www.rat-fte.at/tl_files/uploads/Studien/ Endbericht%20Landkarten%20der%20Wissenschaftskommunikation.pdf

Reiner, D. and Smoliner S. (2012): Outputorientierte Evaluierung öffentlich geförderter FTI-Programme. Study commissioned by the Federal Ministry of Transport, Innovation and Technology (BMVIT), Vienna.

Reinstaller, A. and Reschenhofer, P. (2017): Using PageRank in the analysis of technological progress through patents: An illustration for biotechnological inventions, WIFO.

RFTE (2009): Rat für Forschung und Technologieentwicklung. Strategie 2020, Vienna.

RFTE (2016): Empfehlung zur innovationsfördernden öffentlichen Beschaffung in Österreich, Vienna.

Rodriguez-Pose, A. and Crescenzi, R. (2008): Mountains in a flat World: why Proximity still matters for the Location of Economic Activity, Cambridge Journal of Regions, Economy and Society, 1, 371–388.

Roper, S., Du, J. and Love, J. H. (2008): Modelling the innovation value chain, Research Policy, 37, 961–977.

Saviotti, P. P. and Metcalfe, J. S. (1984): A theoretical approach to the construction of technological output indicators, Research Policy, 13(3), 141–151.

Schaper-Rinkel, P., Weber, M., Wasserbacher, D., van Oost, E., Ordonez-Matamoros, G., Krooi, M., Hölsgens, R., Nieminen, M. and Pelkonen, A. (2012): Exploring future research and innovation: Trends and drivers in doing and organizing research, Stocktaking report on results of FLAs and State-of-the-Art in research, RIF project.

Schomberg, R. (2013): A vision of responsible research and innovation, in: Owen, R., Bessant, J., Heintz, M. (Eds.), Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society, Chichester, 51–74.

Schroeder, R. (2008): e-Sciences as research technologies: reconfiguring disciplines, globalizing knowledge, Social Science Information, 47(2), 131–157.

Schumpeter, J. A. (1939): Business cycles, 1, McGraw-Hill, New York.

Srholec, M. (2007): High-tech exports from developing countries: A symptom of technology spurts or statistical illusion?, Review of World Economics, 143(2), 227–255.

Statistics Austria (2008): Systematik der Wirtschaftstätigkeiten ÖNACE, Band 1, Vienna.

Statistics Austria (2016): Input-Output-Tabelle 2012, Vienna.

Streicher, J. (2017): Evaluations, Actors and Institutions. The Case of Research, Technology and Innovation Policy in Austria. http://epub.wu.ac.at/id/eprint/5445

Tichy, G. (2016): Geht der Arbeitsgesellschaft die Arbeit aus?, WIFO-Monatsberichte, 89(12), 853–871.

Torre, A. and Rallet, A. (2005): Proximity and Localization, Regional Studies, 39(1), 47–59.

Tsipouri, L. and Sidiropolous, N. (2014): RTDI evaluation culture in the EVAL-INNO countries. In: Zupan I, Gajdusek MF and Marinkovic I (eds.) Fostering Evaluation Competencies in Research, Technology and Innovation – the EVAL-INNO experience, 11–20, http://www.eval-inno.eu/images/EVAL-INNO_Final_Publication_WEB_7526e.pdf

Ulrich, H. (2015): Open Science in der Soziologie: eine interdisziplinäre Bestandsaufnahme zur offenen Wissenschaft und eine Untersuchung ihrer Verbreitung in der Soziologie, Schriften zur Informationswissenschaft, 67, Hülsbusch, Glückstadt.

Unterlass, F., Hranyai, K. and Reinstaller, A. (2013): Patentindikatoren zur Bewertung der erfinderischen Leistung in Österreich, Study commissioned by the Council for Research and Technology Development (RFTE), Vienna.

Vernon, R. (1966): International Investment and international Trade in the Product Cycle, Quarterly Journal of Economics, 80, 190–207.

Wang, J., Veugelers, R. and Stephan, P. (2016): Bias against Novelty in Science: A Cautionary Tale for Users of Bibliometric Indicators, Working Paper 22180, National Bureau of Economic Research.

Warta, K. and Dudenbostel, T. (2007): Radikale Innovationen: Mehr Freiraum für innovative und risikobehaftete Forschung, Technopolis, Vienna.

Warta, K. and Philipp. S. (2016): Was bringt die Plattform fteval und zu was hat sie es gebracht? Rückblicke und Ergebnisse einer Mitgliederbefragung, The fteval Journal for Research and Technology Policy Evaluation, edition 41, 5–14. www.fteval.at/upload/fteval_Journal_for_Research_and_Technology_Policy_Evaluation_-_41_.pdf

Weber, M. and Rohracher, R. (2012): Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework, Research Policy, 41(6), 1037–1047.

Weber, M. and Burgelman, J. C. (2015): Die Zukunft von Forschung und Innovation, in: Rat für Forschung und Technologieentwicklung (Eds.): Die Gestaltung der Zukunft, Vienna, 550–585.

WEF (2016): The Global Competitiveness Report 2016–2017, World Economic Forum, Geneva.

Wickson, F. and Carew, A. L. (2014): Quality criteria and indicators for responsible research and innovation: learning from transdisciplinarity, Journal of Responsible Innovation, 1(3), 254–273. http://doi.org/ 10.1080/23299460.2014.963004

Wood, P. A. (2005): A Service-informed Approach to regional Innovation – or Adaptation?, Service Industries Journal, 25, 429–445.

Zahradnik, G., Rhomberg, W. and Leitner, K-H. (2016): EMS 2015: Innovationen in der Produktion: Basisauswertung und Sonderauswertung zum Thema Industrie 4.0, AIT-IS-Report 125, Vienna.

8 Annex I

8.1 Country codes

Country/region	Codes	Country/region	Codes	Country/region	Codes	Country/region	Codes
Albania	AL	Estonia	EE	South Korea	KR	Romania	RO
Argentina	AR	Greece	EL	Liechtenstein	LI	Serbia	RS
Austria	AT	Spain	ES	Lithuania	LT	Russia	RU
Australia	AU	Finland	FI	Luxembourg	LU	Sweden	SE
Belgium	BE	France	FR	Latvia	LV	Singapore	SG
Bulgaria	BG	Hong Kong	HK	Montenegro	ME	Slovenia	SI
Brazil	BR	Croatia	HR	Malta	MT	Slovakia	SK
Canada	CA	Hungary	HU	Mexico	MX	Turkey	TR
Switzerland	CH	Ireland	IE	Nigeria	NG	Taiwan	TW
China	CN	India	IN	Netherlands	NL	United Kingdom	UK
Cyprus	CY	Israel	IL	Norway	NO	United States of America	US
Czechia	CZ	Iceland	IS	New Zealand	NZ	South Africa	ZA
Germany	DE	Italy	IT	Poland	PL		
Denmark	DK	Japan	JP	Portugal	PT		

8.2 Explanations of the abbreviations for MULLAT types

Public-Public Partnership:

- 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 (FP7: 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.

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 a separate strategic agenda, 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 a 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, very different structurally.
- 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 scientists → 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 research and development 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 Federal Ministry of Science, Research and Economy (BMWFW)).

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 European Investment Bank EIB Group (European Investment Bank and European Investment Fund) and the European Commission.
- EFSI – European Fund for Strategic Investments: joint initiative between the EIB Group and the European Commission aimed at stimulating private investment in strategic areas (strategic infrastructure, including digital networks, transportation and energy; education, research, development and innovation, development of renewable energy and resource effi-

ciency, 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 partner organisations – "Alliance for Responsible Science"

Overview of partner organisations – "Alliance for Responsible Science"	
ACIB – Austrian Centre of Industrial Biotechnology	AIT Austrian Institute of Technology
Federal Institute for the Education of the Blind	Federal Ministry of Science, Research and Economy (BMWFW)
CeMM – Research Center for Molecular Medicine of the Austrian Academy of Sciences	Democracy Centre Vienna
The University for Continuing Education Krems	Essl Foundation
St. Pölten University of Applied Sciences	University of Applied Sciences Technikum Wien
Federal secondary schools Bundesgymnasium and Bundesrealgymnasium, Vienna 6	IMC University of Applied Sciences Krems
INNOC – Austrian Society for Innovative Computer Sciences	IHS – Institute for Advanced Studies
JOANNEUM RESEARCH Forschungsgesellschaft mbH	Karl Landsteiner University of Health Sciences
KinderUniGraz	Lauder Business School
Ludwig Boltzmann Society	Museum of Natural History Vienna
Naturschutzbund	OeAD – Österreichische Austauschdienst GmbH
Austrian Academy of Sciences	
Austrian Higher Education Conference	Austrian University Conference
WIFO – Austrian Institute of Economic Research	RCE Vienna – Regional Centre of Expertise in Education for Sustainable Development
Red Cross	Environment Agency Austria
Rudolfinerhaus Privatklinik GmbH	
Umweltdachverband (Environmental Umbrella Organisation)	University of Natural Resources and Life Sciences, Vienna
University of Veterinary Medicine Vienna	FWF – Austrian Science Fund
Wissenschaftsladen Wien (Science Shop Vienna)	ZSI – Centre for Social Innovation
ZOOM Children's Museum Vienna	
See http://www.responsiblescience.at for further members of the Alliance	

8.4 Overview of open innovation measures and associated current examples of their implementation

		Measure 1	Measure 2	Measure 3	Measure 4	Measure 5	Measure 6
		Create 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	Development of a culture of open innovation and teaching open innovation skills among all age groupes in all age groups	Federal Chancellery (BKA) - GovLab Austria	Federal Ministry of Education (BMB) initiatives (e.g. joint research - Open Labs) Federal Ministry for Transport, Innovation and Technology (BMVIT) - Massive Open Online Courses "Smart Cities"	Federal Chancellery (BKA) - GovLab Austria			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	AustriaTech - Urban mobility laboratories AIT - open innovation and experimentation environments	Federal Ministry of Education (BMB) initiatives (e.g. project instruction with external partners)	PPPI - Matchmaking platform & crowdsourcing challenges Federal Chancellery (BKA) - GovLab Austria	Federal Chancellery (BKA) - GovLab Austria Federal Ministry for Transport, Innovation and Technology (BMVIT) & KLIEN - Future of energy 2050 dialogue process	Austrian Patent Office – Open Data Initiative Austrian Research Promotion Agency (FFG) – info network Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) - EIP AGRI	
Action area 3	Mobilisation of resources and the creation of framework conditions for open innovation	Federal Chancellery (BKA) – GovLab Austria Austrian Federal Railways (ÖBB) – Open Innovation Lab & Service Design Center Austrian Research Promotion Agency (FFG) – innovation laboratories and innovation workshops	Federal Ministry of Education (BMB) initiatives (e.g. development of open educational resources)	PPPI - Community management		FEDERAL MINISTRY FOR 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 crowd-work	Further develop and provide of open innovation methods and open innovation instruments spe-cifically for small and medium-sized enterprises (SMEs)	Develop and implement co-cre-ation and open innovation training programmes	Emged principles of open data and open access in research	Gear the IP and exploitation strate-gies of companies,, universities, research institutes 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
	University of Applied Sciences Wiener Neustadt – Geo-Wiki St. Pölten University of Applied Scienc-es – Brelomate 2, Use-able Privacy Box		Salzburg - Com-petence Centre for Open Innovation (KOI) Austria Wirtschafts-service (aws) - Open innovation toolkit for SMEs	Austrian Patent Office - Training and events	Austrian Patent Office - Open Data Initiative Austrian Science Fund (FWF) - Open Access Policy 2020	Austrian Patent Office - Raising awareness of exploitation strat-egies	FH Joanneum - "Ich bin Open Innova-tion" (I am open innovation) platform Federal Ministry of Science, Research and Economy (BMWFW) & Federal Ministry for Trans-port, Innovation and Technology (BMVIT) - Information & communication work via the official Open Innovation website (www.openinnova-tion.gv.at)
	AIT - Co-Creation research projects	Austria Wirtschafts-service (aws) (ncp-ip) working group on compensation mechanisms	Austrian Research Promotion Agency (FFG) - Open Innovation priority area at the 9th COIN networks proposal		FEDERAL MINISTRY FOR TRANSPORT, INNOVATION AND TECHNOLOGY (BMVIT) - "e-ge-nius" open content platform		FEDERAL MINISTRY FOR TRANSPORT, INNOVATION AND TECHNOLOGY (BM-VIT) - Information & communication work within the scope of the Open4Innovation platform
Austrian Research Promotion Agency (FFG) - Bridge Programme CDG - Partnership in Research	OeAD - Top Citizen Science Austrian Research Promotion Agency (FFG) - Innovation pilot programme		Salzburg - Com-petence Centre for Open Innovation (KOI) Austrian Patent Of-fice - SME research service offering	FEDERAL MINISTRY FOR TRANSPORT, INNOVATION AND TECHNOLOGY (BMVIT) - Open4In-novation platform	Austrian Patent Office - Patent Scan Austrian Science Fund (FWF) - Open Access Policy 2020 Universities, Federal Ministry of Science, Research and Economy (BMWFW) university structural funds - Austria Transition to Open Access (AT2OA) Universities, Federal Ministry of Science, Research and Economy (BMWFW) university structural funds - E-Infra-structures Austria Plus		

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 ministries in 2016. 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 former Federal Ministry for Science and Research. The mandatory reporting of the ministries to the respective Science Ministry is recorded in the Research Organisation Act (FOG), Federal Law Gazette No. 341/1981, last amended by the Federal Law Gazette I No. 74/2002. The last far-reaching adaptation took place in 2008 with the migration to a database to which all ministries have access and where all research-related funding and contracts can be entered independently. The federal research database can be accessed publicly since June 2016 and it provides the latest overview of the projects funded by the federal ministries.[1] The B_f.dat database it not used for recording payments. Instead, it is a documentation database which also records contextual information on the R&D projects. With regard to the relevant reporting year, the database makes a distinction between ongoing, newly granted 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 the project financing.

The data in the B-f.dat reveals that the total funding for the 633 currently ongoing or completed R&D projects in the reporting year amounts to around €604.32 million in 2016, where €421.15 million (70%) of this are already paid out in this year. Approximately 85% of the funds for 2016 are paid out as global funding to research institutes[2] and research promotion agencies. Funding amounting to €63.58 million remains once this global funding for institutions is excluded from the partial amounts paid. While the amount of this funding has fallen by €7.27 million as compared with 2015, the number of projects has remained constant (476 projects). 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 lead to annual fluctuations depending on the relevant progress of the project.

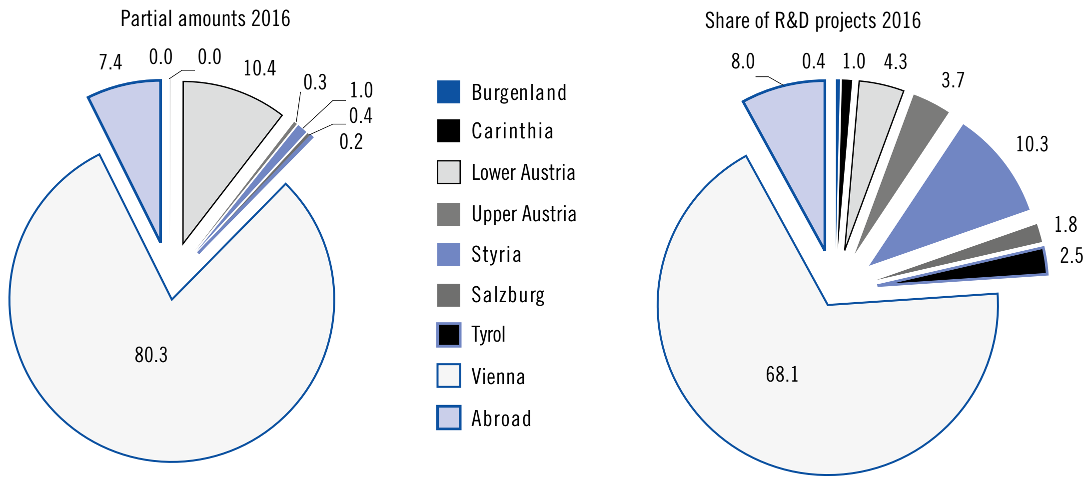
When a distinction is made according to the main location of the applicants, then Vienna (as in 2015) is the federal Austrian state with the largest share in both R&D funds paid out (80.3%) as well as ongoing and completed projects (68.1%). Around 7% of amounts go abroad, predominantly in the form of member contributions. In contrast to the previous reporting year there are two projects attributed to the state of Burgenland in 2016 with a total of €19,650 paid out in R&D funds, while no project has been documented for Vorarlberg.[3]

1 Link to the database: www.bmwfw.gv.at/bfdat-public

2 The data takes into account funding for institutions at amounts of more than €500,000 in each case.

3 One project was attributed to Vorarlberg in 2015.

Fig. 9-1: Share of R&D projects and partial amounts in 2016 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 2016 (0.005% of the partial amounts).

Source: Federal Ministry of Science, Research and Economy (BMWFW), Federal research database B_f.dat. Reference date 27 March 2017.

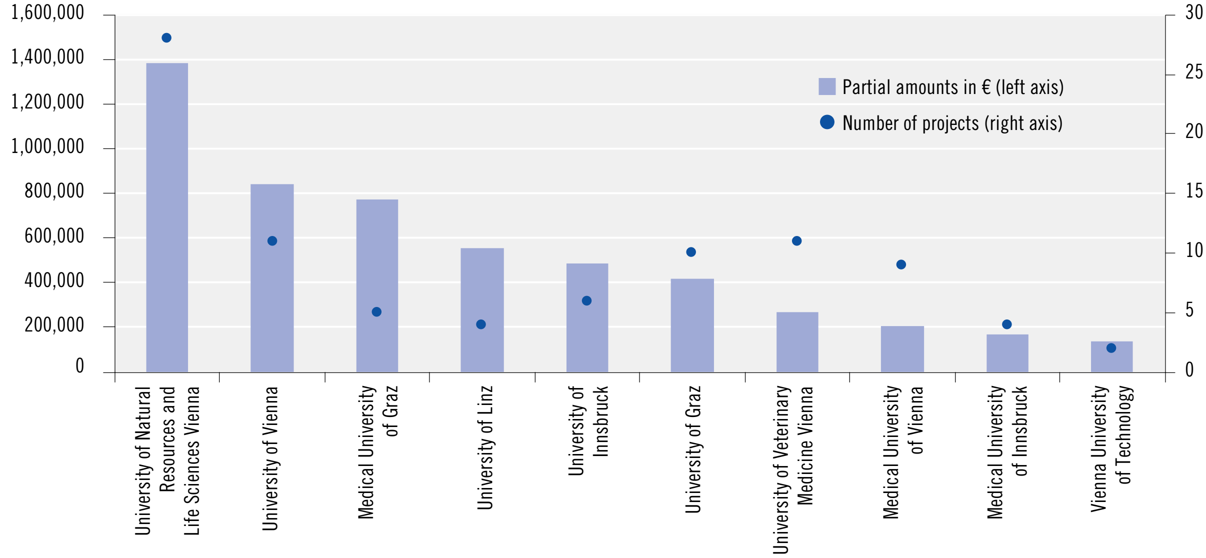
With 108 projects, the number of ongoing and completed projects with university applicants fell slightly in 2016 compared to 2015 (2015: 115), while the funds paid out increased significantly to €5.46 million (2015: €4.33 million). The number of projects at universities corresponds with 21.2% of the total ongoing and completed projects and 1.3% of the paid funds in 2016. The University of Natural Resources and Life Sciences features the highest total amounts both in terms of number of projects as well as partial amounts; this is different from 2015 when the Medical University of Graz had the highest totals for the partial amounts. 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.

Although there were differences among the universities between 2015 and 2016, the shares broken down by fields of science remained relatively consistent. As in the previous year the natural sciences feature the greatest share of funds paid out (19.7%; 2015: 20.2%), while the social sciences predominate in terms of the number of ongoing and completed R&D projects (33.8%; 2015: 36.1%).

In the reporting year 2016 a total of 242 R&D-related projects[4] with a funding volume of €421.65 millions were newly approved. Consequently more projects (2015: 216) were approved with a higher overall total (2015: €413.5 million) than it was the case in 2015. Although it is difficult to make a direct comparison of the shares of the federal ministries over the various reporting years since the composition of the ministries has changed, it can still be seen that the Federal Ministry of Science, Research and Economy (BMWFW) features the largest share of approved projects and funding amounts both for 2015 and for 2016. Nearly half (49,6%) of the applications for newly approved projects (not including global financing) were submitted by the Federal Ministry of Science, Research and Economy (BMWFW) in 2016, followed by the Federal Ministry of Finance (BMF) at 13.9 % and the Federal Ministry of Labour, Social Affairs and Consumer Protection (BMASK) at 10.1%. The greatest portion of the

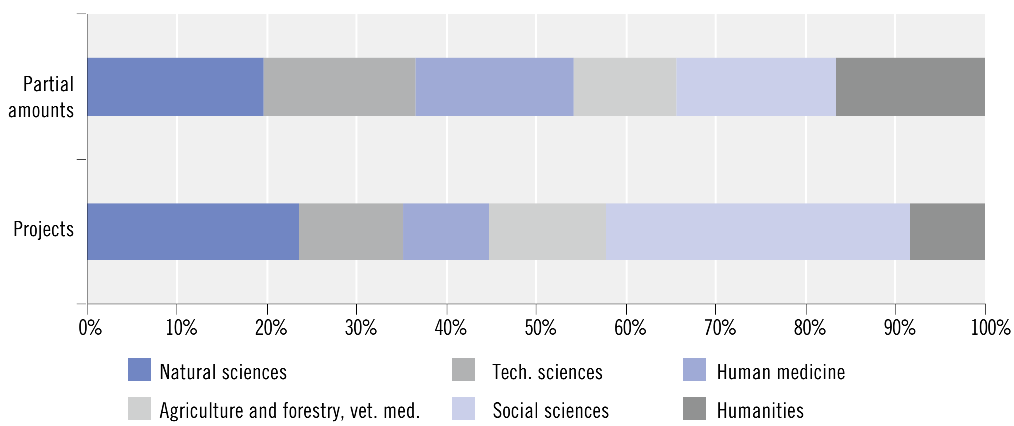
4 Some projects may be counted twice as a result of combined projects between ministries.

Fig. 9-2: Partial amounts and projects by selected universities, 2016



Source: Federal Ministry of Science, Research and Economy (BMWFW), Federal research database B_f.dat. Reference date 27 March 2017.

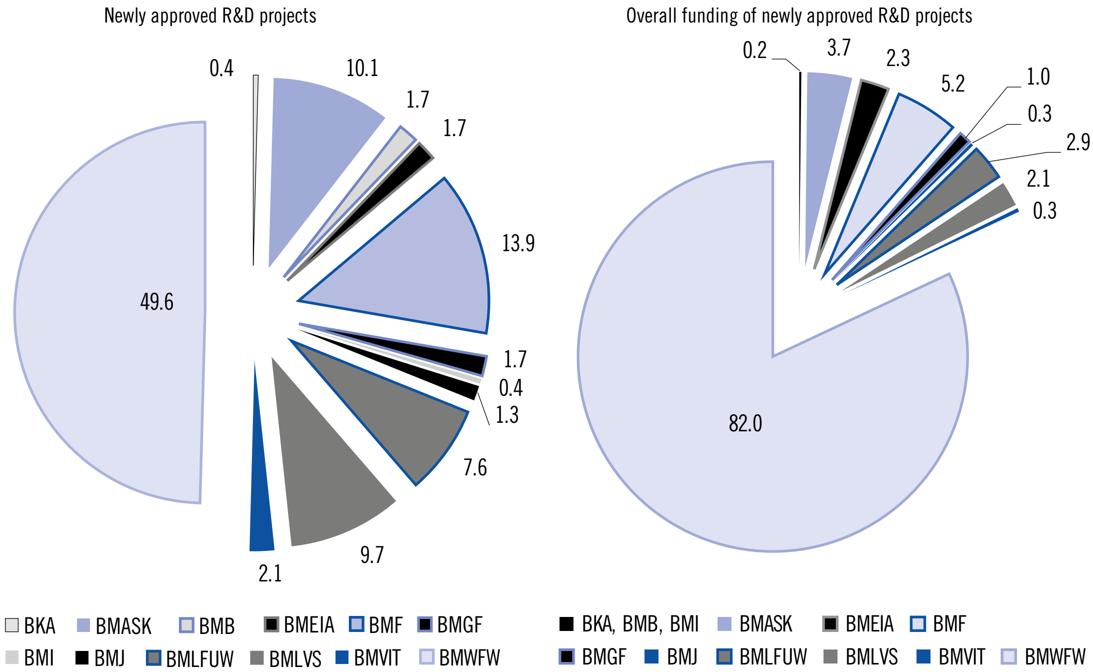
Fig. 9-3: Partial amounts and projects by fields of science (in %), 2016



Note: including “major” global financing for research institutions and the Austrian Science Fund (FWF).

Source: Federal Ministry of Science, Research and Economy (BMWFW), Federal research database B_f.dat. Reference date 27 March 2017.

Fig. 9-4: New approvals by number and total financing amounts by ministry (in %), 2016



Note: excl. "major" global financing with funding amounts higher than €500,000.

Source: Federal Ministry of Science, Research and Economy (BMWFW), Federal research database B_f.dat. Reference date 27 March 2017.

total financing volume of these projects (82.0%) was also attributed to the Federal Ministry of Science, Research and Economy (BMWFW) as client. The reason that the Federal Ministry for Transport, Innovation and Technology (BMVIT) had a small percentage is because most of the R&D funds were handled by 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 can be found on the on the Federal Ministry of Science, Research and Economy's website.[5]

5 Link to the publications: http://bmwfw.gv.at/jb-bfdat

10 Statistics

1. Financing of gross domestic expenditure on R&D (Tables 1 and 2)[1]

The estimate by Statistics Austria concludes that the gross domestic expenditure in Austria on research and experimental development (R&D) in 2017 will be about €11.33 billion, or 3.14% of the gross domestic product. This will put the research intensity clearly above the European target for 2020 which is 3%, although it will still be below the national target that Austria was striving for of 3.76%. The research intensity (R&D expenditures as a percentage of GDP) has already been over 3% since 2014; now a slight rise is expected from 2016 to 2017, from 3.12% to 3.14%. Domestic research expenditure will increase in total in 2017 by 3.8%, surpassing the forecasted increase of the nominal gross domestic product of 3.3%.

Although the domestic business enterprise sector remains the most important source of funds in 2017 with 48.2% and around €5.46 billion, 36% of total R&D expenditures are funded by the public sector – around €4.08 billion. While the increase in public funding was 2.2% in the previous year, this value is expected to increase to 5.2% between 2016 and 2017. This is essentially due to the increase of the research tax premium: the promotion of R&D expenditures by firms that are recognised for tax purposes increased from 10% to 12% for R&D carried out starting in 2016. It is expected that in 2017 around €100 million more will be reimbursed to Austrian firms than in the previous year. Overall, the federal government will therefore contribute around €3.44 billion to domestic research in 2017. The regional governments are expected to fund R&D of around €515 million. Other public institutions (municipal authorities, chambers of commerce, social insurance institutions) account for about €122 million.

A total of 15.4% of the R&D funding (around €1.74 billion) comes from abroad, with foreign firms representing the most significant sources of funding. The foreign funding also includes returns from the EU Research Programmes. The private non-profit sector features the lowest funding volume with around €51 million (0.4% of total R&D expenditure).

Austria's research intensity, the indicator that represents gross domestic expenditure for R&D as a percentage of nominal gross domestic product (GDP), has grown substantially over the last twenty years: in 1997 it was still only 1.66% and in 2007 it came to 2.43%. This year the research intensity is expected to reach its highest value to date of 3.14%.

With a research intensity of 3.12% in 2015 (the last year for which international comparative figures are available), Austria was second be-

1 Each year, Statistics Austria creates a "Total estimate of the gross domestic expenditures 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, but Austrian payments for R&D performed abroad are not (domestic concept).

hind Sweden (3.26%). They were followed by Denmark with 3.03%, Finland (2.90%) and Germany (2.87%). The average research intensity among the EU 28 in 2015 was 2.03%. The only other countries to feature a national research intensity that is above the EU average are Belgium, France and Slovenia. The research intensity was well below the EU average in two large EU nations, the United Kingdom (1.70%) and Italy (1.33%). The OECD countries of the Republic of Korea (4.29%) and Japan (3.59%) featured research intensity above 3.5% in 2014, while the US intensity amounted to 2.73% (2013). China achieved intensity of 2.05% in 2014.

The estimates and year-end closing data of the federal and the regional governments, current economic forecasts and the preliminary results of the last R&D survey for the reporting year 2015 in the business enterprise sector were all taken into account in estimating the Austrian gross domestic expenditure on R&D in 2017. Research intensity depends not only on the amount of expenditure in Austria on R&D, but also to a high degree on the actual and forecasted trend of gross domestic product.

2 Federal R&D expenditure in 2017

2.1. The federal expenditure shown in Table 1 for R&D carried out in Austria in 2017 is composed as described below. According to the methodology used for the R&D global estimate, the core is the total amount of Part b of the "Detailed overview of research-related appropriation of federal government funds" in the R&D Annex to the Federal Finances Act (BFG) 2017. The estimate also includes the funds that should be paid out in 2017, according to the information currently available, as well as the R&D funds from the financial stability contribution for banks and the "Austria Fund" (Source for both: Federal Ministry of Finance (BMF)).

2.2. In addition to its expenditures for R&D in Austria, in 2017 the federal government will pay **contributions to international organisations** aimed at research and the promotion of research amounting to €101 million. They are shown in the "Detailed overview of research-related appropriation of federal funds" in the Federal Finances Act (BFG) 2017 (Part a), but according to the domestic concept they are not included in the Austrian gross domestic expenditure on R&D.

2.3. The research-related expenditure by the federal government that is summarised in the "Detailed overview of research-related appropriation of federal funds" in the R&D Annex to the Federal Finances Act (BFG) 2017 (Part a and Part b), which includes the research-related shares of contribution to international organisations (see Pt. 2.2 above), are included under the title **"Federal expenditure on research and research promotion."** These correspond to what is called the "GBARD" concept[2] that is used by the OECD and the EU on the basis of the Frascati Manual, referring primarily to the budgets of the central or federal government. It includes (in contrast to the domestic concept) research-related contributions to international organisations and provides the basis for classification of R&D budget data by socio-economic objectives as required for reporting to the EU and OECD.

In 2017 the following socio-economic objectives will receive the largest portions of federal expenditure on research and research promotion:

- Promotion of general knowledge advancement: 31.4%
- Promotion of trade, commerce, and industry: 24.8%
- Promotion of the health care system: 21.4%
- Promotion of social and socio-economic development: 4.6%
- Promotion of research covering the earth, the seas, the atmosphere and space: 4.4%
- Promotion of energy production, storage and distribution 3.8%

2 GBARD: Government Budget Allocations for Research and Development.

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. An international comparison of 2014 R&D expenditure

The overview in Table 12 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 2016-2).

5 Austria's participation in the European Framework Programmes

Tables 13 through 16 provide an overview of Austria's participation in the European Framework Programmes for research and development.

6. Research funding by the Austrian Science Fund (FWF)

Tables 17 and 18 provide detailed information about the funding of projects in Austrian Science Fund (FWF) projects.

7. Funding by the Austrian Research Promotion Agency (FFG)

Tables 19 and 21 provide detailed information on funding approvals by the Austrian Research Promotion Agency (FFG).

8. The Austria Wirtschaftsservice (aws) technology programmes

Tables 22 through 24 show an overview of disbursed funding under the auspices of the Austria Wirtschaftsservice (aws) technology programmes.

9. Christian Doppler Gesellschaft

Tables 25 to 28 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: Global estimate for 2017: Gross domestic expenditure on R&D financing of research and experimental development carried out in Austria in 2002–2017

Financing	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1. Gross domestic expenditure on R&D (in € millions)	**4,684.31**	**5,041.98**	**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**	**10,222.38**	**10,612.60**	**10,906.09**	**11,325.42**
of which financed by:																
Federal government[1]	1,362.37	1,394.86	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	3,226.89	3,261.33	3,439.62
Regional governments[2]	171.26	291.62	207.88	330.17	219.98	263.18	354.35	273.37	405.17	298.71	416.31	307.45	461.59	447.24	493.17	514.54
Business enterprise sector[3]	2,090.62	2,274.95	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	5,136.80	5,295.01	5,458.10
Abroad[4]	1,001.97	1,009.26	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	1,614.07	1,637.92	1,688.37	1,740.37
Other[5]	58.09	71.29	87.49	96.32	106.20	113.04	115.83	132.97	137.86	140.77	147.99	155.19	159.41	163.75	168.21	172.79
2. Nominal GDP[6] (in € billions)	226.30	231.00	241.51	253.01	266.48	282.35	291.93	286.19	294.63	308.63	317.12	322.54	330.42	339.90	349.49	361.18
3. Gross domestic expenditure on R&D as a % of GDP	***2.07***	***2.18***	***2.17***	***2.38***	***2.37***	***2.43***	***2.59***	***2.61***	***2.74***	***2.68***	***2.93***	***2.97***	***3.09***	***3.12***	***3.12***	***3.14***

As at: 20 April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) 2002, 2004, 2006, 2007, 2009, 2011, 2013: Survey results (federal government including the Austrian Science Fund, the two research promotion funds (FFF/FFG) and in 2002 also including ITF).
2003, 2005, 2008, 2010 and 2012: Annex T of the Federal Finances Acts (in each case Part b, Outlays); 2014, 2015: Federal Finances Act 2016 and 2017, Detailed overview of research-related appropriation of federal funds (Part b, Outlays).
2016, 2017: Federal Finances Act 2017, Detailed overview of research-related appropriation of federal funds (in each case Part b, Financing proposal).
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.
2015: including €85.0 million National Foundation for Research, Technology and Development and €501.9 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 €58.7 million National Foundation for Research, Technology and Development and an expected €627.7 million research tax premiums (Source: Federal Ministry of Finance (BMF), based on the currently available information).

2) 2002, 2004, 2006, 2007, 2009, 2011, 2013: survey results. 2003, 2005, 2008, 2010, 2012, 2014-2017: Based on the R&D expenditure reported by the state government offices.

3) 2002, 2004, 2006, 2007, 2009, 2011, 2013: survey results. 2003, 2005, 2008, 2010, 2012, 2014-2017: Estimates made by Statistics Austria.

4) 2002, 2004, 2006, 2007, 2009, 2011, 2013: survey results. 2003, 2005, 2008, 2010, 2012, 2014-2017: 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.
2002, 2004, 2006, 2007, 2009, 2011, 2013: survey results. 2003, 2005, 2008, 2010, 2012, 2014-2017: Estimates made by Statistics Austria.

6) 2002-2016: Statistics Austria, as of March 2017. 2017: Austrian Institute of Economic Research (WIFO), economic forecast March 2017.

Table 2: Global estimate for 2017: Gross domestic expenditure on R&D financing of research and experimental development carried out in Austria in 2002–2017 (as a percentage of GDP)

Financing	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1. Gross domestic expenditure on R&D (in % of GDP)	***2.07***	***2.18***	***2.17***	***2.38***	***2.37***	***2.43***	***2.59***	***2.61***	***2.74***	***2.68***	***2.93***	***2.97***	***3.09***	***3.12***	***3.12***	***3.14***
of which financed by:																
Federal government[1]	0.60	0.60	0.61	0.70	0.66	0.68	0.81	0.80	0.88	0.85	0.94	0.88	0.93	0.95	0.93	0.95
Regional governments[2]	0.08	0.13	0.09	0.13	0.08	0.09	0.12	0.10	0.14	0.10	0.13	0.10	0.14	0.13	0.14	0.14
Business enterprise sector[3]	0.92	0.98	1.03	1.09	1.15	1.18	1.19	1.23	1.24	1.24	1.34	1.45	1.48	1.51	1.52	1.51
Abroad[4]	0.44	0.44	0.42	0.43	0.44	0.44	0.42	0.44	0.44	0.45	0.47	0.49	0.49	0.48	0.48	0.48
Other[5]	0.03	0.03	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
2. Nominal GDP[6] (in € billions)	**226.30**	**231.00**	**241.51**	**253.01**	**266.48**	**282.35**	**291.93**	**286.19**	**294.63**	**308.63**	**317.12**	**322.54**	**330.42**	**339.90**	**349.49**	**361.18**

As at: 20 April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

Footnotes: see Table 1.

Table 3: Federal expenditure on research and research promotion, 2014–2017
Breakdown of the detailed overviews of research-related appropriation of federal funds (Parts a and b)

Ministries [1]	Outlays				Financing budgeted			
	2014[2]		2015[3]		2016[3]		2017[3]	
	in € millions	in %	in € millions	in %	in € millions	in %	in € millions	in %
Federal Chancellery (BKA)[4]	34.805	*1.3*	35.686	*1.3*	39.095	*1.4*	40.981	*1.4*
Federal Ministry of the Interior (BMI)	1.040	*0.0*	1.135	*0.0*	1.219	*0.0*	1.309	*0.0*
Federal Ministry for Education and Women's Affairs (BMBF)	46.194	*1.7*	38.098	*1.4*	.	.	.	.
Federal Ministry of Education (BMB)	.	.	.	.	40.059	*1.4*	36.224	*1.3*
Federal Ministry of Science, Research and Economy (BMWFW)	2,044.037	*77.3*	2,107.858	*76.9*	2,163.212	*77.9*	2,208.008	*77.5*
Federal Ministry of Labour, Social Affairs and Consumer Protection (BMASK)	7.034	*0.3*	6.484	*0.2*	5.707	*0.2*	6.511	*0.2*
Federal Ministry for Health (BMG)	7.342	*0.3*	5.669	*0.2*	.	.	.	.
Federal Ministry of Health and Women's Affairs	.	.	.	.	7.043	*0.3*	6.982	*0.2*
Federal Ministry for Europe, Integration and Foreign Affairs (BMEIA)	2.161	*0.1*	1.718	*0.1*	2.151	*0.1*	2.198	*0.1*
Federal Ministry of Justice (BMJ)	-	-	0.017	*0.0*	-	-	0.040	*0.0*
Federal Ministry of Defence and Sports (BMLVS)	2.325	*0.1*	1.972	*0.1*	3.311	*0.1*	3.800	*0.1*
Federal Ministry of Finance (BMF)	29.629	*1.1*	30.490	*1.1*	31.931	*1.1*	31.843	*1.1*
Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW)	46.105	*1.7*	44.637	*1.6*	43.372	*1.6*	43.942	*1.5*
Federal Ministry for Family and Youth (BMFJ)	1.118	*0.0*	0.886	*0.0*	1.427	*0.1*	1.620	*0.1*
Federal Ministry for Transport, Innovation and Technology (BMVIT)	425.699	*16.1*	470.194	*17.1*	440.030	*15.8*	470.862	*16.5*
Total	**2,647.489**	***100.0***	**2,744.844**	***100.0***	**2,778.557**	***100.0***	**2,854.320**	***100.0***

As at: April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) In accordance with the applicable version of the Act Governing Federal Ministries of 1986 (2014, 2015: Federal Law Gazette I No. 11/2014; 2016, 2017: Federal Law Gazette I No. 49/2016).

2) Federal Finances Act 2016, Detailed overview of research-related appropriation of federal funds.

3) Federal Finances Act 2017, Detailed overview of research-related appropriation of federal funds.

4) Including the highest executive bodies.

Table 4: Detailed overview of research-related appropriation of federal funds, 2015–2017

Table 4

Federal spending on research from 2015 to 2017 by ministry

The following tables for the years 2015 to 2017 are broken down according to

1. Contributions from federal funds to international organisations whose goals include research and the promotion of research (**Part a**)

2. 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 Statistik Austria as a benchmark in carrying out surveys of research and experimental development (R&D).

BUNDESVORANSCHLAG 2017

Detailübersicht Forschungswirksame Mittelverwendungen des Bundes

(Beträge in Millionen Euro)

Seite 1

a) Beitragszahlungen an internationale Organisationen - Finanzierungsvoranschlag

VA-Stelle	Konto	Ugl	Bezeichnung	Anm	Finanzierungsvoranschlag 2017			Finanzierungsvoranschlag 2016			Erfolg 2015		
					Insgesamt	hievon		Insgesamt	hievon		Insgesamt	hievon	
						%	Forschung		%	Forschung		%	Forschung
			Bundeskanzleramt										
			UG10										
10010100	7800	100	Mitgliedsbeiträge an Institutionen im Ausland		0,194	100	0,194	0,192	100	0,192	0,181	100	0,181
10010100	7800	101	Mitgliedsbeitrag für OECD		3,675	20	0,735	3,368	20	0,674	3,605	20	0,721
10010100	7800	102	OECD-Energieagentur (Mitgliedsbeitrag)		0,220	20	0,044	0,230	20	0,046	0,219	20	0,044
10010100	7800	103	OECD-Beiträge zu Sonderprojekten		0,010	20	0,002	0,010	20	0,002		20	
10010100	7800	110	Mitgliedsbeitrag AV-Infostelle		0,030	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		**4,135**		**0,979**	**3,836**		**0,918**	**4,041**		**0,950**
			Summe Bundeskanzleramt		**4,135**		**0,979**	**3,836**		**0,918**	**4,041**		**0,950**
			BM für Europa, Integration und Äußeres										
			UG12										
12020200	7840	000	Internationale Atomenergie-Organisation (IAEO)		3,190	35	1,117	3,190	35	1,117	3,306	17	0,562
12020200	7840	002	Organisation der VN für industr.Entwicklung(UNIDO)		0,695	46	0,320	0,695	46	0,320	0,936	46	0,431
12020200	7840	003	Org. VN Erziehung,Wissensch.u.Kultur(UNESCO)		2,270	30	0,681	2,112	30	0,634	2,258	25	0,565
12020200	7840	056	Drogenkontrollprogramm der VN (UNDCP)		0,400	20	0,080	0,400	20	0,080	0,800	20	0,160
			Summe UG12		**6,555**		**2,198**	**6,397**		**2,151**	**7,300**		**1,718**
			Summe BM für Europa, Integration und Äußeres		**6,555**		**2,198**	**6,397**		**2,151**	**7,300**		**1,718**
			BM für Bildung										
			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		0,090	100	0,090	0,004	100	0,004	0,115	100	0,115
			Summe UG30		**0,121**		**0,121**	**0,035**		**0,035**	**0,138**		**0,138**
			Summe BM für Bildung		**0,121**		**0,121**	**0,035**		**0,035**	**0,138**		**0,138**
			BM für Wissenschaft, Forschung und Wirtschaft										
			UG31										
31030100	7800	000	Laufende Transferzahlungen an das Ausland		0,500	100	0,500	0,500	100	0,500	0,401	100	0,401
31030100	7800	066	Forschungsvorhaben in internationaler Kooperation		1,152	100	1,152	1,402	100	1,402	0,440	100	0,440
31030100	7800	200	Beiträge an internationale Organisationen		1,730	50	0,865	1,480	50	0,740	1,127	50	0,564
31030204	7800	062	ESO		6,350	100	6,350	6,300	100	6,300	6,075	100	6,075
31030204	7800	063	Europ. Zentrum für mittelfristige Wettervorhersage		1,260	100	1,260	1,110	100	1,110	1,292	100	1,292
31030204	7800	064	Molekularbiologie - Europäische Zusammenarbeit		3,077	100	3,077	2,900	100	2,900	2,811	100	2,811
31030204	7800	065	World Meteorological Organisation		0,520	50	0,260	0,640	50	0,320	0,491	50	0,246
31030204	7800	200	Beiträge an internationale Organisationen		0,825	50	0,413	0,810	50	0,405	0,794	50	0,397
31030204	7800	242	Beitrag für die CERN		23,700	100	23,700	19,600	100	19,600	23,619	100	23,619
			Summe UG31		**39,114**		**37,577**	**34,742**		**33,277**	**37,050**		**35,845**
			UG40										

Seite 2

40020100	7800	100	Mitgliedsbeiträge an Institutionen im Ausland		1,000	11	0,110	1,000	11	0,110	1,155	11	0,127
			Summe UG40		**1,000**		**0,110**	**1,000**		**0,110**	**1,155**		**0,127**
			Summe BM für Wissenschaft, Forschung und Wirtschaft		**40,114**		**37,687**	**35,742**		**33,387**	**38,205**		**35,972**
			BM für Verkehr, Innovation und Technologie										
			UG34										
34010100	7800	200	Beiträge an internationale Organisationen		0,060	100	0,060	0,060	100	0,060	0,031	100	0,031
34010100	7800	600	ESA-Pflichtprogramme		17,900	100	17,900	17,900	100	17,900	17,964	100	17,964
34010100	7800	601	EUMETSAT		9,600	100	9,600	9,600	100	9,600	5,824	100	5,824
34010100	7800	602	OECD-Energieagentur		0,070	100	0,070	0,070	100	0,070			
34010100	7800	603	ESA-Wahlprogramme		30,364	100	30,364	30,364	100	30,364	37,628	100	37,628
34010100	7830	000	Laufende Transfers an Drittländer		0,130	100	0,130	0,130	100	0,130	0,261	85	0,222
			Summe UG34		**58,124**		**58,124**	**58,124**		**58,124**	**61,708**		**61,669**
			UG41										
41010100	7800	200	Beiträge an internationale Organisationen		0,180	6	0,011	0,180	6	0,011	0,115	9	0,010
41020100	7800	200	Beiträge an internationale Organisationen		0,021	100	0,021	0,021	100	0,021	0,018	100	0,018
41020402	7800	200	Beiträge an internationale Organisationen		0,050	15	0,008	0,060	15	0,009	0,046	15	0,007
41020500	7800	200	Beiträge an internationale Organisationen		0,020	15	0,003	0,020	15	0,003	0,034	15	0,005
41020500	7830	000	Laufende Transfers an Drittländer		0,482	15	0,072	0,442	15	0,066	0,453	15	0,068
41020601	7800	200	Beiträge an internationale Organisationen		0,050	50	0,025	0,050	50	0,025	0,037	12	0,004
41020700	7800	200	Beiträge an internationale Organisationen		0,570	20	0,114	0,570	20	0,114	0,566	20	0,113
			Summe UG41		**1,373**		**0,254**	**1,343**		**0,249**	**1,269**		**0,225**
			Summe BM für Verkehr, Innovation und Technologie		**59,497**		**58,378**	**59,467**		**58,373**	**62,977**		**61,894**
			BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft										
			UG42										
42010100	7800	100	Mitgliedsbeiträge an Institutionen im Ausland		0,020	50	0,010	0,017	50	0,009		50	
42020202	7800	080	FAO-Beiträge		3,400	50	1,700	3,400	50	1,700	3,356	50	1,678
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**	**3,442**		**1,734**	**8,381**		**4,203**
			Summe BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft		**3,445**		**1,735**	**3,442**		**1,734**	**8,381**		**4,203**
			Teil a -Summe		**113,867**		**101,098**	**108,919**		**96,598**	**121,042**		**104,875**

Seite 3

b) Bundesbudget Forschung - Finanzierungsvoranschlag (ausgen. die bereits im Abschnitt a) ausgewiesen sind)

VA-Stelle	Konto	Ugl	Bezeichnung	Anm	Finanzierungsvoranschlag 2017			Finanzierungsvoranschlag 2016			Erfolg 2015		
					Insgesamt	hievon %	hievon Forschung	Insgesamt	hievon %	hievon Forschung	Insgesamt	hievon %	hievon Forschung
			Parlamentsdirektion										
			UG02										
02010500	7330	086	Nationalfonds für Opfer des Nationalsozialismus	*	3,723	5	0,186	3,500	5	0,175	4,450	3	0,139
			Summe UG02		**3,723**		**0,186**	**3,500**		**0,175**	**4,450**		**0,139**
			Summe Parlamentsdirektion		**3,723**		**0,186**	**3,500**		**0,175**	**4,450**		**0,139**
			Bundeskanzleramt										
			UG10										
10010100	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,522	50	0,261	0,508	50	0,254	0,486	50	0,243
10010100	7270	000	Werkleistungen durch Dritte		2,711	4	0,108	3,345	4	0,134	2,876	4	0,115
10010200			Zentralstelle	*	2,114	100	2,114	2,111	100	2,111	2,109	100	2,109
10010200	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,001	50	0,001	0,001	50	0,001	0,016	50	0,008
10010200	7270	000	Werkleistungen durch Dritte		7,380	4	0,295	3,515	4	0,141	3,457	4	0,138
10010401	7340	001	Pauschalabgeltung gem. § 32 Abs.5 BStatG		50,891	1	0,509	50,808	1	0,508	50,466	1	0,505
10010402			Österr. Staatsarchiv		14,897	1	0,149	14,524	1	0,145	14,070	1	0,141
			Summe UG10		**78,516**		**3,437**	**74,812**		**3,294**	**73,480**		**3,259**
			UG32										
32010300			Denkmalschutz		38,343	18	6,902	35,743	18	6,434			
32020300			Denkmalschutz								31,454	18	5,662
32030100			Bundesmuseen		128,162	23	29,477	122,932	23	28,274	111,633	23	25,676
			Summe UG32		**166,505**		**36,379**	**158,675**		**34,708**	**143,087**		**31,338**
			Summe Bundeskanzleramt		**245,021**		**39,816**	**233,487**		**38,002**	**216,567**		**34,597**
			BM für Inneres										
			UG11										
11010200	7270	900	Werkleistungen durch Dritte	*	0,012	100	0,012				0,025	100	0,025
11020600			Bundeskriminalamt	*	15,836	8	1,267	15,234	8	1,219	12,419	8	0,994
11020800	7270	900	Werkleistungen durch Dritte	*	0,030	100	0,030				0,025	100	0,025
11030500	7270	900	Werkleistungen durch Dritte	*							0,078	100	0,078
11040100	7270	900	Werkleistungen durch Dritte	*							0,005	100	0,005
11040100	7660	000	Zuschüsse f. lfd. Aufwand an private Institutionen	*							0,008	100	0,008
			Summe UG11		**15,878**		**1,309**	**15,234**		**1,219**	**12,560**		**1,135**
			Summe BM für Inneres		**15,878**		**1,309**	**15,234**		**1,219**	**12,560**		**1,135**
			BM für Justiz										
			UG13										
13010100	7271	900	Werkleistungen (durch Dritte)	*	0,045	50	0,023				0,033	50	0,017
13030101	7271	900	Werkleistungen (durch Dritte)	*	0,033	50	0,017						
			Summe UG13		**0,078**		**0,040**				**0,033**		**0,017**
			Summe BM für Justiz		**0,078**		**0,040**				**0,033**		**0,017**
			BM für Landesverteidigung und Sport										
			UG14										
14010100	4691	000	Versuche und Erprobungen auf kriegstechn. Gebiet					0,035	10	0,004	0,045	10	0,005
14010100	7270	000	Werkleistungen durch Dritte	*				0,868	58	0,503	0,171	58	0,099
14010100	7270	900	Werkleistungen durch Dritte	*				1,402	100	1,402	0,472	100	0,472
14010202			Heeresgeschichtliches Museum					6,550	20	1,310	6,689	20	1,338
14020100	4691	000	Versuche und Erprobungen auf kriegstechn. Gebiet					0,920	10	0,092	0,576	10	0,058
14040100			Heeresgeschichtliches Museum	*	2,926	20	0,585						
14050100	7270	000	Werkleistungen durch Dritte	*	0,700	58	0,406						
14050100	7270	900	Werkleistungen durch Dritte	*	2,800	100	2,800						
14050202	4691	000	Versuche und Erprobungen auf kriegstechn. Gebiet		0,090	10	0,009						
			Summe UG14		**6,516**		**3,800**	**9,775**		**3,311**	**7,953**		**1,972**

Seite 4

			Summe BM für Landesverteidigung und Sport		**6,516**		**3,800**	**9,775**		**3,311**	**7,953**		**1,972**
			BM für Finanzen										
			UG15										
15010100	6430	001	Arbeiten des WIIW		0,790	50	0,395	1,000	50	0,500	0,750	50	0,375
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		4,085	50	2,043	4,000	50	2,000	3,925	50	1,963
15010100	7270	000	Werkleistungen durch Dritte	*	1,415	100	1,415				1,296	100	1,296
15010100	7661	002	Institut für Finanzwissenschaft und Steuerrecht									50	
15010100	7662	002	Institut für höhere Studien und wiss. Forschung		3,574	50	1,787	3,336	50	1,668	3,309	50	1,655
15010100	7663	005	Forum Alpbach										
15010100	7669	020	Sonstige Förderungsbeiträge	*	0,093	100	0,093						
			Forschungswirksamer Lohnnebenkostenanteil		25,424	100	25,424	27,077	100	27,077	24,515	100	24,515
			Summe UG15		**36,752**		**31,843**	**36,784**		**31,931**	**35,166**		**30,490**
			Summe BM für Finanzen		**36,752**		**31,843**	**36,784**		**31,931**	**35,166**		**30,490**
			BM für Arbeit, Soziales und Konsumentenschutz										
			UG20										
20010101	7340	302	Überweisung an das AMS gem. § 41 (2) (zw)	*	469,612	1	3,992	411,612	1	3,510	405,000	1	3,818
20010201	7270	006	Werkleistungen durch Dritte (zw)	*	374,498		0,749	301,759		0,430	422,380		0,769
			Summe UG20		**844,110**		**4,741**	**713,371**		**3,940**	**827,380**		**4,587**
			UG21										
21010100	7270	000	Werkleistungen durch Dritte		3,282	3	0,098	1,950	5	0,098	2,038	5	0,102
21010300	7270	000	Werkleistungen durch Dritte		0,876	16	0,140	0,825	16	0,132	0,780	16	0,125
21010300	7660	900	Zuschüsse f. lfd. Aufwand an private Institutionen		3,596	2	0,072	2,250	2	0,045	4,364	2	0,087
21010400	7262	001	Beitrag Europ. Zentrum Wohlfahrtspol.u.Sozialfor.		0,587	50	0,294	0,587	50	0,294	0,838	50	0,419
21010400	7270	000	Werkleistungen durch Dritte		2,300	4	0,092	1,769	7	0,124	1,280	7	0,090
21010400	7270	304	Werkleistungen EU-SILC		1,074	100	1,074	1,074	100	1,074	1,074	100	1,074
			Summe UG21		**11,715**		**1,770**	**8,455**		**1,767**	**10,374**		**1,897**
			Summe BM für Arbeit, Soziales und Konsumentenschutz		**855,825**		**6,511**	**721,826**		**5,707**	**837,754**		**6,484**
			BM für Gesundheit und Frauen										
			UG24										
24010100			Zentralstelle	*	1,232	100	1,232	1,295	100	1,295	0,974	100	0,974
24010200	7420	012	Transferzahlungen, Ernährungsagentur (Ges.m.b.H)		49,878	11	5,487	49,878	11	5,487	52,503	8	4,200
24030100	7270	000	Werkleistungen durch Dritte		3,975	4	0,159	3,935	4	0,157	0,929	29	0,269
24030200	7270	000	Werkleistungen durch Dritte		5,204	2	0,104	5,196	2	0,104	4,520	5	0,226
			Summe UG24		**60,289**		**6,982**	**60,304**		**7,043**	**58,926**		**5,669**
			Summe BM für Gesundheit und Frauen		**60,289**		**6,982**	**60,304**		**7,043**	**58,926**		**5,669**
			BM für Familien und Jugend										
			UG25										
25010500	7270	006	Werkleistungen durch Dritte (zw)		1,073	48	0,515	0,650	48	0,312	0,601	5	0,030
25010500	7420	113	Familie und Beruf Management GesmbH.		2,140	33	0,706	2,140	33	0,706	2,140	33	0,706
25010500	7664	007	Forschungsförderung gem. § 39i FLAG 1967 (zw)		0,100	100	0,100	0,100	100	0,100	0,010	100	0,010
25020100	7270	000	Werkleistungen durch Dritte		1,100	11	0,121	1,100	11	0,121	1,074	3	0,032
25020200	7270	000	Werkleistungen durch Dritte		1,782	10	0,178	1,882	10	0,188	1,542	7	0,108
			Summe UG25		**6,195**		**1,620**	**5,872**		**1,427**	**5,367**		**0,886**
			Summe BM für Familien und Jugend		**6,195**		**1,620**	**5,872**		**1,427**	**5,367**		**0,886**
			BM für Bildung										
			UG30										
30010400			Qualitätsentwicklung und -steuerung	*	45,936	8	3,675	31,706	8	2,536	30,536	8	2,443
30010400	7340	000	Transferzahlungen an sonst. Träger		0,001	100	0,001	5,000	100	5,000	4,500	100	4,500

Seite 5

			öffentl.Rechtes										
30010400	7340	003	Basisabgeltung (BIFIE)		12,000	80	9,600	13,000	80	10,400	12,555	80	10,044
30010500			Lehrer/innenbildung		221,204	10	22,120	218,388	10	21,839	206,036	10	20,604
30020700			Zweckgebundene Gebarung Bundesschulen	*	23,558	3	0,707	8,296	3	0,249	12,313	3	0,369
			Summe UG30		**302,699**		**36,103**	**276,390**		**40,024**	**265,940**		**37,960**
			Summe BM für Bildung		**302,699**		**36,103**	**276,390**		**40,024**	**265,940**		**37,960**
			BM für Wissenschaft, Forschung und Wirtschaft										
			UG31										
31010100			Zentralstelle und Serviceeinrichtungen		56,969	20	11,394	56,785	20	11,357	52,070	20	10,414
31010100	7686	007	Vortragstätigkeit im Ausland										
31020100			Universitäten		3.239,461	48	1.554,941	3.219,643	48	1.545,429	3.025,824	48	1.452,396
31020100	7270	000	Werkleistungen durch Dritte		0,330	48	0,158	0,330	48	0,158	0,051	48	0,024
31020100	7342	900	Universitäten - F&E-Mittel			100			100			100	
31020100	7353	440	Klinischer Mehraufwand (Klinikbauten)		62,149	50	31,075	19,649	50	9,825	68,579	50	34,290
31020100	7480	403	VOEST-Alpine Medizintechnik Ges.m.b.H. (VAMED)			50			50			50	
31020200			Fachhochschulen		294,633	15	44,195	281,633	15	42,245	265,600	15	39,840
31020300	7270	900	Werkleistungen durch Dritte		2,468	22	0,543	2,582	22	0,568	4,760	22	1,047
31030100			Projekte und Programme	*	12,866	100	12,866	13,365	100	13,365	13,310	100	13,310
31030100	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,001	100	0,001	0,001	100	0,001		100	
31030100	7270	031	Med Austron	*		100			100			100	
31030100	7270	034	Ersatzmethoden zum Tierversuch		0,370	100	0,370	0,465	100	0,465	0,083	100	0,083
31030100	7270	900	Werkleistungen durch Dritte		7,665	100	7,665	7,597	100	7,597	6,048	100	6,048
31030100	7662	311	Institut für höhere Studien und wiss. Forschung		0,400	100	0,400	0,300	100	0,300	0,360	100	0,360
31030100	7665	007	Stiftung Dokumentationsarchiv		0,405	100	0,405	0,280	100	0,280	0,280	100	0,280
31030100	7679	120	Lfd. Transfers an sonstige juristische Personen		26,019	100	26,019	20,978	100	20,978	19,716	100	19,716
31030201			Zentralanstalt für Meteorologie und Geodynamik		25,670	37	9,498	24,021	37	8,888	25,552	37	9,454
31030202			Geologische Bundesanstalt		11,481	47	5,396	11,378	47	5,348	10,488	47	4,929
31030203			Wissenschaftliche Anstalten			52		5,035	52	2,618	5,295	52	2,753
31030204			Forschungsinstitutionen	*	8,158	100	8,158	7,038	100	7,038	6,048	100	6,048
31030204	7270	031	Med Austron		1,600	100	1,600	5,500	100	5,500		100	
31030204	7332	352	FWF Programme		163,900	100	163,900	170,200	100	170,200	195,933	100	195,933
31030204	7332	452	FWF Geschäftsstelle		11,100	100	11,100	10,300	100	10,300	10,100	100	10,100
31030204	7340	004	ISTA		53,500	100	53,500	53,500	100	53,500	43,153	100	43,153
31030204	7340	006	ÖAW Globalbudget		103,065	100	103,065	98,100	100	98,100	98,192	100	98,192
31030204	7340	010	ÖAW Beauftragungen und Programme		9,125	100	9,125	6,900	100	6,900	6,826	100	6,826
31030204	7348	900	Universitäten - Sonstige Tranferzahlungen		1,075	48	0,516						
31030204	7661	022	Ludwig-Boltzmann-Gesellschaft		7,600	100	7,600	5,000	100	5,000	4,500	100	4,500
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		0,750	100	0,750	0,750	100	0,750	1,031	100	1,031
			Summe UG31		**4.101,760**		**2.065,240**	**4.022,330**		**2.027,710**	**3.864,799**		**1.961,727**
			UG33										
33010100			Kooperation Wissenschaft-Wirtschaft		40,000	100	40,000	40,000	100	40,000	41,271	100	41,271
33010200			Innovation, Technologietransfer		44,591	100	44,591	44,591	100	44,591	48,431	100	48,431
33010300			Gründung innovativer Unternehmen		20,100	100	20,100	17,000	100	17,000	19,898	100	19,898
			Summe UG33		**104,691**		**104,691**	**101,591**		**101,591**	**109,600**		**109,600**
			UG40										
40020100	7270	000	Werkleistungen durch Dritte		6,338	3	0,190	5,770	5	0,289	4,532	5	0,227
40020100	7660	900	Zuschüsse f. lfd. Aufwand an private Institutionen					0,580	6	0,035	1,315	10	0,132
40030100			Eich- und Vermessungswesen	*	83,586		0,200	83,192		0,200	83,531		0,200
			Summe UG40		**89,924**		**0,390**	**89,542**		**0,524**	**89,378**		**0,559**

Seite 6

			Summe BM für Wissenschaft, Forschung und Wirtschaft		**4.296,375**		**2.170,321**	**4.213,463**		**2.129,825**	**4.063,777**		**2.071,886**
			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	1,650	100	1,650
34010200	7413	001	Austrian Institute of Technology AIT-Förderungen			100			100		0,076	100	0,076
34010200	7413	002	Austrian Institute of Technology AIT		50,658	90	45,592	51,893	90	46,704	51,158	90	46,042
34010200	7413	003	Nuclear Engineering Seibersdorf NES		10,550	30	3,165	10,200	30	3,060	6,480	30	1,944
34010200	7414	001	Austria Tech - Förderungen			100			100			100	
34010200	7414	002	Austria Tech		1,400	100	1,400	1,900	100	1,900	1,196	100	1,196
34010200	7660	075	F&T-Förderung		0,300	100	0,300	0,300	100	0,300	0,206	100	0,206
34010200	7661	030	Österreichische Computergesellschaft		0,075	100	0,075	0,075	100	0,075	0,075	100	0,075
34010200	7662	341	Joanneum Research Forsch.ges.m.b.H(Techn.schwerp)		2,350	100	2,350	2,350	100	2,350	2,563	100	2,563
34010200	7663	104	Gesellschaft für Mikroelektronik		0,030	100	0,030	0,030	100	0,030	0,005	100	0,005
34010200	7666	005	Österreichisches Institut für Nachhaltigkeit		0,045	100	0,045	0,045	100	0,045	0,050	100	0,050
34010200	7667	006	Sonstige gemeinnützige Einrichtungen		2,490	100	2,490	1,255	100	1,255	1,554	100	1,554
34010200	7668	040	Salzburg Research		0,300	100	0,300	0,300	100	0,300	0,432	100	0,432
34010200	7668	050	Profactor		0,500	100	0,500	0,500	100	0,500	0,453	100	0,453
34010200	7690	002	Preisverleihungen		0,010	100	0,010	0,010	100	0,010	0,013	100	0,013
34010300	7260	000	Mitgliedsbeiträge an Institutionen im Inland		0,006	100	0,006	0,006	100	0,006	0,153	100	0,153
34010300	7270	000	Werkleistungen durch Dritte		5,000	100	5,000	5,000	100	5,000	4,490	100	4,490
34010300	7280	030	FTI-Projekte, Beauftragungen an Dritte		2,265	100	2,265	2,500	100	2,500	1,439	100	1,439
34010300	7330	352	Translational research (F&E)		0,950	100	0,950	3,450	100	3,450	1,354	100	1,354
34010300	7330	652	Fonds wissensch./Programmabw.		0,250	100	0,250	0,250	100	0,250	0,061	100	0,061
34010300	7411	001	FFG - Basisprogramme		126,052	100	126,052	126,052	100	126,052	106,806	100	106,806
34010300	7411	002	FFG - FTI-Programme, Förderungen		126,798	100	126,798	126,000	100	126,000	158,415	100	158,415
34010300	7411	003	FFG - FTI-Programme (F&E-Dienstleist.,Sonst.WV)		15,000	100	15,000	15,000	100	15,000	10,704	100	10,704
34010300	7411	004	FFG - Administrative Kosten		14,500	100	14,500	14,500	100	14,500	13,580	100	13,580
34010300	7412	001	Austria Wirtschaftsservice GmbH AWS - Förderungen		10,950	100	10,950	5,350	100	5,350	3,057	100	3,057
34010300	7412	002	Austria Wirtschaftsservice GmbH AWS			100			100			100	
34010300	7412	003	Austria Wirtschaftsservice GmbH AWS - Admin.Kost.		0,150	100	0,150	0,150	100	0,150	0,439	100	0,439
34010300	7432	030	FTI-Projekte, Förderungen		0,200	100	0,200	0,200	100	0,200	0,322	100	0,322
34010300	7480	002	Technologieschwerpunkte (Unternehmungen)			100			100			100	
34010300	7680	030	FTI-Projekte, Förderungen an phys. Pers.			100			100			100	
			Summe UG34		**372,629**		**360,178**	**369,116**		**356,787**	**366,731**		**357,079**
			UG41										
41010200	7330	080	Transferzahlungen an Klima- und Energiefonds		47,000	100	47,000	47,000	39	18,330	66,000	69	45,540
41020100	7270	000	Werkleistungen durch Dritte		1,726	50	0,863	1,728	80	1,382	0,975	50	0,488
41020100	7270	800	Elektromobilität		0,200	60	0,120	0,200	80	0,160	0,052	60	0,031
41020100	7270	801	E-Mobilität für alle: Urbane Elektromobilität		0,001	20		0,001	20				
41020100	7411	002	FFG - FTI-Programme, Förderungen		2,000	100	2,000	2,000	100	2,000	2,500	100	2,500
41020100	7411	003	FFG - FTI-Programme (F&E-Dienstleist.,Sonst.WV)		0,200	100	0,200	0,200	100	0,200		100	
41020100	7411	004	FFG - Administrative Kosten		0,100	100	0,100	0,100	100	0,100		100	
41020100	7420	000	Lfd. Transfers an Unternehm. m. Bundesbeteiligung			80			80			80	
41020100	7480	501	Progr.Kombinierter		3,300	50	1,650	3,300	50	1,650	2,367	50	1,184

Seite 7

			Güterverk.Straße-Schiene-Schiff										
41020100	7481	800	Technologieprogramme allgemein (sonst. Anlagen)			80			80			80	
41020100	7660	000	Zuschüsse f. lfd. Aufwand an private Institutionen		0,049	95	0,047	0,049	95	0,047	0,010	95	0,010
41020100	7668	055	Technisches Museum Wien		0,301	80	0,241	0,301	80	0,241	1,058	80	0,846
41020200	7270	000	Werkleistungen durch Dritte					0,599	100	0,599	0,037		
41020300	7270	000	Werkleistungen durch Dritte					0,083	80	0,066	0,225	80	0,180
41020300	7411	002	FFG - FTI-Programme, Förderungen		0,001	50	0,001	0,001	50	0,001		50	
41020300	7411	003	FFG - FTI-Programme (F&E-Dienstleist.,Sonst.WV)					0,001	100	0,001		100	
41020300	7411	004	FFG - Administrative Kosten		0,001	50	0,001	0,001	50	0,001	0,097	50	0,049
41020300	7489	001	Breitbandinitiative (admin. Aufwand)		0,001	50	0,001	0,001	50	0,001		50	
41020300	7489	002	Breitband - Förderungen		0,001	50	0,001	0,001	50	0,001	0,623	50	0,312
41020402	7270	000	Werkleistungen durch Dritte		0,613	5	0,031	0,804	5	0,040	0,457	5	0,023
41020402	7270	006	Werkleistungen durch Dritte (zw)		1,003	5	0,050	1,003	5	0,050	1,166	5	0,058
41020500	7270	116	Spezifische Luftfahrtangelegenheiten										
			Summe UG41		**56,497**		**52,306**	**57,373**		**24,870**	**75,567**		**51,221**
			Summe BM für Verkehr, Innovation und Technologie		**429,126**		**412,484**	**426,489**		**381,657**	**442,298**		**408,300**
			BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft										
			UG42										
42010100			Zentralstelle	*	0,200	100	0,200	1,390	100	1,390	0,565	100	0,565
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	*	1,797	100	1,797	1,500	100	1,500	1,571	100	1,571
42020401			Landwirtschaftliche Schulen	*	46,366	21	9,737	45,550	21	9,566	42,611	21	8,948
42020402			Landwirtschaftliche Hochschule		4,757	3	0,143	4,310	3	0,129	4,381	3	0,131
42020403			Landwirtschaftliche Bundesanstalten		3,188	66	2,104	3,082	66	2,034	2,849	66	1,880
42020405			Bundesanstalt f. alpenländ. Milchwirtschaft Rotholz		4,419	1	0,044	5,082	1	0,051	4,244	1	0,042
42020501			HBLA für Wein- und Obstbau Klosterneuburg		11,093	37	4,104	10,810	37	4,000	10,514	37	3,890
42020502			Bundesamt für Weinbau		5,030	3	0,151	4,969	3	0,149	4,999	3	0,150
42030101	7270	000	Werkleistungen durch Dritte		0,268	20	0,054	0,898	20	0,180	0,514	20	0,103
42030104			Forschung und Sonstige Maßnahmen Forst	*	1,124	100	1,124	1,376	100	1,376	1,124	100	1,124
42030204			Planung, Forschung und Sonstige Maßnahmen					0,670	90	0,603			
42030204	7270	000	Werkleistungen durch Dritte	*	1,040	8	0,083	1,230	8	0,098	1,083	8	0,087
42030205			Bundesamt für Wasserwirtschaft		5,330	25	1,333	5,330	25	1,333	5,013	25	1,253
			Summe UG42		**121,915**		**33,184**	**123,500**		**34,719**	**116,770**		**32,054**
			UG43										
43010200	7700	500	Investitionszuschüsse		46,868	1	0,469	48,268	1	0,483	61,361	1	0,614
43010300			Klima- und Energiefonds		37,720	12	4,526	37,820	12	4,538	49,167	12	5,900
43010500			Nachhaltiger Natur- und Umweltschutz	*	27,826	12	3,339	46,906	1	0,469	26,438	1	0,264
43010500	7270	080	Forschungsaufwendungen		0,240	100	0,240	0,200	100	0,200	0,237	100	0,237
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	*				24,750		0,080	33,075	1	0,182
43020300	7700	251	Investitionsförderungen (zw)	*				348,638		0,700	339,785		0,734
			Summe UG43		**127,610**		**9,023**	**521,538**		**6,919**	**525,019**		**8,380**
			Summe BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft		**249,525**		**42,207**	**645,038**		**41,638**	**641,789**		**40,434**
			Teil b -Summe		**6.508,002**		**2.753,222**	**6.648,162**		**2.681,959**	**6.592,580**		**2.639,969**
			Gesamtsumme Teil a + b		**6.621,869**		**2.854,320**	**6.757,081**		**2.778,557**	**6.713,622**		**2.744,844**

Seite 8

BUNDESVORANSCHLAG 2017

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.
11030500	7270	900	*) Teilbetrag der Voranschlagsstelle.
11040100	7660	000	*) Teilbetrag der Voranschlagsstelle.
11040100	7270	900	*) Teilbetrag der Voranschlagsstelle.
			BM für Justiz
13010100	7271	900	*) Teilbetrag der Voranschlagsstelle.
13030101	7271	900	*) Teilbetrag der Voranschlagsstelle.
			BM für Landesverteidigung und Sport
14010100	7270	900	*) Teilbetrag der Voranschlagstelle.
14010100	7270	000	*) Teilbetrag der Voranschlagstelle.
14040100			*) Teilbetrag (eigene Fistl); Hinweis: 14010202 ist in 14040100 im BVA 2017 gewandert.
14050100	7270	900	*) Teilbetrag der Voranschlagsstelle.
14050100	7270	000	*) Teilbetrag der Voranschlagsstelle.
			BM für Finanzen
15010100	7270	000	*) Teilbetrag der Voranschlagsstelle.
15010100	7669	020	*) Teilbetrag der Voranschlagsstelle.
			BM für Arbeit, Soziales und Konsumentenschutz
20010101	7340	302	*) Forschungsanteil liegt bei 0,85 % (System rundet auf 1%)
20010201	7270	006	*) Forschungsanteil liegt bei 0,2 %.
			BM für Gesundheit und Frauen
24010100			Teilbetrag der Voranschlagsstelle
			BM für Bildung
30010400			Teilbetrag der Voranschlagsstelle
30020700			Teilbetrag der Voranschlagsstelle
			BM für Wissenschaft, Forschung und Wirtschaft
31030100	7270	031	*) Die Voranschlagsstelle wurde im Laufe des Jahres 2015 auf die Voranschlagsstelle 31030204 umgebucht !
31030100			*) Der Restbetrag ergibt sich rechnerisch bei dieser VA-Stelle.
31030204			*) Der Restbetrag ergibt sich rechnerisch bei dieser VA-Stelle.
40030100			*) Fixbetrag
			BM für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft
42010100			*) Finanzstellen 201 (Abt. Forschung u. Entwicklung) und 420 (Eu-Forschungsprojekte).
42010200	7411	000	Finanzstellen 90306 (AGES) und 90309 (BFW).
42020300			Finanzstelle 210 (Abt. Forschung u. Entwicklung).
42020401			*) Finanzstellen 22010 (Francisco-Josephinum), 22013 (Raumberg-Gumpenstein), 22016 (Gartenbau).
42030104			*) Teilbetrag der Voranschlagsstelle.
42030204	7270	000	*) Finanzstellen 701 (Nat. u. int. Wasserwirtschaft).
43010500			*) Teilbetrag der VA-Stelle.
43020200	7700	500	*) Forschungsanteil ist unter 1% (0,3 %).
43020300	7700	251	*) Forschungsanteil ist unter 1% (0,2 %).

Table 5: **Federal expenditure on research and research promotion by socio-economic objectives, 2002–2017**

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	120,334	58,859	686,089	106,716	56,210	81,271	581,440	124,148	43,283	23,080	873	-	862,541
	in %	*100.0*	*4.4*	*2.1*	*25.0*	*3.9*	*2.0*	*3.0*	*21.2*	*4.5*	*1.6*	*0.8*	*0.0*	-	*31.5*
2016[15]	in €1,000	2,778,557	123,220	63,261	697,138	79,695	57,145	85,234	586,332	125,995	44,056	24,229	2,254	-	889,998
	in %	*100.0*	*4.4*	*2.3*	*25.1*	*2.9*	*2.1*	*3.1*	*21.1*	*4.5*	*1.6*	*0.9*	*0.1*	-	*31.9*
2017[15]	in €1,000	2,854,320	124,291	61,799	708,272	108,689	55,381	81,457	609,817	130,136	46,312	24,355	3,480	-	900,331
	in %	*100.0*	*4.4*	*2.2*	*24.8*	*3.8*	*1.9*	*2.9*	*21.4*	*4.6*	*1.6*	*0.9*	*0.1*	-	*31.4*

As at: April 2017

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. – 15) Federal Finances Act 2017, Detailed overview of research-related appropriation of federal funds, financing proposal.

Table 6: Federal expenditure in 2015 for research and research promotion by socio-economic objectives and ministries

Breakdown of annual values for 2015[1] from the Detailed overview of research-related appropriation of federal funds for the Federal Finances Act 2017 (Part a and Part b)

Ministries		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 health care	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	35,686	5,443	-	-	44	2	-	-	7,279	-	504	-	-	22,414
	in %	*100.0*	*15.3*	-	-	*0.1*	*0.0*	-	-	*20.4*	-	*1.4*	-	-	*62.8*
BMI	in €1,000	1,135	-	-	-	-	-	-	-	1,135	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMBF	in €1,000	38,098	-	-	-	-	-	38,098	-	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	*100.0*	-	-	-	-	-	-	-
BMWFW	in €1,000	2,107,858	89,865	26,672	419,572	23,038	24,252	41,963	547,022	93,775	26,371	16,606	239	-	798,483
	in %	*100.0*	*4.3*	*1.3*	*19.9*	*1.1*	*1.2*	*2.0*	*25.9*	*4.4*	*1.3*	*0.8*	*0.0*	-	*37.8*
BMASK	in €1,000	6,484	-	-	-	-	-	-	-	6,484	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMG	in €1,000	5,669	-	-	-	-	-	-	5,669	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	*100.0*	-	-	-	-	-	-
BMEIA	in €1,000	1,718	-	-	-	562	-	-	-	1,156	-	-	-	-	-
	in %	*100.0*	-	-	-	*32.7*	-	-	-	*67.3*	-	-	-	-	-
BMJ	in €1,000	17	-	-	-	-	-	-	-	17	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMLVS	in €1,000	1,972	-	-	-	-	-	-	-	-	-	-	634	-	1,338
	in %	*100.0*	-	-	-	-	-	-	-	-	-	-	*32.2*	-	*67.8*
BMF	in €1,000	30,490	991	967	4,604	206	366	1,051	6,478	7,364	366	252	-	-	7,845
	in %	*100.0*	*3.3*	*3.2*	*15.1*	*0.7*	*1.2*	*3.4*	*21.2*	*24.2*	*1.2*	*0.8*	-	-	*25.7*
BMLFUW	in €1,000	44,637	564	30,927	224	-	-	131	-	4,178	8,380	-	-	-	233
	in %	*100.0*	*1.3*	*69.2*	*0.5*	-	-	*0.3*	-	*9.4*	*18.8*	-	-	-	*0.5*
BMFJ	in €1,000	886	-	-	-	-	-	-	-	886	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMVIT	in €1,000	470,194	23,471	293	261,689	82,866	31,590	28	22,271	1,874	8,166	5,718	-	-	32,228
	in %	*100.0*	*5.0*	*0.1*	*55.7*	*17.6*	*6.7*	*0.0*	*4.7*	*0.4*	*1.7*	*1.2*	-	-	*6.9*
Total	**in €1,000**	**2,744,844**	**120,334**	**58,859**	**686,089**	**106,716**	**56,210**	**81,271**	**581,440**	**124,148**	**43,283**	**23,080**	**873**	**-**	**862,541**
	in %	***100.0***	***4.4***	***2.1***	***25.0***	***3.9***	***2.0***	***3.0***	***21.2***	***4.5***	***1.6***	***0.8***	**0.0**	**-**	***31.5***

As at: April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) Outlays. - 2) Including the highest executive bodies.

Table 7: Federal expenditure in 2016 for research and research promotion by socio-economic objectives and ministries

Breakdown of annual values for 2016[1] from the Detailed overview of research-related appropriation of federal funds for the Federal Finances Act 2017 (Part a and Part b)

Ministries		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	39,095	5,994	-	-	46	2	-	-	8,056	-	530	-	-	24,467
	in %	*100.0*	*15.3*	-	-	*0.1*	*0.0*	-	-	*20.6*	-	*1.4*	-	-	*62.6*
BMI	in €1,000	1,219	-	-	-	-	-	-	-	1,219	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMB	in €1,000	40,059	-	-	-	-	-	40,059	-	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	*100.0*	-	-	-	-	-	-	-
BMWFW	in €1,000	2,163,212	91,075	28,343	432,397	23,640	25,682	43,875	549,970	98,625	27,572	17,630	253	-	824,150
	in %	*100.0*	*4.2*	*1.3*	*20.0*	*1.1*	*1.2*	*2.0*	*25.4*	*4.6*	*1.3*	*0.8*	*0.0*	-	*38.1*
BMASK	in €1,000	5,707	-	-	-	-	-	-	-	5,707	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMGF	in €1,000	7,043	-	-	-	-	-	-	7,043	-	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	*100.0*	-	-	-	-	-	-
BMEIA	in €1,000	2,151	-	-	-	1,117	-	-	-	1,034	-	-	-	-	-
	in %	*100.0*	-	-	-	*51.9*	-	-	-	*48.1*	-	-	-	-	-
BMJ	in €1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	in %	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMLVS	in €1,000	3,311	-	-	-	-	-	-	-	-	-	-	2,001	-	1,310
	in %	*100.0*	-	-	-	-	-	-	-	-	-	-	*60.4*	-	*39.6*
BMF	in €1,000	31,931	1,128	1,097	5,081	227	404	1,097	7,143	6,385	404	278	-	-	8,687
	in %	*100.0*	*3.5*	*3.4*	*15.9*	*0.7*	*1.3*	*3.4*	*22.4*	*20.0*	*1.3*	*0.9*	-	-	*27.2*
BMLFUW	in €1,000	43,372	600	33,537	239	-	-	129	-	1,700	6,919	-	-	-	248
	in %	*100.0*	*1.4*	*77.2*	*0.6*	-	-	*0.3*	-	*3.9*	*16.0*	-	-	-	*0.6*
BMFJ	in €1,000	1,427	-	-	-	-	-	-	-	1,427	-	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-	-
BMVIT	in €1,000	440,030	24,423	284	259,421	54,665	31,057	74	22,176	1,842	9,161	5,791	-	-	31,136
	in %	*100.0*	*5.6*	*0.1*	*58.9*	*12.4*	*7.1*	*0.0*	*5.0*	*0.4*	*2.1*	*1.3*	-	-	*7.1*
Total	**in €1,000**	**2,778,557**	**123,220**	**63,261**	**697,138**	**79,695**	**57,145**	**85,234**	**586,332**	**125,995**	**44,056**	**24,229**	**2,254**	**-**	**889,998**
	in %	***100.0***	***4.4***	***2.3***	***25.1***	***2.9***	***2.1***	***3.1***	***21.1***	***4.5***	***1.6***	***0.9***	***0.1***	**-**	***31.9***

As at: April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) Financing proposal. - 2) Including the highest executive bodies.

Table 8: Federal expenditure in 2017 for research and research promotion by socio-economic objectives and ministries

Breakdown of annual values for 2017[1] from the Detailed overview of research-related appropriation of federal funds for the Federal Finances Act 2017 (Part a and Part b)

Ministries		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	40,981	6,249	-	-	44	2	-	-	8,602	-	665	-	-	25,419
	in %	*100.0*	*15.2*	-	-	*0.1*	*0.0*	-	-	*21.0*	-	*1.6*	-	-	*62.1*
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	92,151	28,514	438,672	23,879	25,840	44,016	574,455	99,615	27,675	17,777	265	-	835,149
	in %	*100.0*	*4.2*	*1.3*	*19.9*	*1.1*	*1.2*	*2.0*	*26.0*	*4.5*	*1.3*	*0.8*	-	-	*37.7*
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	1,036	1,015	4,765	213	379	1,050	6,701	7,860	379	260	-	-	8,185
	in %	*100.0*	*3.3*	*3.2*	*15.0*	*0.7*	*1.2*	*3.3*	*21.0*	*24.7*	*1.2*	*0.8*	-	-	*25.6*
BMLFUW	in €1,000	43,942	600	31,985	243	-	-	143	-	1,700	9,023	-	-	-	248
	in %	*100.0*	*1.4*	*72.7*	*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	24,255	285	264,592	83,436	29,160	24	21,679	1,798	9,235	5,653	-	-	30,745
	in %	*100.0*	*5.2*	*0.1*	*56.1*	*17.7*	*6.2*	*0.0*	*4.6*	*0.4*	*2.0*	*1.2*	-	-	*6.5*
Total	**in €1,000**	**2,854,320**	**124,291**	**61,799**	**708,272**	**108,689**	**55,381**	**81,457**	**609,817**	**130,136**	**46,312**	**24,355**	**3,480**	**-**	**900,331**
	in %	***100.0***	***4.4***	***2.2***	***24.8***	***3.8***	***1.9***	***2.9***	***21.4***	***4.6***	***1.6***	***0.9***	***0.1***	**-**	***31.4***

As at: April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) Financing proposal. - 2) Including the highest executive bodies.

Table 9: General research-related university expenditure by the federal government ("General University Funds"), 2000–2017[1]

Years	General university funds	
	Total	R&D
	in € millions	
2000	1,956.167	842.494
2001	2,008.803	866.361
2002	2,104.550	918.817
2003	2,063.685	899.326
2004	2,091.159	980.984
2005	2,136.412	1,014.543
2006	2,157.147	1,027.270
2007	2,314.955	1,083.555
2008	2,396.291	1,133.472
2009	2,626.038	1,236.757
2010	2,777.698	1,310.745
2011	2,791.094	1,388.546
2012	2,871.833	1,395.130
2013	3,000.004	1,453.596
2014	3,059.949	1,481.744
2015	3,117.320	1,509.576
2016	3,264.854	1,580.644
2017	3,325.605	1,609.839

As at: April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

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.

Table 10: Research promotion schemes and contracts awarded by the federal government in 2016, broken down by sectors/areas of performance and awarding ministries
Analysis of the federal research database [1] without "major" global financing [2]

Ministries	Partial amounts 2016	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 Research Promotion Agency (FFG)	Abroad
	in €	in %																				
BKA	65,016	-	-	-	-	-	-	-	26.6	-	-	26.6	-	-	-	-	-	73.4	73.4	-	-	-
BMASK	3,015,714	11.4	-	-	0.3	-	11.7	43.6	33.1	0.0	-	76.7	0.3	1.4	1.7	-	-	9.9	9.9	-	-	-
BMB	12,563	52.2	-	-	47.8	-	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMBF	75,050	62.7	-	-	-	-	62.7	16.1	-	-	-	16.1	4.8	-	4.8	-	-	16.4	16.4	-	-	-
BMEIA	369,228	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	100.0	-	-	-
BMFJ	64,508	27.5	-	-	-	-	27.5	-	4.2	-	-	4.2	-	-	-	-	-	37.3	37.3	-	-	31.0
BMF	5,185,771	-	-	-	0.1	-	0.1	41.9	17.2	-	-	59.1	0.1	0.7	0.8	-	-	6.6	6.6	-	30.1	3.3
BMG	46,764	57.2	-	-	-	-	57.2	42.8	-	-	-	42.8	-	-	-	-	-	-	-	-	-	-
BMGF	17,029	74.8	-	-	-	-	74.8	-	-	-	-	-	17.6	-	17.6	-	-	7.6	7.6	-	-	-
BMI	133,073	-	-	-	-	-	-	-	58.6	-	-	58.6	-	9.0	9.0	-	-	28.6	28.6	-	-	3.8
BMJ	123,100	-	-	-	-	-	-	-	100.0	-	-	100.0	-	-	-	-	-	-	-	-	-	-
BMLFUW	2,944,853	66.7	-	-	1.7	-	68.4	11.4	1.9	-	0.5	13.8	2.6	-	2.6	3.4	1.6	0.8	5.8	-	6.8	2.6
BMLVS	1,176,126	12.7	-	0.6	18.2	-	31.5	4.2	2.6	-	-	6.8	-	3.4	3.4	17.8	13.4	20.5	51.7	-	-	6.6
BMVIT	1,767,381	-	-	-	-	-	-	-	67.9	-	-	67.9	2.0	-	2.0	4.7	-	25.4	30.1	-	-	-
BMWFW	48,585,672	6.4	0.2	0.1	0.1	0.0	6.8	10.6	13.1	-	0.1	23.8	4.2	0.2	4.4	0.4	0.1	1.6	2.1	-	0.2	62.7
Total	**63,581,848**	**9.0**	**0.1**	**0.1**	**0.5**	**0.0**	**9.7**	**14.2**	**15.4**	**0.0**	**0.1**	**29.7**	**3.5**	**0.3**	**3.8**	**0.9**	**0.4**	**4.2**	**5.5**	**-**	**2.9**	**48.4**

As at: April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) As at: 27 March 2017.

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 2016, broken down by socio-economic objectives and awarding ministries
Analysis of the federal research database [1] without "major" global financing [2]

Ministries		Partial amounts 2016	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	Funding of urban and physical planning	Funding of national defence	Promotion of general knowledge advancement
BKA	in €	65,016	-	-	-	-	-	-	-	65,016	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-
BMASK	in €	3,015,714	-	-	-	-	-	-	-	3,015,714	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-
BMB	in €	12,563	-	-	-	-	-	6,563	-	6,000	-	-	-	-
	in %	*100.0*	-	-	-	-	-	*52.2*	-	*47.8*	-	-	-	-
BMBF	in €	75,050	-	-	-	-	-	50,669	-	19,382	-	-	-	4,999
	in %	*100.0*	-	-	-	-	-	*67.5*	-	*25.8*	-	-	-	*6.7*
BMEIA	in €	369,228	-	-	-	-	-	-	-	369,228	-	-	-	-
	in %	*100.0*	-	-	-	-	-	-	-	*100.0*	-	-	-	-
BMFJ	in €	64,508	-	-	-	-	-	26,741	-	37,767	-	-	-	-
	in %	*100.0*	-	-	-	-	-	*41.5*	-	*58.5*	-	-	-	-
BMF	in €	5,185,771	-	-	-	-	-	-	20,000	3,268,959	89,870	-	-	1,806,942
	in %	*100.0*	-	-	-	-	-	-	*0.4*	*63.1*	*1.7*	-	-	*34.8*
BMG	in €	46,764	-	46,764	-	-	-	-	-	-	-	-	-	-
	in %	*100.0*	-	*100.0*	-	-	-	-	-	-	-	-	-	-
BMGF	in €	17,029	-	-	-	-	-	-	-	15,730	-	-	-	1,299
	in %	*100.0*	-	-	-	-	-	-	-	*92.4*	-	-	-	*7.6*
BMI	in €	133,073	-	-	-	-	-	-	-	128,073	-	-	-	5,000
	in %	*100.0*	-	-	-	-	-	-	-	*96.2*	-	-	-	*3.8*
BMJ	in €	123,100	-	-	-	-	-	-	-	113,100	-	-	-	10,000
	in %	*100.0*	-	-	-	-	-	-	-	*91.9*	-	-	-	*8.1*
BMLFUW	in €	2,944,853	140,955	2,041,996	260,208	9,000	-	-	105,406	72,623	206,161	-	-	108,504
	in %	*100.0*	*4.8*	*69.3*	*8.8*	*0.3*	-	-	*3.6*	*2.5*	*7.0*	-	-	*3.7*
BMLVS	in €	1,176,126	-	4,995	444,921	60,390	-	-	105,847	41,250	-	-	251,447	267,276
	in %	*100.0*	-	*0.4*	*37.9*	*5.1*	-	-	*9.0*	*3.5*	-	-	*21.4*	*22.7*
BMVIT	in €	1,767,381	237,500	-	886,424	31,000	355,980	-	-	115,614	-	-	-	140,863
	in %	*100.0*	*13.4*	-	*50.2*	*1.8*	*20.1*	-	-	*6.5*	-	-	-	*8.0*
BMWFW	in €	48,585,672	8,097,339	9,000	8,250	9,515	-	8,760	3,310,390	2,813,731	132,568	-	-	34,196,119
	in %	*100.0*	*16.7*	*0.0*	*0.0*	*0.0*	-	*0.0*	*6.8*	*5.8*	*0.3*	-	-	*70.4*
Total	**in €**	**63,581,848**	**8,475,794**	**2,102,755**	**1,599,803**	**109,905**	**355,980**	**92,733**	**3,541,643**	**10,082,187**	**428,599**	**-**	**251,447**	**36,541,002**
	in %	***100.0***	***13.3***	***3.3***	***2.5***	***0.2***	***0.6***	***0.1***	***5.6***	***15.9***	***0.7***	**-**	***0.4***	***57.4***

As at: April 2017

Source: Statistics Austria (Bundesanstalt Statistik Österreich)

1) As at: 27 March 2017.

2) i.e. excl. institutional financing with funding amounts higher than €500,000.

Table 12: An international comparison of research and experimental development (R&D) in 2014

Country	Gross domestic expenditure on R&D in % of GDP	Financing of gross domestic expenditure of R&D by: Government	Financing of gross domestic expenditure of R&D by: Business	Employees in R&D in full-time equivalents	Gross expenditure on R&D by the: Business enterprise sector	Gross expenditure on R&D by the: Higher education sector	Gross expenditure on R&D by the: Government sector	Gross expenditure on R&D by the: Private non-profit sector
		in %			in % of gross domestic expenditure on R&D			
Belgium	2.46 [c]	24.1[4]	61.3[4]	68,701[c]	71.2[c]	20.2[c]	8.2[c]	0.4[c]
Denmark	2.92	29.7[c]	59.0[c]	58,361	63.8	33.5	2.3	0.4
Germany	2.89	28.9	65.8	605,252	67.5	17.7	14.8[o]	.[n]
Finland	3.17	27.5	53.5	52,130	67.7	22.9	8.7	0.8
France	2.24	34.6	55.7	417,129	65.0	20.6	12.9	1.5
Greece	0.84	53.3	29.8	43,316	33.9	37.2	27.7	1.2
Ireland [c]	1.51	27.3	52.8	28,379[a]	72.1	23.4	4.5	0.0
Italy	1.38 [c]	40.8[c]	46.2[c]	249,467	55.4[c]	28.4[c]	13.3[c]	3.0[c]
Luxembourg	1.28	48.4[4]	16.5[4]	5,243	53.7	16.4	29.9[o]	.[n]
Netherlands	2.00	33.2	51.1	124,066	56.0	32.1	11.9[o]	.[n]
Austria[c]	**3.09 [5]**	**35.8[5]**	**47.9[5]**	**68,101**	**70.8**	**24.3**	**4.4**	**0.4**
Portugal	1.29	47.1	41.8	46,878	46.4	45.6	6.3	1.7
Sweden	3.15 [c]	28.3[4]	61.0[4]	83,473[c]	67.0[c]	29.0[c]	3.8[c]	0.2[c]
Spain	1.24	41.4	46.4	200,233	52.9	28.1	18.8	0.2
United Kingdom [c]	1.68	28.4	48.0	396,281	65.2	25.8	7.3	1.8
EU 15 [b]	**2.10**	**32.2**	**56.1**	**2,447,010**	**64.0**	**23.2**	**11.7**	**1.0**
Estonia	1.45	49.5	37.1	5,790	43.5	44.3	11.0	1.2
Latvia	0.69	25.6	27.8	5,739	35.5	40.5	24.0	.
Poland	0.94	45.2	39.0	104,359	46.6	29.2	24.0	0.3
Slovak Republic	0.88	41.4	32.2	17,594	36.8	34.4	28.3[d]	0.4
Slovenia	2.38	21.8	68.4	14,866	77.3	10.5	12.2	0.0
Czechia	1.97	32.9	35.9	64,444	56.0	25.4	18.2	0.4
Hungary	1.36	33.5	48.3	37,329	71.5[v]	13.5[v]	13.7[v]	0.0
Romania	0.38	48.6	32.9	31,391	41.5	15.2	43.0	0.4
EU-28[b]	**1.95**	**32.6**	**54.8**	**2,772,387**	**63.2**	**23.4**	**12.4**	**1.0**
Australia	2.11 [c, 4]	34.6[1]	61.9[1]	147,809[b, 2]	56.3[c, 4]	29.6[c, 4]	11.2[c, 4]	2.8[c, 4]
Chile	0.38 [a]	44.2[a]	31.9[a]	15,887	33.4[a]	39.0[a]	8.1[a]	19.5[a]
Iceland	2.01	34.1	35.7	2,736[a, 4]	61.1[o]	32.9	6.1	.[n]
Israel[d]	4.27	12.5	37.1	77,143[c]	84.8	12.3	1.8	1.2
Japan	3.59 [y]	16.0[b]	77.3	895,285	77.8	12.6	8.3	1.3
Canada	1.60 [p]	34.6[c]	45.4[p]	226,620[4]	49.9[g]	40.4[p]	9.2[p]	0.5[p]
Korea	4.29	23.0	75.3	430,868	78.2	9.1	11.2	1.5
Mexico	0.54 [c]	71.8[c]	20.2[c]	59,073[4]	30.6[c]	26.3[c]	38.5[c]	4.6[c]
New Zealand[4]	1.15	39.8	39.8	24,900	46.4	30.4	23.2	0.0
Norway	1.72	45.8[4]	43.1[4]	40,297	53.7	31.0	15.2	0.0
Switzerland[3]	2.97	25.4	60.8	75,476	69.3	28.2	0.8[h]	1.8
Turkey	1.01 [y]	26.3	50.9	115,444	49.8	40.5	9.7	0.0
United States [j]	2.76	26.2	61.7	.	71.1	13.5[p]	11.3	4.1[c]
OECD total [b]	**2.39**	**27.4**	**61.3**	**.**	**68.7**	**17.8**	**11.1**	**2.4**
People's Republic of China	2.02 [y]	20.3	75.4	3,710,580	77.3	6.9	15.8	0.0

Source: OECD (MSTI 2016-2), **Statistics Austria** (Bundesanstalt Statistik Österreich).

a) Break in the time series. – b) Estimate by the OECD Secretariat (based on national sources). – c) National estimate – d) R&D expenditure on national defence not included. – g) Without research and development in the social sciences and humanities. – h) Only federal or central government funds. – j) Excluding investment expenditure. – n) Included elsewhere. – o) Includes other categories as well. – p) Preliminary values. – v) Sum of components does not equal total. – y) GDP according to System of National Accounts 1993.

1) 2008. – 2) 2010. – 3) 2012. – 4) 2013. – 5) Statistics Austria; according to R&D global estimate 2017.

Full time equivalent = person year.

Table 13: 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 Feb. 2017
Number of approved projects with Austrian participation	1,444	1,384	1,324	2,452	1,081
Number of approved Austrian participations	1,923	1,987	1,972	3,589	1,551
Number of approved projects coordinated by Austrian organisations	270	267	213	676	318
Promotion for approved Austrian partner organisations and researchers for which a contract has been signed (in € millions)	194	292	425	1,192	639
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%	2.4%
Austrian share of approved development funds	1.99%	2.38%	2.56%	2.63%	2.82%

Sources: Proviso Overview report from fall of 2013 (FP4–FP6); EC 11/2015 (FP7); EC 02/2017 (H2020)

Processing and calculations: Austrian Research Promotion Agency (FFG).

Table 14: Austrian results in the 7th EU Framework Programme for research, technological development and demonstration activities

	All countries	Austria	Burgen-land	Carin-thia	Lower Austria	Upper Austria	Salzburg	Styria	Tyrol	Vorarl-berg	Vienna	N/A
Projects	**25,363**	**2,452**	**10**	**110**	**233**	**210**	**92**	**509**	**218**	**25**	**1,501**	**-**
Participations	**135,922**	**3,589**	**10**	**142**	**253**	**255**	**106**	**636**	**254**	**29**	**1,902**	**2**
Higher education	50,581	1,312	0	31	51	88	55	262	146	5	674	
Non-university research	33,593	861	0	5	61	46	26	136	2	1	584	
Business enterprises	41,230	1,164	10	105	132	112	21	232	102	21	427	2
Public institutions	6,242	171	0	1	4	3	2	1	3	0	157	
Other	4,276	81	0	0	5	6	2	5	1	2	60	
Declared SME	25,171	776	10	43	101	52	8	161	73	12	315	
Not a declared SME	110,751	2,813	0	99	152	203	98	475	181	17	1,587	
Coordinations	**25,363**	**676**	**0**	**27**	**48**	**34**	**17**	**99**	**43**	**1**	**407**	**-**
Higher education	14,409	360	0	2	27	23	10	45	38	0	215	
Non-university research	7,013	163	0	0	7	7	6	26	0	1	116	
Business enterprises	3,056	133	0	25	14	3	1	28	5	0	57	
Public institutions	480	15	0	0	0	1	0	0	0	0	14	
Other	405	5	0	0	0	0	0	0	0	0	5	
Declared SME	**1,854**	**81**	**0**	**18**	**10**	**1**	**1**	**18**	**5**	**0**	**28**	
Not a declared SME	**23,509**	**595**	**0**	**9**	**38**	**33**	**16**	**81**	**38**	**1**	**379**	

Source: EC 11/2015. As at 11 Nov. 2015

Processing and calculations: Austrian Research Promotion Agency (FFG).

Note: The self-declaration of the SME classification by the organisation is defined by statistical sizes of organisations and is used for all types of organisations. The European Commission considers this to be a subgroup of the PRC sector ("private sector").

Table 15: Austrian results in Horizon 2020

	All countries	Austria	Burgen-land	Carin-thia	Lower Austria	Upper Austria	Salzburg	Styria	Tyrol	Vorarl-berg	Vienna
Projects	**13,031**	**1,081**	**7**	**35**	**114**	**101**	**36**	**247**	**68**	**11**	**645**
Participations	**55,169**	**1,551**	**8**	**48**	**116**	**122**	**38**	**329**	**77**	**12**	**801**
Higher education	18,155	433	2	5	29	25	16	75	40	0	241
Business enterprises	18,447	596	4	35	64	55	11	145	33	11	238
Non-university research	12,080	329	2	3	17	28	6	93	0	0	180
Public institutions	3,564	101	0	4	1	5	2	5	4	1	79
Other	2,923	92	0	1	5	9	3	11	0	0	63
Participations with an agreement	**50,477**	**1,430**	**7**	**40**	**105**	**107**	**36**	**307**	**75**	**8**	**745**
Declared SME	11,529	356	2	14	39	31	8	107	17	1	137
Not a declared SME	38,948	1,074	5	26	66	76	28	200	58	7	608
Coordinations	**13,031**	**318**	**0**	**11**	**35**	**20**	**5**	**62**	**15**	**0**	**170**
Higher education	6,143	141	0	0	23	3	2	14	14	0	85
Business enterprises	3,585	100	0	11	9	7	2	32	1	0	38
Non-university research	2,761	61	0	0	3	10	1	15	0	0	32
Public institutions	292	8	0	0	0	0	0	0	0	0	8
Other	250	8	0	0	0	0	0	1	0	0	7
Coordinations with an agreement	**11,626**	**293**	**0**	**13**	**33**	**18**	**5**	**59**	**17**	**0**	**148**
Declared SME	2,992	84	0	10	7	13	0	26	1	0	27
Not a declared SME	8,634	209	0	3	26	5	5	33	16	0	121

Source: EC 2/2017. As at: 28 Feb. 2017

Processing and calculations: Austrian Research Promotion Agency (FFG).

Note: The self-declaration of the SME classification by the organisation is defined by statistical sizes of organisations and is used for all types of organisations. The European Commission considers this to be a subgroup of the PRC sector ("private sector").

Table 16: Overview of projects and participations in Horizon 2020

Participations	Approved participation (all countries)	Approved Austrian participations	Austria's share of participation by all countries [in %]
Total	**55,169**	**1,551**	**2.8**
EC Treaty	54,287	1,544	2.8
Excellent science	15,754	358	2.3
Industrial leadership	13,080	415	3.2
Societal challenges	23,867	708	3.0
Spreading excellence and widening participation	467	16	3.4
Science with and for society	693	38	5.5
Cross-theme	426	9	2.1
Euratom	882	7	0.8

Projects	Approved projects (all countries)	Approved projects with Austrian participation	Austria's share of participation by all countries [in %]
Total	**13,031**	**1,081**	**8.3**
EC Treaty	12,983	1,076	8.3
Excellent science	7,168	307	4.3
Industrial leadership	2,147	230	10.7
Societal challenges	3,379	486	14.4
Spreading excellence and widening participation	121	15	12.4
Science with and for society	74	30	40.5
Cross-theme	94	8	8.5
Euratom	48	5	10.4

Source: EC 2/2017. As at: 28 Feb. 2017

Processing and calculations: Austrian Research Promotion Agency (FFG).

Note: The Austrian Research Promotion Agency's analysis was commissioned by the Federal Ministry of Science, Research and Economy (BMWFW), the Federal Ministry for Transport, Innovation and Technology (BMVIT), and the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW).

Table 17: Austrian Science Fund (FWF): Shares of new approvals by discipline (ÖFOS 2012 3-digit level), 2014–2016

Discipline	New approvals					
	2014		2015		2016	
	in %	in € millions	in %	in € millions	in %	in € millions
Mathematics	9.4	19.2	9.2	18.4	14.1	26.0
Computer science	5.5	11.1	4.4	8.8	4.4	8.1
Physics, astronomy	11.3	23.0	16.8	33.6	10.9	19.9
Chemistry	5.4	10.9	5.7	11.4	4.4	8.0
Geosciences	2.1	4.3	3.0	6.0	3.4	6.1
Biology	23.3	47.4	21.7	43.2	20.0	36.8
Other natural sciences	1.5	3.0	0.7	1.4	0.3	0.6
Construction	0.5	1.0	0.8	1.6	0.5	0.9
Electrical engineering, electronics, information technology	0.9	1.9	0.8	1.6	0.8	1.5
Mechanical engineering, machinery	0.6	1.3	0.2	0.4	0.1	0.1
Chemical industry and petrol industry, basic materials chemistry	0.3	0.5	0.04	0.1	0.03	0.1
Advanced materials					0.6	1.1
Medical engineering			0.1	0.2	0.2	0.4
Environmental engineering, applied geosciences	0.2	0.3	0.4	0.7	0.2	0.4
Environmental biotechnology					0.1	0.1
Industrial biotechnology			0.1	0.2	0.2	0.4
Nanotechnologies			0.3	0.6	1.0	1.9
Other engineering	0.4	0.9	0.4	0.8	0.2	0.3
Medical/theoretical sciences, pharmaceutics	11.5	23.4	10.4	20.8	11.9	21.8
Clinical medicine	4.6	9.3	2.5	5.1	4.4	8.1
Health sciences	0.5	1.0	0.3	0.6	0.9	1.6
Medical biotechnology			0.1	0.1	0.2	0.4
Other human medicine, health sciences	0.4	0.9	0.2	0.5	0.04	0.1
Agriculture and forestry, fisheries	0.5	0.9	0.7	1.5	0.3	0.5
Livestock breeding, animal production	0.2	0.3	0.1	0.1	0.4	0.7
Veterinary medicine	0.1	0.2	0.1	0.2	0.5	0.9
Agricultural biotechnology, food biotechnology			0.03	0.1	0.1	0.1
Other agricultural sciences	0.3	0.6	0.6	1.2		
Psychology	2.0	4.1	1.1	2.1	1.5	2.7
Economics	1.8	3.7	1.0	2.0	3.2	5.8
Educational sciences	0.1	0.2	0.2	0.4	0.4	0.8
Sociology	0.8	1.6	0.9	1.9	1.4	2.6
Jurisprudence	0.5	1.1	0.6	1.2	0.8	1.5
Political science	0.3	0.7	0.9	1.7	0.4	0.7
Human geography, regional geography, spatial planning	0.03	0.1	0.2	0.5	0.5	0.9
Media and communication sciences			0.2	0.3	0.2	0.4
Other social sciences	1.4	2.8	1.4	2.8	0.3	0.5
History, archaeology	5.0	10.2	3.9	7.8	3.4	6.2
Linguistics and literary studies	4.1	8.2	4.4	8.8	2.9	5.3
Philosophy, ethics, religion	1.8	3.6	1.7	3.4	2.4	4.4
Art sciences	2.2	4.4	3.2	6.3	2.1	3.8
Other humanities	0.8	1.6	0.6	1.2	0.7	1.2
Total	**100.0**	**203.7**	**100.0**	**199.3**	**100.0**	**183.8**

Source: Austrian Science Fund (FWF).

Table 18: Austrian Science Fund (FWF): Shares of new approvals by organisation type, 2014–2016

Organisation type	2014		2015		2016	
	in %	in € millions	in %	in € millions	in %	in € millions
Universities[1]	85.0	173.0	83.7	166.9	83.0	152.5
Universities of applied sciences	0.3	0.6	0.1	0.2	1.3	2.4
Private universities	0.8	1.5	0.9	1.7	1.1	2.1
Academy of Sciences	8.4	17.1	8.9	17.8	7.8	14.4
Non-university research locations[2]	5.6	11.4	6.4	12.8	6.7	12.4
Total	**100.0**	**203.7**	**100.0**	**199.3**	**100.0**	**183.8**

Source: Austrian Science Fund (FWF).

1 Including the University for Continuing Education Krems.

2 Including research locations abroad.

Table 19: Austrian Research Promotion Agency (FFG): Shares of new approvals by topic area of the promotion, 2014–2016

(in € millions)	2014		2015		2016	
	in %	in € millions	in %	in € millions	in %	in € millions
Energy/Environment	16.5	101.5	16.9	79.1	16.9	88.0
ICT	15.4	95.3	17.6	82.2	20.3	105.7
Mobility	8.7	53.6	13.5	62.9	11.6	60.4
Production	26.2	161.7	24.3	113.7	22.8	118.7
Life Sciences	14.6	90.1	9.8	45.8	10.7	56.0
Safety	1.3	8.2	2.8	12.9	1.6	8.1
Space	2.5	15.2		0.1	1.5	7.6
Other	14.8	91.4	15.1	70.5	14.8	76.9
Total	**100.0**	**617.0**	**100.0**	**467.1**	**100.0**	**521.5**

Source: Austrian Research Promotion Agency (FFG).

Table 20: Austrian Research Promotion Agency (FFG): Funding by regional government, 2014–2016

Regional government	2014		2015		2016	
	in %	Total [in € millions]	in %	Total [in € millions]	in %	Total [in € millions]
Burgenland	1.0	6.1	1.3	5.9	1.3	6.7
Carinthia	6.4	39.3	5.8	27.0	4.6	23.7
Lower Austria	10.3	63.7	6.1	28.5	8.9	46.6
Upper Austria	20.2	124.6	21.2	99.3	19.8	103.2
Salzburg	3.4	21.0	3.2	14.8	3.7	19.1
Styria	29.6	182.4	29.4	137.5	23.3	121.4
Tyrol	6.0	37.3	5.9	27.7	5.9	31.0
Vorarlberg	3.2	19.9	1.8	8.2	3.2	16.8
Vienna	19.2	118.6	23.9	111.8	28.1	146.6
Abroad	0.7	4.0	1.4	6.4	1.2	6.3
Total	**100.0**	**617.0**	**100.0**	**467.1**	**100.0**	**521.5**

Source: Austrian Research Promotion Agency (FFG).

Table 21: Austrian Research Promotion Agency (FFG): Project costs and funding by Subject Index Code, 2016

Subject Index Code	Total costs [in €1,000]	Total funding [in €1,000]	Cash value [in €1,000]
Industrial manufacturing	132,657	66,354	40,437
ICT applications	100,856	47,641	39,209
Surface transport and technologies	82,985	47,629	39,714
Advanced materials	90,078	46,631	31,977
Electronics, microelectronics	109,046	46,085	28,642
Information processing, information systems	78,676	34,227	30,308
Renewable energy sources	39,302	28,673	27,387
Energy storage, conversion and transport	27,875	19,876	18,553
Automation	53,573	19,357	16,552
Biosciences	32,651	18,374	12,034
Medicine, health	39,179	18,142	14,193
Energy savings	28,467	17,622	14,495
Measuring techniques	28,096	14,641	8,236
Construction engineering	19,472	11,529	8,108
Other technologies	21,522	10,987	6,584
Space	12,085	8,630	8,630
Medical biotechnology	13,920	8,220	5,685
Waste management	12,266	8,049	5,106
Safety	10,339	7,602	7,463
Mathematics, statistics	10,058	6,848	4,711
Industrial biotechnology	4,159	2,814	1,724
Aviation and technologies	3,772	2,791	2,791
Sustainable development	3,469	2,552	2,410
Foodstuffs	4,213	2,520	2,028
Environment	3,849	2,426	1,675
Robotics	3,311	2,159	2,090
Business aspects	2,285	1,543	1,055
Economic aspects	3,422	1,529	996
Nanotechnologies and nanosciences	1,450	1,087	1,087
Network technologies	4,019	1,004	1,004
Information, media	1,721	980	576
Agricultural biotechnology	1,883	962	962
Social aspects	726	475	475
Agriculture	852	433	433
Other energy topics	559	396	396
Regional development	535	383	383
Coordination, cooperation	613	370	370
Meteorology	355	261	261
Geosciences	378	211	211
Research on climate change and the carbon cycle	130	129	129
Telecommunications	228	100	100
Project management methods	67	47	47
without classification	16,794	9,235	9,117
Total result	**1,001,893**	**521,522**	**398,341**

Source: Austrian Research Promotion Agency (FFG).

Table 22: Austria Wirtschaftsservice (aws): Shares of new approvals by topic area of the promotion (industry), 2014–2016

Discipline, topic area or industry sector	2014		2015		2016	
	in %	in € millions	in %	in € millions	in %	in € millions
Services	15.3	112.9	15.5	128.2	19.5	158.4
Electricity, gas and water supply	0.6	4.5	0.2	1.9	0.2	1.4
Trade, maintenance, repair	8.2	60.6	14.4	118.6	15.0	121.2
Food products, beverages and tobacco, LW, FW	9.8	72.0	11.5	94.8	12.8	104.1
Manufacturing	49.8	367.1	45.6	376.3	37.5	304.0
Other industries	1.0	7.7	1.1	9.0	0.7	6.0
Tourism	10.5	77.7	6.8	56.3	9.8	79.7
Transport and communication	1.6	12.2	2.2	18.1	2.0	15.9
Not classified	3.0	22.2	2.7	22.4	2.5	20.1
Total	**100.0**	**736.8**	**100.0**	**825.6**	**100.0**	**810.9**

Source: Austria Wirtschaftsservice (aws).

Table 23: Austria Wirtschaftsservice (aws): Shares of new approvals by organisation size, 2014–2016

Organisation type	2014		2015		2016	
	in %	in € millions	in %	in € millions	in %	in € millions
Sole proprietorships	10.6	78.3	9.7	80.2	8.0	64.6
Microenterprises	12.0	88.4	13.4	110.6	15.2	122.9
Small enterprises	25.9	191.1	25.8	213.1	29.9	242.6
Medium-sized enterprises	20.4	150.1	29.6	244.5	28.4	230.6
Large firms	28.2	207.7	19.1	158.1	16.7	135.5
Not classified	2.9	21.0	2.3	19.1	1.8	14.7
Total	**100.0**	**736.8**	**100.0**	**825.6**	**100.0**	**810.9**

Source: Austria Wirtschaftsservice (aws).

Table 24: Austria Wirtschaftsservice (aws): Overview of funding performance by region, 2015–2016

	Confirmed		Financing amount (in € millions)		Cash value (in € millions)		Total project costs (in € millions)		New jobs	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Burgenland	83	63	20.4	4.5	2.7	0.9	35.3	11.7	188	73
Carinthia	311	360	68.8	74.1	4.8	4.5	120.8	127.4	383	401
Lower Austria	624	493	95.8	135.8	14.3	17.7	243	350	864	697
Upper Austria	1,465	1,090	275.7	314	16.7	25.1	447.5	539.4	1,606	1,723
Salzburg	424	257	51.9	53.7	3.8	6.8	99.6	106.6	296	253
Styria	728	458	137.2	77.3	17.7	10.3	293	164.7	1,267	423
Tyrol	420	301	77.4	46.6	10.4	8.2	173.9	113.5	368	258
Vorarlberg	175	84	12	15.9	1.6	1.6	46.3	33.1	87	51
Vienna	874	738	69.2	71.2	23.1	22.7	390	208.7	537	825
Abroad	14	18	8.8	9.2	0.2	0.5	17.1	27.3	22	26
Without classifica-tion	8	12	8.4	8.6	8.2	8.2	8.5	9.5	8	21
Total	**5,126**	**3,874**	**825.6**	**810.9**	**103.4**	**106.6**	**1,874.90**	**1,691.90**	**5,627**	**4,750**

Source: Austria Wirtschaftsservice (aws).

Table 25: CDG: CD laboratories by university/research institute and JR Centres by university of applied sciences, 2016

University/research institute	Number of CD laboratories	Budget [in €]
University for Continuing Education Krems	1	186,000
Medical University of Graz	1	173,680
Medical University of Innsbruck	3	257,200
Medical University of Vienna	10	3,141,471
University of Leoben	7	2,463,417
Graz University of Technology	4	1,551,857
Vienna University of Technology	16	5,511,885
University of Natural Resources and Life Sciences Vienna	9	2,499,867
University of Innsbruck	1	242,073
University of Linz	8	2,437,442
University of Salzburg	2	991,318
University of Vienna	2	431,737
University of Veterinary Medicine Vienna	2	705,523
Vienna University of Economics and Business	1	129,562
Austrian Academy of Sciences	1	336,436
Research Center for Non Destructive Testing GmbH	1	80,757
Forschungszentrum Jülich GmbH	1	452,623
University of Göttingen	1	96,667
University of Cambridge	1	385,442
Total	**72**	**22,074,957**

University of applied sciences	Number of JR Centres	Budget [in €]
Fachhochschule Joanneum Gesellschaft mbH	1	114,625
Carinthia University of Applied Sciences - non-profit foundation	1	315,971
Fachhochschule Salzburg GmbH	1	188,653
Fachhochschule St. Pölten GmbH	1	319,991
University of Applied Sciences Technikum Wien	1	319,055
Fachhochschule Vorarlberg GmbH	2	362,790
FH OÖ Forschungs und Entwicklungs GmbH	1	357,691
IMC Fachhochschule Krems GmbH	1	180,120
Total	**9**	**2,158,896**

Source: CDG.

Note: Budget data 2016 are plan data as of 16 Dec. 2016.

Table 26: CDG: Development of the CDG 1989–2016 and JR Centres, 2012–2016

Year	Expenditure of the CD laboratories and JR Centres [in €]	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	24,233,853	72	9	137

Source: CDG.

Note: Budget data 2016 are plan data as of 16 Dec. 2016.

Table 27: CDG: CD laboratories by thematic cluster, 2016

Thematic clusters	Number of CD laboratories	Budget [in €]
Chemistry	10	3,741,546
Life Sciences and environment	13	4,173,585
Manufacture of machinery and equipment, instruments	5	1,566,063
Mathematics, informatics, electronics	17	5,228,837
Medicine	13	2,707,654
Metals and alloys	8	2,767,266
Non-metal materials	4	1,483,169
Economics, social sciences and jurisprudence	2	406,836
Total	**72**	**22,074,957**

Source: CDG.

Note: Budget data 2016 are plan data as of 16 Dec. 2016.

Table 28: CDG: JR Centres by thematic cluster, 2016

Thematic clusters	Number of JR Centres	Budget [in €]
Chemistry	1	114,625
Life Sciences and environment	-	
Manufacture of machinery and equipment, instruments	-	
Mathematics, informatics, electronics	6	1,743,511
Medicine	1	180,120
Metals and alloys	-	
Non-metal materials	1	120,640
Economics, social sciences and jurisprudence	-	
Total	**9**	**2,158,896**

Source: CDG.

Note: Budget data 2016 are plan data as of 16 Dec. 2016.