



**Rat für Forschung und
Technologieentwicklung**

Report on Austria's Scientific and Technological Capability 2022



Preamble

The Austrian innovation system is characterised, as in other highly developed national economies, by complex interrelations and interdependencies. Not least of all the Covid-19 pandemic and the challenges of climate change and digitalisation (*twin transition*) have made it crystal clear how deeply interwoven the innovation system is with society and the speed at which it changes. For this reason, the Austrian Council for Research and Technology Development (AC) regularly promotes increased awareness for the urgency of measures and the need for systemic action.

In a highly networked innovation system it is generally not effective to begin with subsystems or individual fine tuning points. Players in the RTI system, but also the political decision makers must pursue a systemic approach for this, which requires agile governance, high transparency and steering instruments, to be able to act swiftly. Such an approach also requires an appropriate digital infrastructure, which is capable of quickly making relevant data available. Likewise, the availability of associated management knowledge is also a requirement for the success of the green and digital transformation.

»
A systemic approach requires agile governance, high transparency and steering tools.

With the annual *Report on Austria's Scientific and Technological Capability*, since 2012 the Austrian Council has been offering RTI system players and political decision makers an appropriate solid foundation for evidence-based, systemic and effective action. This year, the Austrian Council takes the constantly changing requirements with this task for a freshly thought-out report and the new web-based RTI monitor¹ into account.

Linking the indicators with the goals of the RTI Strategy 2030

In the RTI Strategy 2030, the Austrian Government has defined the most important goals and areas of action of the RTI policy for this decade, to develop Austria into a leading nation in research, technology and innovation. This necessitates continuous goal-oriented monitoring of the RTI system. The Austrian Council therefore pursues a new approach with this *Report on Austria's Scientific and Technological Capability*: By first linking the indicators for measuring the RTI system's performance with the goals of the RTI Strategy 2030, not only will systemic correlations become clear, but rather direct and indirect leverage effects on the individual strategy goals will also become visible by way of example. The systemic causal relations will then be illustrated. The graph on the right of the table of contents symbolises the impact-oriented RTI instruments portfolio. RTI framework conditions, core RTI system, RTI cross-cutting issues and impact. On one hand, the report allows the RTI goals to be located in the RTI system areas and on the other hand, the leverage effect on the goal achievement, coming from the RTI system areas, can be emphasised.

1 Austrian Council's RTI Monitor at fti-monitor.rfte.at

FTI-Ziele

1. Zum internationalen Spitzenfeld aufschließen und den FTI-Standort Österreich stärken

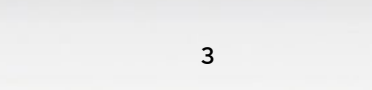
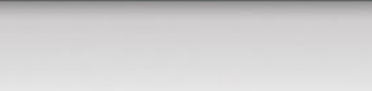
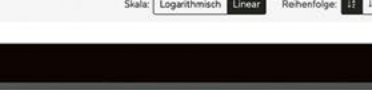
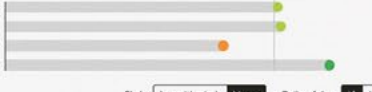
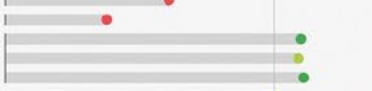
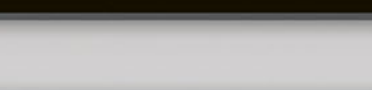
- 110 DSI Index
- 112 DES
- 113 Global Innovation Index
- 12 F&E-aktive Unternehmen um 20% steigern
- 13 Teilnahme an 3 weiteren IPCEIs
- 14 Digitalisierung stärken

2. Auf Wirksamkeit und Exzellenz fokussieren

- 21 OECD-Top-5 bei F&E-Quote
- 22 Venture Capital Investitionen auf 0,5% des BIP heben
- 23 100 % mehr wirtschaftlich erfolgreiche akademische Spin-offs
- 24 Top-10-Platzierung bei ERC Grants
- 25 Beteiligung an Horizon Europe stärken
- 26 Top-3-Platzierung bei Erfolgsquote Horizon Europe
- 28 Steigerung Erfolgsquote Unternehmenssektor (Horizon Europe) von 18,2% auf 20%

3. Auf Wissen, Talente und Fertigkeiten setzen

- 311 MINT-Absolvent*innen um 20% steigern
- 312 Steigerung des Frauenanteils bei Graduierten in technischen Fächern um 5 %
- 32 Top-3-Platzierung im IMD-World Talent Ranking
- 33 Zwei österreichische Universitäten unter den Top 100
- 34 Universitäten: Auslandsanteil bei neuen Anwerbungen 45%

FTI-RAHMENBEDINGUNGEN
RESSOURCEN & ANREIZE

Ratsempfehlungen

- Empfehlung "Sense of Urgency in der FTI-Politik", 2021
- Ratsempfehlung zur Etablierung von Entrepreneurship-fördernden Kompetenzen im österreichischen Bildungssystem, 2019
- Empfehlung zur Finanzierung von Bildung, Forschung und Innovation in Österreich, 2016
- Zur langfristigen Finanzierung des österreichischen Bildungs- und FTI-Systems, 2012

Auftragsstudien

- Entrepreneurship-fördernde Kompetenzen im österreichischen Bildungssystem, BDO Consulting, 2019
- Migration, Integration und Bildung, Rat FTE, 2015/2017
- Auswirkungen der Transatlantischen Handels- und Investitionspartnerschaft (TTIP) auf den Bildungs- u... OFSE, 2016
- Aufgaben und Anforderungen an Forschung, Bildung und Innovation... SERI, 2015
- Vision Österreich 2050, IHS, 2013

Daten

- Stärken- und Schwächenanalyse, 2022
- Indikatorenliste, 2022

Weitere Bereiche FTI-Querschnittsthemen



Indikator



Internationaler Vergleich



Teilindikatoren



Focus on the most important findings and evaluations

Decisions that influence the RTI system must be made efficiently and effectively and their systemic effects must be assessable. This requires faster and more direct access to data, analyses and statistics. Precisely this has been implemented in this report: Concise descriptions and quickly found data focus on the most important findings and evaluations. The systemic interdependencies within and between the subsystems of the RTI instrument portfolio and the goal achievement progress are highlighted with visual and structural elements.

RTI monitor: Digital possibilities provide added value

There is high valuable information potential, which cannot be illustrated and exploited in a print medium. The corresponding digital RTI monitor therefore begins with this year's report: In this new, web-based monitor, we provide our stakeholders structured comprehensive data, resources and functions, which analyse, visualise and therefore make the innovation policy correlations and their development easier to record over time.

» The RTI Monitor uses digital possibilities, to fully exploit the potential of the report.

To quickly illustrate the data it is then possible to select from various presentation forms, have individual or composite indicators displayed or to analyse them dynamically over a period of time and in relation to the respective innovation leaders, the EU and the top three countries.

The already mentioned embedding of the RTI strategy goals in the RTI system's indicators allows us to quickly identify direct and indirect leverage effects and to specify need for action.

All visualisation elements and calculated values are also available for the general public to download, such as the Council recommendations, statements, strategy documents and studies relevant for the respective indicators.

This report is closely linked with the RTI monitor: Via QR codes, the readers go directly to the RTI system indicator or the RTI Strategy 2030 goal they want – and therefore to the described data, resources and functions.

Overcoming the challenges of the *twin transition*

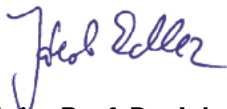
In view of the deep-seated global structural change, effectively and efficiently increasing the Austrian RTI system's performance and exploiting its potential are key issues for the Austrian Council. With the new report and the RTI monitor, the Austrian Council offers all stakeholders in the RTI system an instrument that delivers important, reliable information as the basis for systemically effective decisions and which contributes to securing Austria's competitiveness and overcoming the grand challenges of our time, such as the green transformation and the digital transformation.



Dr.ⁱⁿ Klara Sekanina
Chairperson



Dr.ⁱⁿ Dr.ⁱⁿ Sabine Herlitschka
Deputy Chairperson



Univ.-Prof. Dr. Jakob Edler



Dr. Hermann Hauser



**em. Univ.-Prof.ⁱⁿ Dr.ⁱⁿ
Helga Nowotny**



**Univ.-Prof.ⁱⁿ Dr.ⁱⁿ
Sylvia Schwaag-Serger**

Introduction

Two years of the COVID-19 pandemic have produced countless socio-economic changes and challenges, such as the massive falloff in economic activity coupled with increased uncertainty. The European Commission and the Austrian Government have reacted with appropriate support measures to mitigate the negative effects on long-term growth potential. The planning uncertainty, which is high anyway, is now even higher because of Russia's invasion of Ukraine, whereby, along with welfare and security aspects, we are also seeing severe supply chain interruptions.

European countries and the European Commission have summoned up significant resources to counter the economic effects of the COVID-19 crisis. With NextGenerationEU², the European Commission has also initiated a stimulus package in the billions to boost the upturn in Europe, the largest component of which is the Recovery and Resilience Facility (RRF)³ crisis management plan. The RRF is an important instrument to make national economies more resistant and to accelerate the transformation towards a green and digital economy. In this context, Austria has developed the Austrian Recovery and Resilience Plan⁴ (RRP), which, following positive evaluation by the European Commission in July 2021, was subsequently adopted by the EU's Council of Finance Ministers.

The RRP consists of reform measures and investments. The plan's most important investments are those made in environmentally friendly mobility, broadband expansion and measures to promote companies' ecological transformation (see Dachs/Weber 2022: 17). About half of the research and innovation-related resources goes to the Austrian universities. In the areas of hydrogen and GreenTech innovation, for example, Austria, however, invests significantly less in places in research and development than the innovation nations. Briefly, therefore, Austria only invests (ex aequo with Sweden) about 7 percent of funding in innovation and R&D, while, for example, in Belgium it is 17 percent and in Finland 21 percent (see Dachs/Weber 2022: 24ff.). Even if Austria's RRP is small compared to Italy, Spain or France's plans, the transformative content compared to the EU average (see Dachs/Weber 2022: 27), and also to the innovation leaders, Finland, Sweden and Belgium, is comparatively high. The RRP includes a high level of transformative investments, which are aimed at climate and digitization goals. The climate measures in the international comparison in particular may have a high impact here.

» The transformative content of Austria's RRP is high even in comparison to the Innovation Leaders is high.

- 2 European Recovery Plan, ec.europa.eu/info/strategy/recovery-plan-europe_de
- 3 NextGenerationEU, Recovery and Resilience Facility, ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_de
- 4 The EU Recovery Plan: Economic comeback with green and digital focus, bundeskanzleramt.gv.at/eu-aufbauplan/der-eu-aufbauplan.html and oesterreich.gv.at/nachrichten/allgemein/EU-Aufbauplan.html

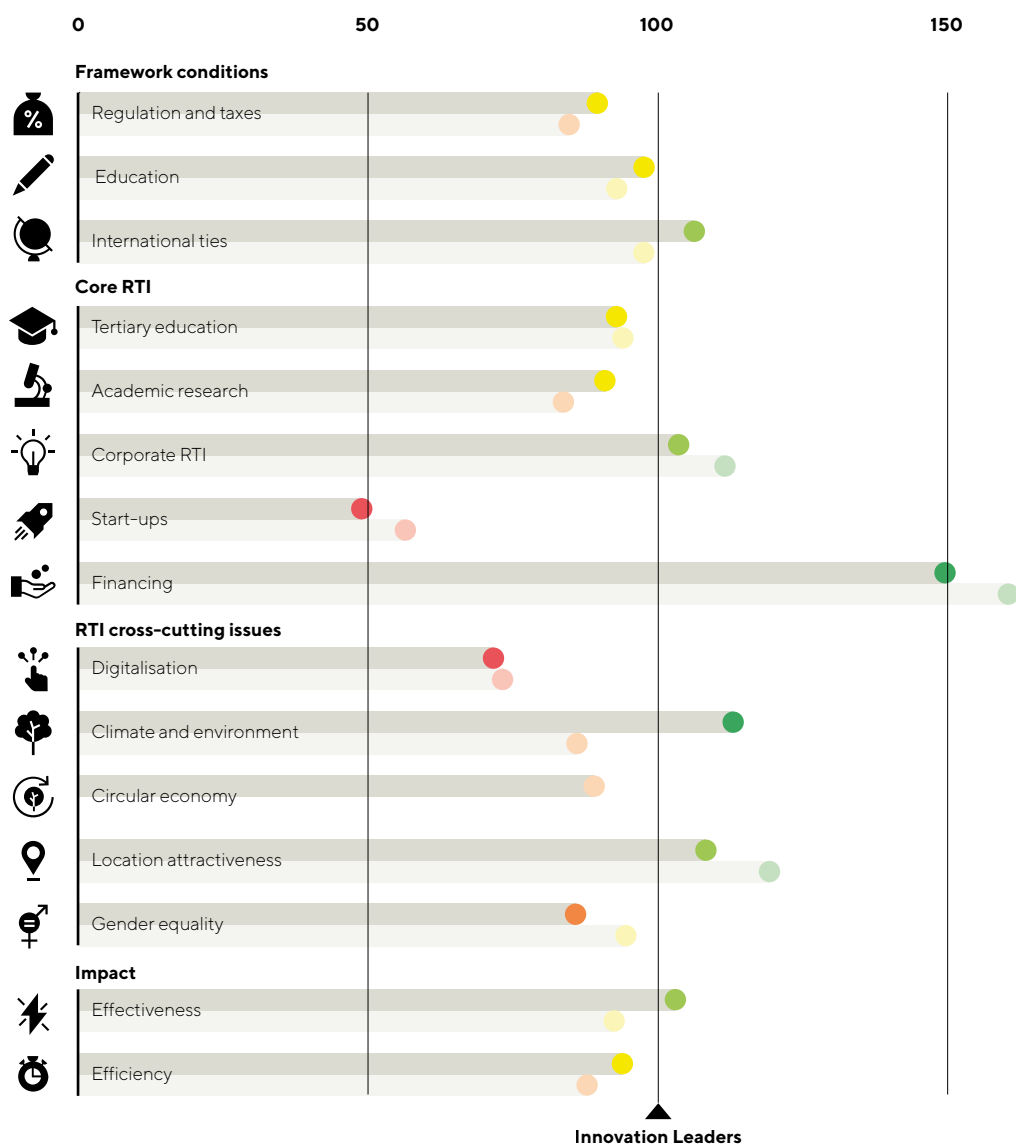


Figure I: Overview of Austria's strengths and weaknesses compared with the innovation leaders, 2022 versus 2021

- Value $\geq 109,5$
- $99,5 \leq \text{Value} < 109,5$
- $89,5 \leq \text{Value} < 99,5$
- $74,5 \leq \text{Value} < 89,5$
- Value $< 74,5$



The national COVID aid measures attach even greater importance compared to the RRP (see Loretz et al. 2021: 53-65). The measures should in particular protect companies and employees against the negative effects of the crisis, however only earmark a small amount of funding for research, innovation or transformation. From the transformation point of view, the investment premium is the most interesting part of the national stimulus package. It is practically unique in its objective, its regulations and its scope within the European Union. In the long term, the measure should in particular increase the location's competitiveness.

Against the backdrop of the targeted location securing and improvement, the overview graphic for the overall indicators of each of the RTI areas of the RTI system dealt with in the report, verifies mixed performance with some strengths and significant weaknesses.

Based on the indicators, on the whole we see the image of an open national economy with good international ties, which intensively (open-theme) promote RTI activities with companies in particular and therefore, in addition to other factors, also achieve good performance with economic and social indicators. To date the RTI system has addressed challenges such as the green transformation and the digital transformation considerably less theme-specific. In the chapter on location and industry policy, for the first time the 2020-2024 Austrian government programme announced the development of a strategic measures plan for environmental technologies and for the circular and recycling economy (see Austrian Government 2020: 61ff.). Furthermore, following extensive preparations and with the inclusion of more than 400 stakeholders, in 2021 the Federal Ministry of Climate Protection, Environment, Energy, Mobility, Innovation and Technology (BMK) presented the Austrian circular economy strategy in a first draft, which will define the guiding framework for the years ahead (BMK 2021b). The Austrian Council has already incorporated the RTI goals contained herein into this report and proactively defined them as a priority topic. The Council also takes into account the requirement for an appropriate monitoring system to implement the circular economy, by presenting a corresponding set of indicators in section III for the first time (see chapter C.3 Circular economy). Entirely in line with the holistic concept of the circular economy, this report itself was also designed as a *cradle-to-cradle* product.

»
To date the RTI system has addressed challenges such as the green transformation and the digital transformation considerably less theme-specific.

Together with the RRP, the increase in the public sector environment and energy R&D financing, which is a positive development for the climate and environment area compared to the previous year, marked the beginning of a new phase of the Austrian RTI system, in which even more effective efforts to manage the transformation grow in importance. This is all the more important, as Austria continues to score poorly with the key impact indicators in the environment area (see chapter C.2 Climate and environment, with CO₂ emissions, for example).

In the areas of international ties and effectiveness, Austria's level is above that of the innovation leaders⁵. The greatest weaknesses and problem areas in the core RTI system, however, include the area of innovative start-ups and the RTI cross-cutting issues of the digitalisation global megatrend – both of which the EU Commission and the Austrian Government have declared as priority areas of action. Austria is also behind the innovation leaders in the areas of education (primary and secondary), tertiary education and academic research. Especially significant here, too, is the gender equality deficit, where the situation has even further deteriorated compared with previous years.

Accelerated by the COVID-19 crisis, the deep-seated structural change clearly lays bare the weaknesses of the RTI system. It is therefore no longer enough to simply twist and turn on individual fine tuning points. It is now a collective responsibility to swiftly address the necessary systemic change while safeguarding the respective European values. As in other countries, for Austria the crisis not only meant an accelerated structural change – it also opened a window of opportunity to actively steer this change. However, from this point of view in particular, the stimulus packages also offer more scope for improvements. Research and innovations, which target a transformative change, require a different intervention logic to subsidies for other investments. More agile measures, aimed at a radical change and which accelerate stronger interaction between the various players, are required (see Dachs/Weber 2022: 19).

5 Innovation Leaders 2021: Denmark, Finland, Sweden, Belgium. See European Innovation Scoreboard, ec.europa.eu/research-and-innovation/en/statistics/performance-indicators/european-innovation-scoreboard/eis [1.3.2022].

Report on Austria's Scientific and Technological Capability 2022

The inside of this report's jacket cover presents the priority goals of the Austrian Government's RTI Strategy 2030, which are systematically numbered for easier referencing in the report's sections. The RTI system, however, is in the form of a graph, consisting of the subsystems (RTI framework conditions, core RTI system, RTI cross-cutting issues, impact) and the respective areas within these subsystems (in the RTI framework conditions subsystem of the "A.1 Regulation and taxes" area, for example). The graph maps the causal relations within the system. The area is linked with the RTI Strategy 2030 goals that are relevant for it via an alphanumerical index. This allocation is based on the performance pinpointing with the indicators that measure the performance of the respective area. The colour coding resembles a traffic light system and provides immediate information on the current capability with regard to the goal achievement compared with the innovation leaders in this performance period.

In the web-based RTI monitor⁶ introduced this year, the allocation is bidirectional – beginning with the individual RTI goals, reference is made to the respective RTI subsystems and their areas and vice versa, depending on the users' points of view. The key RTI policy leverage, which each of the RTI areas from the strengths-weaknesses analysis has on the goal achievement, is also pinpointed by way of example. All data can be historically traced over time series via the web-based RTI monitor. There are quantitative goal values for most of the objectives, to be able to measure the performance with the implementation of the RTI strategy. However not all goals can be illustrated with available data and statistics.

This report is closely connected with the web-based RTI monitor briefly described in the preamble. Each chapter leads via a QR code directly to the respective RTI system indicator and to further detailed data material and corresponding statistics. This performance report therefore no longer includes annexes and redundant figures and tables are intentionally avoided. The realigned performance report is structured as follows:

- **I. Analysis of the objectives of the RTI Strategy 2030**

In this section, the objectives and the respective goal values are presented together in a table and selected goals are then described in more detail.

- **II. Strengths and weaknesses of the Austrian RTI system in the international comparison**

The analytical approach for the strengths-weaknesses analysis is essentially identical to the previous report the year before; details on the methodology are provided in a baseline study by the Austrian

»
Report and RTI Monitor
are closely linked and
complement each other.

⁶ see fti-monitor.rfte.at [1.3.2022].

Institute of Economic Research (WIFO – Janger/Strauss-Kollin 2020: 3ff.). In each section, there are various subareas with corresponding individual indicators and an overall indicator. The latter is calculated as the arithmetic average of the respective individual indicators. Such aggregated indicators enable a simplified presentation of essential RTI system performance findings. Recommendations for action based on these findings are worked out after each section.

Dynamic benchmarking based on the innovation leaders

As already in the reports of past periods, the innovation leaders as per the European Innovation Scoreboard⁷ are used as a benchmark. This year, these are once again the countries that have already ranked in the leader group for some years now, Denmark, Finland and Sweden – rapidly catching up, Belgium joined these in 2021, while the Netherlands and Luxembourg departed. These changes also contribute to Austria's annually fluctuating relative performances, as each country has different performance profiles. Belgium, for instance, is more industrialised than the Netherlands, spends more on business support, but is not as advanced as the Netherlands in the academic research area. A purely static benchmark would have the disadvantage of not being able to trace dynamic performance changes, as in Belgium's case, for example. Considering the changes within the international leader groups also enables Austria's logical relative positioning in a changing competitive environment. The Council therefore believes the agile orientation on a dynamically changed leader group is advantageous, despite the resulting challenges for interpreting the annually changing rankings.

»
The agile orientation to a dynamically changing top group enables a meaningful relative positioning of Austria.

Indicators set-up and logic

For additional illustration the average of the EU member states and that of the (for the respective indicators) top three countries⁸ are also used as comparative values, which are more reliable relative to Austria. The colours in the figures or tables visualise these ratio values with regard to Austrian performance, similar to a traffic light system. A value of 100 percent corresponds in this logic with the average performance value of the respective comparison group (EU, innovation leaders or top 3 countries). Green and bright green here indicate Austrian performance that is at or above the average level of the respective comparison countries. Yellow shows a lower, orange and red a higher or very high distance to the average level of the comparison countries.

7 EU Commission (2021), *European Innovation Scoreboard 2021*, ec.europa.eu/info/research-and-innovation/statistics/performance-indicators/european-innovation-scoreboard [1.3.2022].

8 In naming the respective top three countries, only those countries for which data is available with all individual indicators are used for the composed indicators. However, Austria's ratio value for the top three in the composed indicators is calculated based on the average of the top 3 ratio value in the individual indicators. Occasionally there is therefore a discrepancy here between the countries named with the composed indicators and Austria's ratio value with the top three, which is produced from the average of the individual indicators.

- Value $\geq 109,5$
- $99,5 \leq \text{Value} < 109,5$
- $89,5 \leq \text{Value} < 99,5$
- $74,5 \leq \text{Value} < 89,5$
- Value $< 74,5$

As before, the report on Austria's scientific and technological performance is based on public access databases of international organisations such as Eurostat, the OECD, Statistik Austria, UniData, THE or the World Bank, which were compiled by WIFO as commissioned by the Austrian Council to be delivered on 2 February 2022.

I

Analysis of selected goals of the RTI Strategy 2030

GOALS OF THE RTI STRATEGY 2030		Current value	RTI goal	Goal achievement
1	Become an international innovation leader and strengthen Austria as an RTI location			
1.1.1	Rank improvement in international indices: European Innovation Scoreboard (EIS)	10	5	50
1.1.2	Rank improvement in international indices: Digital Economy and Society Index (DESI)	10	5	50
1.1.3	Rank improvement in international indices: Global Innovation Index (GII)	18	10	56
1.2	Increase number of R&D-active companies by 20 %	3872	4187	92
1.3	Participating in at least 3 additional IPCEI	4	5	80
1.4	Drive forward digital transformation	composite indicator		70
2	Focus on efficiency and excellence			
2.1	OECD top 5 in R&D rate	7	5	71
2.2	Expansion of the venture capital pool to 0.1% compared to GDP	0.07%	0.1%	72
2.3	100 % more economically successful academic spin-offs			
2.4	Top 10 placing with European Research Council (ERC) grants	4	10	100
2.5.1	Strengthen participation in Horizon Europe	2.9%	> 2.9%	na
2.5.2	Top 3 ranking in Horizon Europe (or Horizon 2020) success rate	3	3	100
2.6	Increase the corporate sector's success rate with Horizon Europe	17.3	20	86
3	Promote knowledge, talents and skills			
3.1.1	Increase STEM graduates by 20 %	23.4	28.1	83
3.1.2	Increase the percentage of women with graduates in technical subjects by 5 %	49.8	52.3	95
3.2	Top three place in the IMD-World Talent Ranking	6	2	33
3.3	2 Austrian universities among the top 100 (THE World University Ranking)	0	2	4
3.4	Universities: Foreign share in new recruitments 45 %	46%	45%	100

Degree to which the goals of the RTI Strategy 2030 were achieved in the 2022 performance period

On the left side, table 1 shows the objectives structured according to the three overriding goals of the RTI Strategy 2030 (see BKA 2020a: 7). These were already described in detail in the last performance report and compared with the corresponding areas of action from the RTI Package 2021-2023 (see BKA 2020b: 4-13). A corresponding overview has been added on the right side to illustrate the progress made in achieving these objectives and the distance to the goal values. The last available statistical value (as of January 2022) is used as the starting point for the respective detailed goals ("Current value"). The defined goal value from RTI Strategy 2030 is shown in the centre (second) column; the ratio between these two values is the degree of goal achievement⁹. The values of the goal distances are indicated by blue shading. The more intense the shade of blue is, the smaller the distance to goal attainment.¹⁰ A detailed description of the indicators used, the precise indicator names and the statistical sources are provided in the report via the QR code online in the RTI monitor¹¹.

Development paths of the past were then also analysed in the present using time series, and are provided as trend barometers in the web-based RTI monitor. In this report two subgoals are singled out from the "Join the international leaders and strengthen Austria as an RTI location" RTI Strategy goal. The subgoal "Participate in 3 more IPCEI" has almost been achieved and is a good example for the Austrian Council for an effective, systemically thought-out cross-sector and department approach for goal achievement. Analysis of the achievement of the "Increase digitalisation" RTI goal on the other hand shows that the urgency to accelerate the implementation of measures must once again be emphasised. Austria continues to lag far behind the innovation leaders here, and is also below the EU average, as shown by the strengths-weaknesses analysis.

⁹ This is an index value, which is calculated as follows: $(\text{current value}/\text{goal value}) \times 100$. A value of 100 indicates the achievement of an RTI Strategy 2030 goal; the lower the value, the greater the distance to achieving a goal.

¹⁰ For a detailed description of the traffic light system see "Indicators set-up and logic", page 11.

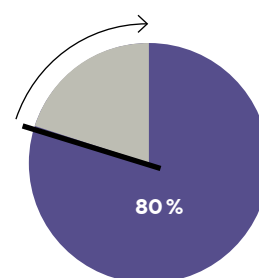
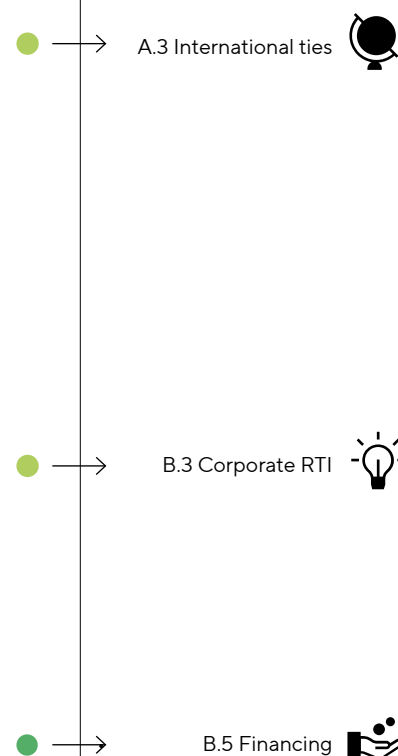
¹¹ Provisionally for the draft version of the PR 2022: fti-monitor-dev.rat-fte.at

1.3: Participate in 3 more IPCEI

RTI goal

—> Join the international leaders and strengthen Austria as an RTI location

Important Projects of Common European Interest (IPCEI) are a state aid mechanism for funding large-scale consortia projects, in which companies (together with “their” member states) implement big projects with European importance in strategically important value creation chains, whereby the member states and companies participating in the project are essentially responsible for the financing, and the European Commission is responsible for the approval (notification). This instrument is a key part of the current European industrial policy (see European Commission 2021), but can also be an important tool in pursuing other objectives (in the environment, energy, transport policy, for example) and is also explicitly intended for this (see European Commission 2014). The basis for reviving this instrument during the course of the initiative to modernise EU state aid laws was the awareness of restrictions on possible actions and mechanisms, which the EU possesses to respond to global competition and major economic and social challenges. Due to their effect logic that addresses the entire value creation chain and the competition conditions in the global context, the IPCEI are therefore a particularly promising response to a whole series of challenges, from sovereignty in especially important strategic technologies to the sustainable set-up of value creation, through to a general increase in the sustainability, innovation performance and competitiveness of European national economies.



Degree of goal achievement: 80 percent

Council recommendations picked out for this goal:

- > Recommendation for Austrian industrial policy realignment
- > 10 theses on technology sovereignty – basis for discussion



Data at:
fti-monitor.rfte.at/Z/1.3

Austria currently participates in four IPCEI¹² and has already virtually achieved the RTI Strategy 2030 goal of participating in another IPCEI (so five in total). This development is a success of the increased coordination between the two primarily responsible departments (BMK and BMDW), based on the proven finding that IPCEI (but also the resources of the Recovery and Resilience Facility) can open windows of opportunity to make significant progress with innovative economic and social transformations. It should, however, be noted, that IPCEI previously came about when larger member states took over the coordination, that is, whether or not Austria will be able to push forward with its interests in matters regarding future IPCEI is more than uncertain, and Austria's early and intensive commitment to the coordination processes necessary in this respect is required. Where the financing for further IPCEI might come from also remains unclear. To enable further participations and in this sense to be able to utilise Austria's strength in a strong Europe, that is, participation in setting up sustainable structures in technological and economic topics of the future, it is therefore necessary for the corresponding discussions, consultations and administration processes to provide significantly more resources than before and to also secure agile governance across and beyond department boundaries, via better coordination, for example.

In this respect, it is also important that the objectives that are pursued with the IPCEI participants, that is Austria's participation in the development of strategically important technologies and in particular the corresponding value creation within the scope of large-scale projects, are not exclusively linked with this instrument. Due to the high complexity with development, notification and so on, other support measures or demand-oriented instruments are more beneficial, as they are more agile and therefore more effective in implementation. Austria must also be in a position to set its own focus points when a European discussion on future focus points (and therefore also IPCEI), which are often dominated by bigger member states, does not address these. In this respect, it can be helpful to support bigger projects with comparable objectives in some other way (even if the state aid law liberties of an IPCEI are not used as a result). Appropriate implementation examples for this are the financing of Quantum Austria¹³, foundation of the Austrian Institute for Precision Medicine¹⁴ at the MedUni Campus of Vienna General Hospital (AKH Wien) and the further financing of digital infrastructures with funds of the Austrian Recovery and Resilience Plan.

¹² Microelectronics, Batteries, Microelectronics II, Hydrogen.

¹³ Federal Chancellery: Quantum Austria: Funding of quantum research and technologies, bundeskanzleramt.gv.at/eu-aufbauplan/projekte/quantum-austria.html

¹⁴ Eric Kandel, Institute for Precision Medicine, meduniwien.ac.at/web/forschung/eric-kandel-institut-fuer-praezisionsmedizin/

1.4: Increase digitalisation

RTI goal

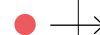
→ Join the international leaders and strengthen Austria as an RTI location

If we consider the historical development of digitalisation in Austria on the basis of the indicators this report is based on, we see the following situation, in which compared with the EU average, stagnation set in following a significant increase in performance during the report years 2011 and 2012, which only turned once again towards an upward trend in the past two years when the new indicators were considered (see figure 2). A linear extrapolation of the average performance change of the past twelve years would only first forecast for 2029 and only the exceeding of the EU average.

Compared with the innovation leaders, the dynamic of recent years does however show a declining trend, and with a current value of 71.5 percent, Austria is only very slightly above the average value of the past ten years. The current development for 2030 correspondingly does not result in any significant closing of the gap to the innovation leaders, indicating that the efforts made in this area must be increased significantly. A fact that is also taken into account in the current RTI Strategy 2030: The intensification of the digital transformation (see Austrian Government 2020: 7). Increasing the national efforts in this respect is actually possible and definitely necessary, as shown by the section on the current status of digitalisation in Austria. This is not just for scientific-technological reasons, but rather also has economic implications.

In this respect, it must be positively noted that – as part of the Recovery and Resilience Facility (NextGenerationEU) – Austria uses a significant share of the funds available for investments in digitalisation. The corresponding funds, which are to be used for digitalisation projects, run to € 1.8 billion (see BMF 2021: 9) and therefore to 41 percent of the total funds expended.

The applicable index for the digital economy and society (DESI) maps the status of digitalisation in the EU member states. In the analysis (DESI 2021) on which this report is based Austria occupies 10th place and turned around the downward trend of recent years (see European Commission 2021: 3). A significant increase in the respective efforts is nevertheless required for the targeted positioning among the top five by 2030 in accordance with the RTI Strategy 2030 (see Austrian Government 2020: 7). Currently this goal achievement does however appear possible – moving up into the top four, on the other hand, would be difficult.



C.1 Digitalisation



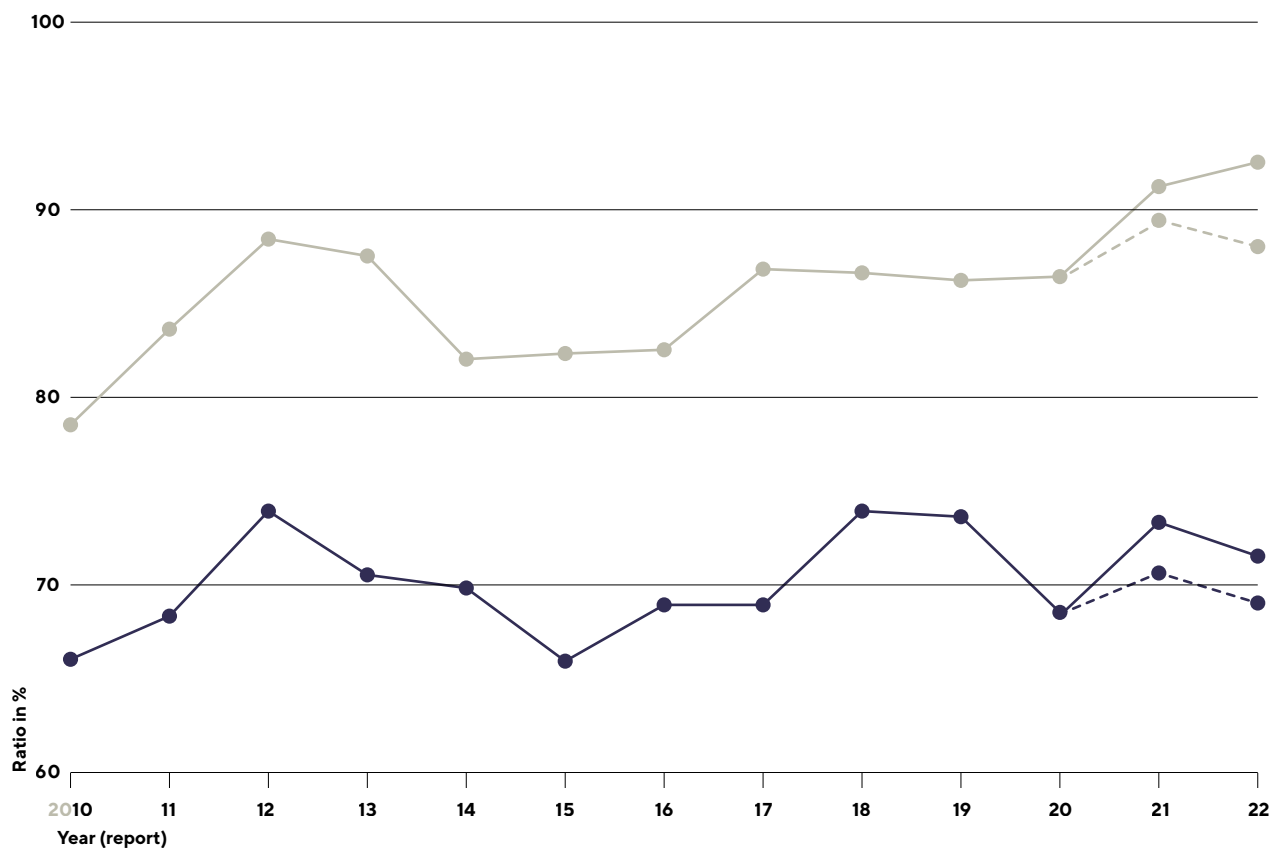
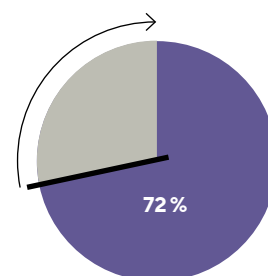


Figure 2: Historical development of digitalisation in Austria in relation to the EU and the respective innovation leaders in the period from 2010 to 2022

—●— IL ratio —●— EU ratio
 - - -●- - IL ratio (without AI etc.) - - -●- - EU ratio (without AI etc.)

Council recommendations picked out for this goal:

- > Recommendation, “Sense of Urgency in the RTI Policy”
- > Implementation of the Austrian Micro Data Center and the further development of a national research data strategy
- > Recommendation for the RTI policy during and after the COVID-19 crisis
- > Recommendation for the establishment of an holistic industry and technology policy strategy for a platform economy in Austria
- > Recommendation “create your UNiVerse” – Recommendations for action for the future shaping of the universities



Degree of goal achievement: 72 percent



Data at:
fti-monitor.rfte.at/Z/1.4

II

Strengths and weaknesses of the Austrian RTI system in the international comparison

RTI framework conditions

On one hand, framework conditions influence the incentives the innovation system will introduce for RTI activities. Product market regulation, for example, influences innovation incentives in a market via the intensity of competition. On the other hand, framework conditions offer supports or resources for innovation activities, by highly qualified employees, for example.

Three areas within the framework conditions are examined in more detail in the following analysis: In A.1 **Regulation and taxes**, these are the product, work and capital market regulation and the performance level of the capital market, as well as the tax system as general macroeconomic framework conditions; in A.2 the **education** system; and in A.3 Austria's **international ties**.

Regulation and taxes



Education



International ties



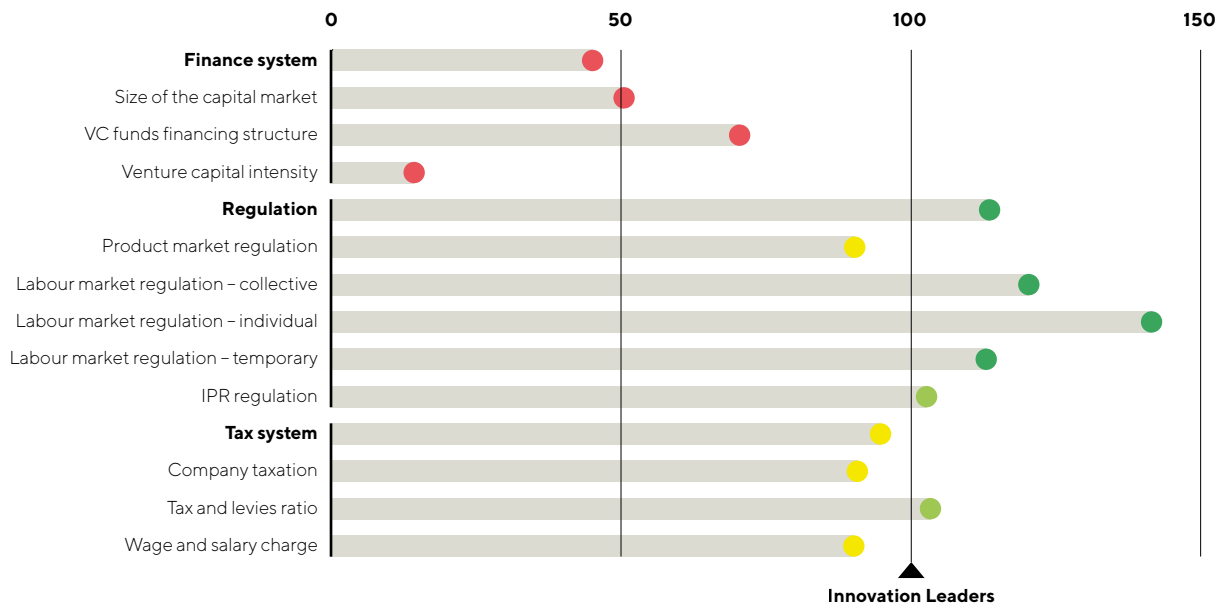


Figure 3: Strengths and weaknesses in the A.1 Regulation and taxes area compared with the innovation leaders

Direct goal assignment:

Goal 2: Focus on efficiency and excellence

2.2 Raise venture capital investments to 0.1% of GDP

Goal 3: Promote knowledge, talents and skills

3.2 Top three placing in IMD World Talent Ranking

Lever to goal achievement:

Goal 1: Strengthen Austria as an RTI location



Regulation and taxes

Regulation and taxes



Regulation and taxes are part of the essential framework conditions for the RTI system, as they significantly influence incentives and the resources available for innovation. Corresponding area-specific innovation incentives, for example, can be introduced via green taxes or the attractiveness for top executives to migrate (an RTI Strategy objective) can be influenced via income taxes. Product market regulation can stimulate competition, which itself in turn stimulates innovation activities.

Tax rates and regulation are based on laws and ordinances, which do not change as often as the financing indicators do. Changes of the indicators this year compared with the previous year are therefore, with the exception of the financing area, in particular attributable to Belgium's rise to join the leading innovation countries and the Netherlands' and Luxembourg's departure. On the whole, Austria remains just below-average, however compared with Belgium shows a more liberal labour market regulation, and taxes and levies in Belgium are also comparatively high.

Lack of venture capital continues to be a serious obstacle

As already in recent years and consistent with the Council's findings in earlier monitoring reports, the indicators for risk capital and the financial market score negatively. Indeed the recent major financing rounds (especially for Go Student and Bit Panda) and other positive activities, such as the successful start of the venture capital arm of IST Austria (IST Cube), for example, appear not yet to be reflected in the data. This however changes nothing with the basic evaluation that as a framework condition for successful RTI activities a bigger capital market and more comprehensive financing capital with venture investments are still required (see Keuschnigg et al. 2017). This finding is also reached based on the fact that Vienna is still not among the top fifteen European start-up hubs in various Start-up city rankings.¹⁵

» The quality and size of the capital market are important for financing of innovation activities enormous important.

RTI Strategy 2030 does not, however, include any reference to necessary regulatory and structural reforms of the Austrian capital market, and even with the measures to achieve the goal for higher risk capital intensity there is no such reference. Necessary here, nevertheless, are both an already long called for alternative corporate form for venture capital funds, for example, and the removal or reforming of those regulations that currently obstruct the growth of start-ups, such as the restrictive awarding of the "Rot-Weiß-Rot-Karte" (a kind of Austrian green card),

15 eu-startups.com/2020/11/top-30-europes-biggest-startup-hubs-in-2020/

which makes it difficult for talent to come to Austria. In this respect, the Council already proposed a 10-point programme to strengthen venture capital in Austria in 2019 (see Keuschnigg/Sardadvar 2019).

The eco-social tax reform is indeed the first step in the right direction, however further important measures are still required

In the taxation area with the tax reform just recently adopted there was a slight reduction in the corporation tax rate, however cornerstones of an eco-social tax reform in particular were also implemented for the first time. The call for higher taxation on environmental pollution (*public bads*) in the form of a successive increase in the taxation on CO₂ emissions is in turn met with a reduction in income tax. The latter is an already long-standing topicalised problem, because taxes on work are particularly negative employment inhibitors, especially in the area of part-time employment for women. It should be critically pointed out that within the scope of the implementation of the eco-social tax reform, only individual fine tuning points were tweaked and the systemic nature is not visible.

With regard to the (necessary) transformation towards the circular economy one aspect therefore becomes clear again: The introduction of individual instruments, twisting and turning on individual fine tuning points (the establishment of a higher CO₂ tax without support measures or setting up a general R&D funding programme for the circular economy, for example) will not be sufficient to decisively drive the transformation forward.

Basically a trade-off between the need to provide public assets for the RTI system (such as specialists, researchers, basic research, for example) and to gain the revenues required for this via taxation, which, for example, reduces the returns from innovations for companies and consequently can introduce negative innovation inhibitors. Efficient, but in particular high-quality public services are therefore especially important. In the direct comparison with the leading innovation nations, Austria does not exhibit any massive deficits in the taxation area, unlike the venture capital area, for example.

» Alternative corporate forms for venture capital funds and reform of the Rot-Weiß-Rot-Card are required.

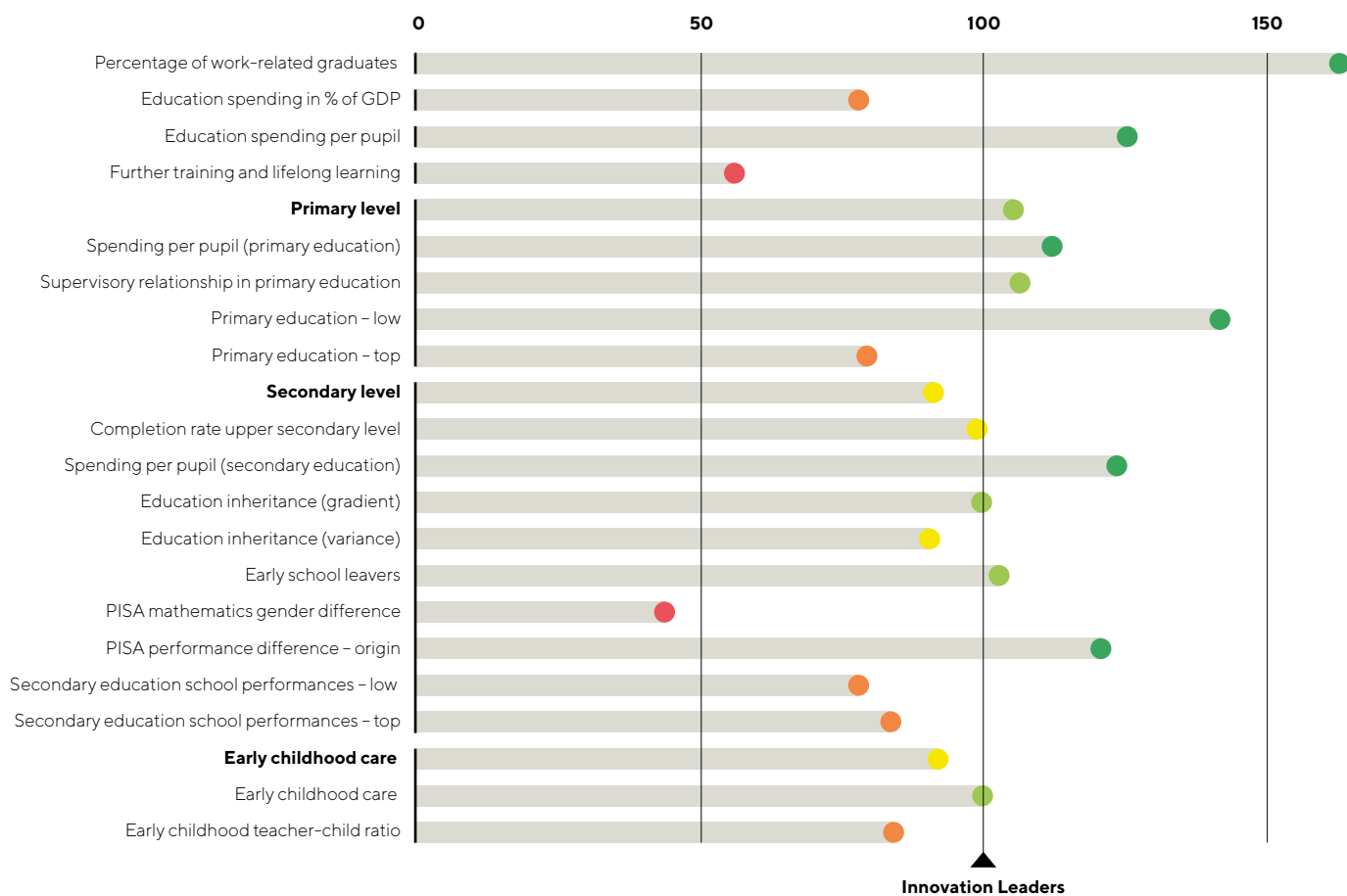


Figure 4: Strengths and weaknesses in the education area compared with the innovation leaders

Direct goal assignment:

Goal 3: Promote knowledge, talents and skills

3.2 Top three placing in IMD World Talent Ranking

Lever to goal achievement:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

1.4 Increase digitalisation

Goal 3: Promote knowledge, talents and skills

3.1.1 Increase STEM graduates by 20 %

3.1.2 Increase the percentage of women with graduates in technical subjects by 5 %



Education



Education



The school education system forms the foundation for both our country's innovation performance and for the lifestyle of each person. The fact that the indicators for the education area (without tertiary education) have already been showing significant weaknesses of the Austrian education system for some years now is therefore all the more problematic.¹⁶ Although the Austrian education system does indeed score better with many indicators than the EU average and there were also slight improvements, with the early childhood care ratio, for example, at the same time there is still a considerable deficit compared with the innovation leaders, which has even increased with some indicators (with education spending in percentage of GDP, for example). And compared with the top three Austria now only scores positively with one single indicator, the percentage of career-oriented graduates, as 76 percent of all graduates achieve a secondary education level II vocational graduation (especially in teaching, vocational secondary or higher level schools); the rest achieve a general education graduation (especially secondary school leaving qualifications). This fact, based on the traditionally good vocational training system in Austria, not only enables early job specialisation – it also and in particular contributes to the comparatively low youth unemployment rate in this country (see OECD 2021a, para. A3.5). On the whole however, the completion rate in the upper secondary level, that is with the percentage of people that are expected to achieve graduation in the secondary area II by the time they are 26 years old, is just below that of the innovation leaders (see OECD 2021a, table B3.3). Not least of all therefore, the Cabinet decision of 23 February 2022¹⁷ calling on the National Council to initiate a legislation development process for higher vocational education must be positively emphasised. The prospects of a higher vocational education will upgrade the standing of the dual training (teaching), however can also be an incentive for more people to achieve a graduation in the secondary area II.

» Austria is a country with a sharp focus on vocational training.

One of the most notable indicators has long been the very high performance difference in mathematics between girls and boys in Austria¹⁸ – and this although on the whole mathematics is the subject in which

¹⁶ That the situation has also changed very little this year as well is primarily attributable to the fact that there is currently no new education test data (PISA, TIMSS). The PISA survey planned for 2021 had to be postponed due to the COVID-19 pandemic and will now be held in 2022. The results can therefore only be expected in December 2023.

¹⁷ Cabinet presentation on 23 Feb. 2022, bundeskanzleramt.gv.at/medien/ministerraete/ministerraete-seit-dezember-2021/7-mr-23-feb.html [1.3.2022].

¹⁸ See RTI monitor: Strengths and weaknesses analysis 2022: A.2 Education, fti-monitor.rfte.at/B/A.2 [1.3.2022].



Austrian pupils score better in the international comparison than in other areas.¹⁹ The serious differences with the mathematics performances of girls and boys are also reflected in their self-image and their enjoyment in studying mathematics. Girls therefore perceive themselves as far less competent and also enjoy mathematics less. Children with migration backgrounds also perceive themselves as less competent, but show more enjoyment in learning mathematics (see BMBWF 2021a: 320, para. D2.5c). The “Strengthening training and further education, especially in the STEM area” need for action formulated in the RTI Strategy and “Strengthening equality and diversity in R&D” are also afforded special importance in this respect. However, already in the primary and secondary area measures must be urgently implemented to reduce the significant performance difference between girls and boys in mathematics and to also remove the accompanying social selectivity.

Learning with and via digitalisation as the basis for digitalisation

With regard to the “Consideration of creativity, critical investigative mind and environmental awareness on all education levels” formulated in the RTI Strategy, we will have to wait and see if and in what form this will be implemented in the new curricula that will apply from the 2023/2024 school year in the elementary and secondary schools, as well as the grammar school lower grades.

Increasingly of fundamental importance here are also the competencies in dealing with digital technologies. The COVID-19 pandemic in particular, especially however the need for distance learning connected with it, have illustrated the requirement both for digital literacy, therefore the identification of relevant content on the Internet, and for basic computer literacy and skills and an understanding of data-intensive technologies, such as artificial intelligence, for example.

» Of fundamental importance is *digital literacy*, i.e. competence in dealing with digital technologies.

The capacity for critically-competently dealing with these technologies is all the more urgent than with the plans of the tech giants with regard to a new interactive Internet (keyword – *metaverse*), where users will be faced with entirely new challenges, in the area of data security or identifying disinformation, for example.

The introduction of the digital basic education compulsory subject into secondary level I is to be welcomed. It must be ensured here that both application knowledge is valued and that computer science education and media literacy are implemented across the board. As a result, children and young people will consequently be enabled to make decisions, critically and well informed with regard to the role that these technologies play in their lives (*computational empowerment* – see BMBWF 2018).

¹⁹ The percentage of pupils with above-average performances in mathematics is 13 %, in the sciences on the other hand it is only 6 % and with reading only 7 %; at the same time the percentage of risk pupils in mathematics is 21 %, in the sciences 22 % and in reading 24 % (see BMBWF 2021: 301ff, esp. para. D2.4.d).

Continuing influence of socio-economic factors and migration backgrounds on competency acquisition

For years unchanged now there is the fact that, apart from in the vocational schools, in Austria what is referred to as “education inheritance” is highly visible and the percentage of children from socially vulnerable and educationally underprivileged families is disproportionately high among poor performance pupils, whereby high-performance pupils, on the other hand, are underrepresented. In this country, and also in the international comparison, considerable influence of the socio-economic background is thus shown here in the acquisition of competencies, which, even after consideration of further special features (migration background and first language), is maintained, although reduced.²⁰ With regard to the comparatively bad scoring in the area of reading literacy, the migration background and the first language also have a high explanatory power in the family home. Especially notable here is the fact that the percentage of poor performance pupils among children born here was sharply reduced in recent years compared with that with children with migration backgrounds (see BMBWF 2021a: 261ff, 321ff).

The effects that the COVID-19 pandemic and the distance learning phases it caused will have on educational justice and social selectivity cannot yet be conclusively evaluated. It has been shown, however, that children from disadvantaged socio-economic circumstances were faced with greater challenges when adapting to the pandemic-related changes than their same age peers who do not have the same disadvantages (see Bock-Schappelwein/Famira-Mühlberger 2021), which further exacerbates the problems of the Austrian school system. There is therefore cause for concern that the COVID-19 pandemic will also have medium and long-term effects, which cannot be removed with the introduction (basically beneficial) of summer schools alone, but rather also require additional intensive funding measures, because a lack of suitable applicants for apprenticeship openings could cause the scarcity of specialists, which is already virulent anyway, to further deteriorate.

Education



» Education inheritance, reading skills and gender difference in mathematics are problem areas.”

²⁰ See RTI monitor: Strengths and weaknesses analysis 2022: A.2 Education, fti-monitor.rfte.at/B/A.2 [1.3.2022].

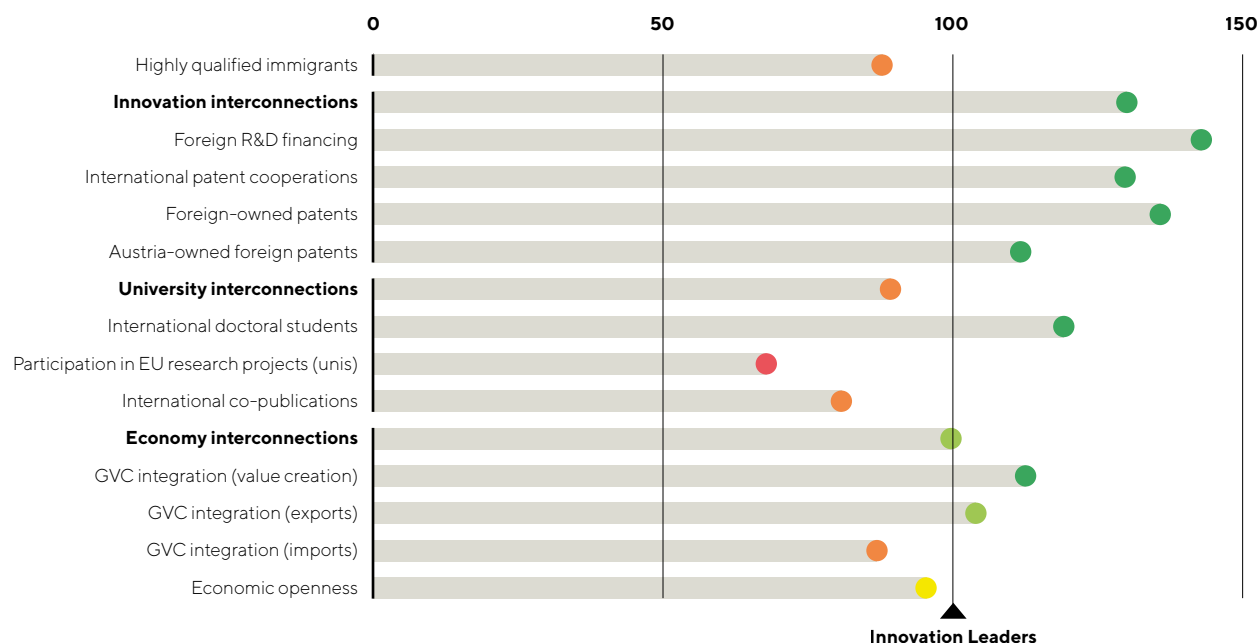


Figure 5: Strengths and weaknesses in the international ties area compared with the innovation leaders

Direct goal assignment:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

1.3 Participation in three more IPCEI

Goal 2: Focus on efficiency and excellence

2.5.1: Strengthen participation in Horizon Europe

2.5.2: Top 3 ranking in Horizon Europe (or Horizon 2020) success rate

2.6: Increase the corporate sector's success rate with Horizon Europe

Goal 3: Promote knowledge, talents and skills

3.4: Universities: Foreign share in new recruitments 45 %



International ties



Austria's international ties are measured using four dimensions: Labour market (immigration), universities, innovation and economy. The latter increased sharply in recent years with the increase in global economic and scientific relations, especially since EU accession, and is both the basis and result of an export-oriented national economy. The export rate (that is, goods and service exports measured on GDP) of 33.5 percent (1995) therefore rose rapidly to 52.6 percent (2020) and is currently significantly above the EU average (EU27) of 46.7 percent.²¹ This very successful development is clearly mapped in the data available for this report (see figure 5).

International ties



Economy as driver of strong international ties

Especially highlighted here is the fact that the majority of company-associated indicators show the same or even higher values than the innovation leaders group. This high level of international ties is also verified in the ETH Zurich globalisation index. Austria ranks seventh here (see KOF Swiss Economic Institute 2021). The fact that there were clear relative shifts with just a few indicators compared with the previous report the year before is, however, attributable to changes in the composition of the comparison groups (the Netherlands have stronger international ties than Belgium). As an example here we can point to the minimally adjusted foreign financing of R&D activities in Austria, which, based on data from 2019, is now clearly far higher above the level of the innovation leaders.

The more up-to-date data on ties in innovation activities (that is, patent analyses) also shows hardly any changes, apart from the patents in foreign ownership interpreted as an expression of location attractiveness, which have increased significantly, absolutely and relatively. Here too Austria is for the first time significantly above the level of the innovation leaders. Austria's international ties in innovation activities, which are excellent anyway, have thus increased once again and continue to be clearly above the also rather high general economic ties (integration into global value creation chains). The dependency of Austrian value creation on foreign demand (GVC Integration 1) in particular has once again increased here.

» In the area ›patents in foreign ownership‹ Austria is for the first time significantly above the level of the innovation leaders.

²¹ Statistik Austria: STATcube, foreign trade table.

In this context, it is also relevant that Austria has set itself the goal of participating in a total of five IPCEI by 2030. This objective has on one hand almost already been achieved, as Austria is already active in four IPCEI. Relevant for participation in a fifth IPCEI, on the other hand, would be how the substantial financial resources required for such can be provided. Theoretically, the corresponding established value creation chains could have effects that result in Austria's deeper economic integration in international correlations. As these IPCEI are neither in an early phase or even in the notification process, such an effect is, however, still unforeseeable at the moment.

International ties



Universities increasingly networking internationally

The indicators for the universities international networking are significantly above the EU average, but on the whole below the average of the innovation leaders. Data for international co-publications, international doctoral students and universities' participation in EU research projects is used for this report. Notable here is that this shows low participation by Austrian universities in EU research projects relative to the leading research countries, whereby the success rate on the other hand is evaluated as very good. The researchers at universities and non-university research institutions are also very successful with the acquisition of ERC grants.²² A strong participation rate in Horizon Europe, which is one of the goals of the RTI Strategy 2030 requires, among other things, stronger international cooperation activities with universities and research-active companies. Some universities have already defined focus points in their internationalisation strategies. A significant increase in the cooperation and participation activities, however, requires additional resources, that is, both human resources and funds for participating in international collaborations. This is because access to international research infrastructures is especially important for successful research at the top of the field. In addition to the research strengths and career conditions of recruiting institutions, this in turn is also an essential framework condition for achieving a further RTI Strategy goal, namely "to increase the percentage of science and research staff applying from abroad to universities in particular to 45 percent". Compared with the previous year this value improved once again, whereby Austria is now among the eight best ranked countries²³ and therefore in the area of the innovation leaders.

» Cutting-edge research requires access to international research infrastructure.

Significant growth can be seen with the international co-publications indicator, however compared with the leading research nations this exhibits a somewhat lower dynamic.²⁴ Nevertheless, the researchers at Austrian universities and research institutions point to above-average publication output, although the distance to the leading countries remains as it is.

²² See "Strengths and weaknesses analysis 2022: Academic research" table, fti-monitor.rfte.at/B/B.2 [1.3.2022].

²³ Eurostat

²⁴ See "Strengths and weaknesses analysis 2022: International ties", fti-monitor.rfte.at/B/A.3 [1.3.2022].

Experts say there is catch-up requirement with the institutional networking of international university institutions in particular. The importance of the internationalisation of studies and teaching is underscored here by the goals of the “National university mobility and internationalization strategy 2020-2030 (UMIS)” (see BMBWF 2020). The European Universities Initiative will make a key contribution to international networking in this respect. With the further development of the European higher education area synergies will be leveraged with the participating universities, shared values anchored and the international competitiveness of the European universities strengthened. Along with the participation of further Austrian universities in the European University Alliances, in addition to the options provided via the Erasmus Plus Programme, the BMBWF already supports the international prospects of researchers and students. Appropriate resources are also provided for to fund the measures named in the RTI Strategy.

International ties



To increase the international visibility of the Austrian university, research and innovation area, it is also key to expand existing network structures and enable inter-organisational networking. The low immigration rate of highly qualified specialists and researchers in Austria is a continuing obstacle to strengthening international competitiveness. In the European comparison, Austria is placed in the lower half in this evaluation. On one hand the framework conditions for researchers are a decisive criterion for whether or not they want to come to Austria (for this see also sections, B.1 Tertiary education and B.2 Academic research). It is also essential however to improve the presentation of the successes of Austrian science and research internationally and, aside from scientific framework conditions, to formulate transparent and administratively appropriate immigration and residency regulations for citizens from non-EU states. Excessive, partially intransparent application requirements, costly visa procedures, document checking processes, and so on, often present unsurmountable hurdles for international students and researchers from non-EU countries to arrange a research stay and subsequently a professional career in Austria.

» Further massive obstacles with specialists migrating from non-EU countries.

Recommendations for action

A.1 Regulation and taxes

—> Implementation of an extensive package of measures to strengthen the availability of venture capital in Austria, focusing on structural-regulatory factors, such as an appropriate corporate form for venture capital funds, for example, simplification of investment in venture capital funds for pension funds, strengthening the Vienna Stock Exchange with a technology segment. Start, for example, with a prioritisation and feasibility test of these reform proposals with a “stakeholder convention”, which the Council could coordinate.

—> Further implementation of the eco-social tax reform via a stronger systemic approach based, for example, on the Mirrlees Report model (see Mirrlees et al. 2010, 2011) focusing on high efficiency in public service provision. This triggers incentives for environmentally friendly innovations and helps with the recruitment of international top executives.

A.2 Education

—> Development of an “Education strategy” similar to the RTI Strategy, within the scope of which specific, that is, quantifiable and therefore also verifiable goals are formulated on the basis of the required *21st century skills*. Special attention should be paid here to improving educational justice and to the fact that the pupils change significantly due to factors such as migration background and first language, and this produces corresponding challenges, which the existing education system cannot meet sufficiently.

—> In addition to the steps already taken in recent years, still further measures must be implemented to expand early childhood education institutions, especially, however, to improve the quality of early childhood education. This also appears to be an important requirement to be able to reduce the significant performance difference in mathematics between girls and boys.

A.3 International ties

—> Achievement of the corresponding set RTI goals is key to increasing the international visibility of the Austrian university, research and innovation location across and beyond Europe. For the university area, those measures that result in achieving lead positions for Austrian universities in international rankings must in particular be prioritised. The positive ties of the innovation location would in turn benefit greatly from a higher start-up dynamic. Cross-sector a joint, coordinated image for Austrian RTI institutions (including companies) would also be beneficial. Building on the recommendations for internationalisation (*beyond europe*), which were already worked out as part of the RTI Strategy 2020 by representatives of numerous stakeholder organisations, a joint “marketing strategy” to increase the visibility of the science, research and innovation location should be worked out and implemented. Funds required for the respective financing must be provided for by the Austrian Government.



—→ An increase in the immigration rate of highly qualified specialists to strengthen international competitiveness and to satisfy the requirement for specialists. To revise the legislative regulations and framework conditions as well as the administrative procedures for checking the requirements for residence permits (the Rot-Weiß-Rot-Karte, for example), an interministerial task force, which includes specialists and legal experts, for international mobility of researchers should be set up for this at government level. Coordination with the “immigration legislation forum” initiated by Universities Austria is also necessary here in every case.



Core RTI system

This area describes the performance of core areas of the Austrian innovation system, which produce knowledge and innovations directly, which in turn are included in Austria's measured innovation performance. Universities and companies are both divided here (B.1 **Tertiary education**, B.2 **Academic research**, B.3 **Corporate RTI** and B.4 **Startups**). The public sector research funding (B.5 **Financing**) completes the core area.

Tertiary education



Academic research



Corporate RTI



Start-ups



Financing



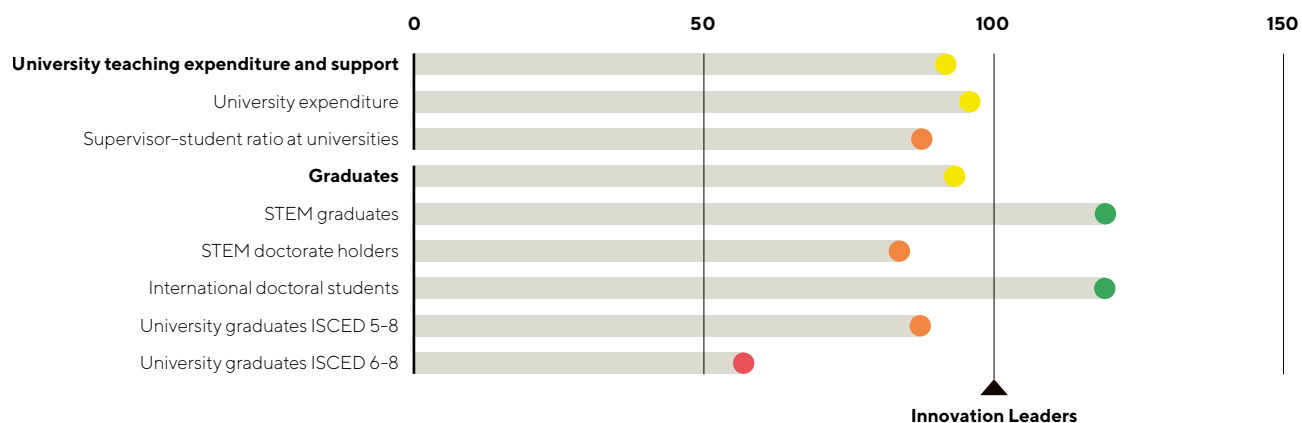


Figure 6: Strengths and weaknesses in the tertiary education area compared with the innovation leaders

Direct goal assignment:

Goal 3: Promote knowledge, talents and skills

- 3.1.1: Increase STEM graduates by 20 %
- 3.1.2: Increase the percentage of women with graduates in technical subjects by 5 %
- 3.2: Top three place in the IMD-World Talent Ranking
- 3.3: Two universities in top 100 (THE World University Ranking)



Tertiary education



Investments in the tertiary education area pay off for the state in the long term (OECD 2021b). The quality of the education system, especially the higher education sector, is increasingly a critical factor in the RTI system and for a society's innovativeness (see Hanushek/Woessmann 2020). The Austrian Government took this fact into account in the objectives of the RTI Strategies 2020 and 2030, the RTI Package 2021-2023 and the areas of action stipulated herein and in defined measures.

And successfully so – because science, research and development remain on a continuous growth path. The cumulative indicator for tertiary education shows Austria above the EU average. At the same time, however, there is still a deficit in the tertiary sector area with regard to the group of innovation leaders (see figure 6).

Tertiary education: Above the EU average, but not in the top three

The distance to the leading countries also becomes visible because Austria is not in the top three places with any of the indicators shown for tertiary education. Luxembourg and the United Kingdom score especially well, but 13 other countries also occupy one of the first three places in at least one of the comparison values.²⁵

In the detailed analysis, both positive and negative trends are confirmed in the long term. With average annual growth of 3.65 percent, the indicator for higher education spending verifies a continuous budget increase for public universities.²⁶ Austria therefore does actually remain significantly behind the leading countries, but can claim a place in the top third of the OECD countries. This trend continues with the increase in the university budget for the performance agreement period 2022-2024 by approximately € 1.3 billion and the increase in study place funding rates at the technical colleges by approximately 10 percent (see University Conference 2022; Austrian Council 2017a, b). The recent sharply increasing inflation and added costs for staff and infrastructure, however, already reduce the potential for important structural and qualitative improvements, to be able to take a place among the international leaders in teaching and research.

Tertiary education



» Austria is clearly behind the innovation leaders, but in the upper third of the OECD countries.

²⁵ See "Strengths and weaknesses analysis 2022: Tertiary education" table, fti-monitor.rfte.at/B/B.1 [1.3.2022].

²⁶ See "Strengths and weaknesses analysis 2022: Tertiary education" table, fti-monitor.rfte.at/B/B.1 [1.3.2022].

The “Supervisor-student ratio at universities” indicator has improved slightly over recent years, however the dynamic of this development path is not sufficient to achieve a significant closing of the gap to the leading countries. In the years ahead, university managers should therefore also be able to further pursue the initiatives introduced in the last performance agreement periods to fill approximately 360 new professorships and job opportunities.

The discussion of the indicators for university graduates must, as in previous years, be held with the inclusion of structural differences in the various education systems and training paths of the comparison countries. A significant increase in STEM graduates must also be once again emphasised (ISCED 5-8).²⁷ With average growth of more than 16 percent annually since 2000, this dynamic exceeds that of the innovation leaders. Responsible here is both a growing offering of training places in the STEM area at universities and technical colleges, and also the contribution of vocational higher level schools (higher technical and business schools).

Tertiary education



At the same time, the percentage of graduates, especially the ISCED 6-8 education levels, in the international comparison continues to be very low. An explanation for the distance to the EU countries’ average (in the OECD area Austria occupies ranks 32nd of a total of 38) may perhaps be provided in the already mentioned structural diversity of the different education systems,²⁸ this area is, however, still the source of significant improvement potential – not least of all against the backdrop of a future further rising requirement for highly qualified specialists.

Increased resources required for tertiary education

The data on which this report is based confirms²⁹ that the previously implemented RTI measures were successful in implementing a positive long-term development of the tertiary education sector in Austria. The continuation of the STEM focus point at universities and the concomitant expansion of the study places, as well as additional professorships in special subjects and accompanying measures at the universities, will further improve the situation. Still stronger commitment by the Austrian Government to education, science and research is, however, required to join the European leaders. Without a significant increase in the budget to fund support measures at the universities, which contribute to creating the framework conditions for the subgoals formulated in the RTI Strategy 2030 under goal 3 (“Promote knowledge, talents and skills”), achieving these goals appears to be as difficult as the successful implementation of the measures named for this in the RTI Package 2021-2023.

» Still stronger commitment by the Austrian Government to education, science and research is required to join the European leaders.

²⁷ Consider change in the country samples on the EIS 2021 for the previous year.

²⁸ High percentage of adults (25 to 64 years old) with an upper secondary education level graduation in Austria (see OECD 2021c).

²⁹ See “Strengths and weaknesses analysis 2022: Tertiary education” table, fti-monitor.rfte.at/B/B.1 [1.3.2022].

In view of the rising requirement for well-trained academic specialists, significant resources to develop and promote human potential across and beyond the measures named in the RTI package should therefore be provided – and not just for higher education institutions. To further promote interest in studies in STEM subjects, STEM initiatives for students should be expanded even more intensively, parallel with measures at the universities.³⁰ Improvement of the educational success of socio-economically disadvantaged young people must be afforded extra special attention, especially for those with migration backgrounds (see A.2 Education). Austria is significantly below the average of the OECD countries in places here (OECD 2021d). Also important here is that the visibility of the research location be increased and attractive offers for international students and graduates are further developed to attract highly qualified academics for science and research (see A.3 International ties).

Tertiary education



³⁰ For this, see section C.5 Gender equality.



Figure 7: Strengths and weaknesses in the research at universities and non-university institutions area compared with the innovation leaders

Direct goal assignment:

Goal 2: Focus on efficiency and excellence

2.4: Top 10 placing with European Research Council (ERC) grants

Goal 3: Promote knowledge, talents and skills

3.3: Two universities in top 100 (THE World University Ranking)

3.4: Universities: Foreign share in new recruitments 45 %

Lever to goal achievement:

Goal 2: Focus on efficiency and excellence

2.3: 100 % more economically successful academic spin-offs

2.5.1: Strengthen participation in Horizon Europe

2.5.2: Top 3 ranking in Horizon Europe (or Horizon 2020) success rate



Academic research



The set goals of the RTI Strategy 2030 and the areas of action and measures defined in the RTI Package 2021-2023 continue the Austrian Government's dedicated path to have Austria join the leading countries in science, research and technology. With the "Fund excellent basic research" area of action for goal 2 ("Focus on efficiency and excellence"), focus is once again further intensified in the RTI Strategy 2030 and in the RTI Package 2021-2023.

Figure 7 provides an overview of the strengths and weaknesses in the area of academic research in Austria, the public sector research institutions of which – universities, technical colleges and non-university research institutes – embody an essential pillar of the innovation system. The indicators illustrate a similar situation to that in the previous year here. The input indicators (most) are continuously rated as good, as they are significantly above the average value of the EU 27 and are in the innovation leaders area. A slight improvement compared with the previous year is also shown for the research performance cumulative indicator. In detail, the strengths-weaknesses analysis in particular shows a very successful position for the acquisition of ERC grants by researchers at Austrian research institutes. Austria is number 4 EU-wide and therefore above the innovation leaders' average. Austrian universities can also point to an above-average success rate in the EU framework programme ("University success rate" indicator).³¹ A solid basic research quota over the year is also a given – with a value of 0.55 percent³² Austria is firmly within the group of scientific leading countries.³³

Academic research



And of course more people are active in research and development: The number of researchers in Austria has more or less doubled in the past 20 years. This development started, however, beginning from a low level. With the percentage of R&D staff from the overall labour force, in the EU comparison in 2019 Austria is therefore at 4th place, behind Denmark, Finland and Luxembourg, but ahead of Sweden, Germany and Belgium. To continue efforts to join the research-oriented nations, there are still no alternatives for the expansion of the higher education sector in relevant subjects and a general increase in the level of education, if the future requirement for highly qualified specialists is to be met (see also A.2 Education and B.1 Tertiary education).

» The number of researchers in Austria has doubled in the last 20 years.

³¹ For this, see A.3 International ties: Universities' participation in EU programmes.

³² See "Strengths and weaknesses analysis 2022: Academic research" table, fti-monitor.rfte.at/B/B.2 [1.3.2022].

³³ The goal of a basic research quota of 0.94 percent of GDP was targeted in the RTI Strategy 2020. See Hranyai et al. (2013).

The largely public sector financed higher education sector is perhaps not affected by the recently stagnating total expenditure for R&D (the GDP share of public expenditure in the state sector and universities is only just below the average of the innovation leaders), however it must be pointed out that the necessary expansion of the tertiary education sector requires an increase in the budget for higher education (see Austrian Council 2017c).

»

There are no alternatives for the expansion of the higher education sector in relevant subjects and a general increase in the level of education

Basic research: A success story that requires further measures to remain successful

The significantly underfunded project-financed basic research (competitive basic research funding) in Austria continues to be a persistent disadvantage compared with strong research nations. The current values confirm that research-active countries, especially Switzerland, Sweden, Finland and the Netherlands, invest several times more in funding competitive research³⁴. Measured on the number of publications, the quality of publications and the number of international co-publications (see Austrian Council 2019) the named countries exhibit high research performance, and therefore lay the foundation stone for innovations.

Academic research



Funding commitments of € 250 million are settled with the funds of the *excellent=austria* excellence initiative provided for up to 2024 (BMBWF/ FWF 2021). Furthermore the “Future Fund Austria” (see Austrian Council 2020), which was established as part of the National Foundation RTD and is funded with € 140 million annually, provides an important mechanism in basic and applied research. It must therefore be expected that the funds of the excellence initiative and “Future Fund Austria” taken together significantly improve the situation, this would not, however, mean any kind of substantial closing of the gap to the leading countries in the area of competitive research funding. If the goal of the RTI Strategy 2030 to increase the share of competitively awarded funds in research funding is not accompanied by significant budget increases, expected positive effects will not occur or will only be marginal. If we want, as also formulated as a goal, to place two Austrian universities among the top 100 universities in the world by 2030, and therefore increase the visibility of the Austrian research sphere, science, research and development must not only be policy-prioritised topics during the pandemic, but rather must also remain so across and beyond the entire coming decade. That this has not been the case to date is most clearly expressed in the most recent Eurobarometer survey (see European Commission 2021b). The research policy must therefore also promote instruments that contribute to mitigating latent science scepticism in Austria. This also requires a clear commitment by the Austrian Government to illustrate the benefits of science and research among the general public and therefore to increase its interest in science and research.

³⁴ See “Strengths and weaknesses analysis 2022: Academic research” table, fti-monitor.rfte.at/B/B.2 [1.3.2022].



Figure 8: Strengths and weaknesses in the corporate RTI area compared with the innovation leaders

Direct goal assignment:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

- 1.2: Increase R&D-active companies by 20 %
- 1.3: Participate in three more IPCEI

Goal 2: Focus on efficiency and excellence

- 2.6: Increase the corporate sector's success rate with Horizon Europe

Lever to goal achievement:

Goal 2: Focus on efficiency and excellence

- 2.1: OECD top five with R&D rate
- 2.5.1: Strengthen participation in Horizon Europe
- 2.5.2: Top 3 ranking in Horizon Europe (or Horizon 2020) success rate



Corporate RTI



Research, technology development and innovation in existing companies remain one of the strengths of the Austrian innovation system. As figure 8 (above) illustrates, the greater part of the indicators are at or even above the level of the leading European innovation nations, however all but three indicators are below the level of the global top three. With very few exceptions, Austria's position compared with all three comparison groups (EU, innovation leaders and top three) is only marginally changed compared with last year's report, however it is slightly worse for the most part.

Continuing high innovation performance in small and medium-sized enterprises

As in previous years, the high propensity to cooperate of Austrian companies³⁵ in particular stands out. The participation of small and medium-sized enterprises (SMEs) in cooperative innovation projects, however, has changed and is now significantly behind the innovation leaders and the top three. On the whole, this negative development is one of the most notable changes in the corporate area. The innovation performance of domestic SMEs nonetheless remains high. Austrian SMEs' turnover achieved with innovations continues to be above that of the innovation leaders; the share of innovative SMEs is practically on a par.

Corporate RTI



» Austrian SMEs' turnover achieved with innovations continues to be above that of the innovation leaders.

The R&D expenditure of companies last raised in 2020 has fallen significantly and Statistik Austria's current global estimate (2021) also refers to the fact that R&D expenditure in the³⁶ corporate sector in 2020 compared to 2019 was only stabilised by increased state financing (federal and states). This can be attributed to a successful anticyclical RTI policy to temporarily absorb deficits in private R&D financing and to mitigate possible negative consequences for innovation activity and productivity growth. There has however also been a substantial increase in the research premium included here, which is scarcely attributable to the effects of the pandemic.

How the state and companies will act in terms of funding and R&D expenditure after the pandemic-related crisis has ended remains to be seen. The development of innovation and R&D expenditure in the years ahead will depend on how successful the consolidation of public sector spending is. Although companies see innovation as a key strategy to

³⁵ Although partially based on 2018 data.

³⁶ That is, the spending by companies themselves and the state financing of the companies' R&D activities.

successfully bridge the crisis and also endeavoured in 2021 to maintain the level of their innovation efforts, extended uncertainty or a volatile economic development could result in a reassessment, also and especially in view of the situation in Ukraine.

The continuing economic uncertainty inhibits innovative entrepreneurial activity

The COVID-19 pandemic has at any rate resulted in higher planning uncertainty, which has a negative effect on companies' innovation activity (see Reinstaller 2020). A special feature of the COVID-19 pandemic is the severely asymmetric effect across and beyond various sectors and industries (see OECD 2020a). This asymmetric effect can be seen, for example, in the application activity of patents, that is, industries or sectors that are affected more by the pandemic (the automotive industry, for example) have applied for fewer patents, while strong growth was seen for other sectors, such as the pharma industries. A recovery in research and innovation-related spending by companies can be expected for 2021 and 2022, on the basis of surveys at the very least (see Reinstaller 2022). A stabilisation of the shifts between sectors (away from automotive and towards ICT, for example) must be assumed here. There are also indications of a possibly more persistent negative effect by the pandemic on the innovation spending of small and medium-sized enterprises (see Reinstaller 2022). The innovation-reducing effects of the war in Ukraine are unforeseeable at the moment. What we can already see, however, are the effects on technology-intensive industries caused by interrupted supply chains, as Ukraine, for example, is an important supplier of cable harnesses³⁷ for automotive manufacturing, among other things.

The number of innovative companies and researchers in companies (which, however, was also already below the values of the innovation leaders), has only fallen slightly. The latter at least partially encompasses the current conditions and can therefore be entirely evaluated as a positive signal. Whether the goal of increasing the number of research-active companies by 20 percent by 2030 under the changed conditions (that is, crisis and the corresponding countermeasures, the accelerated structural change as challenge and opportunity, and so on) remains realistic, even if the respective indicator recently has for the most part developed positively, cannot be answered at the moment.

At the bottom end of the comparative set of indicators are output indicators such as invention performance, which on the whole is fed by the number of triadic patent applications³⁸, the aptly-named super patents³⁹ and patent applications. In 2020, Austria, unlike many countries, recorded a slight decline in patent applications, however European Patent Office data for some of the leading states in Europe and around the world

» The asymmetric effects of the pandemic can be seen in the application activity of patents.

Corporate RTI



³⁷ handelsblatt.com/unternehmen/industrie/ukraine-krieg-autohersteller-helfen-zulieferern-bei-verlagerung-der-produktion/28161752.html [17.3.2022].

³⁸ Patent applications to all three of the world's most important patent offices in Japan, the USA and Europa.

³⁹ Patents for revolutionary inventions. See Reinstaller/Reschenhofer (2019).

also shows significant increases in the same period. With regard to the effects of innovations developed in export and the relative importance of knowledge-intensive sectors for GDP the situation looks considerably better, even if the Austrian position has deteriorated in places here vis-à-vis the innovation leaders.

A new indicator records a very specific feature of knowledge-intensive companies, namely their (successful) participation in funding projects of the European research framework programme. The respective quota in 2021 at 17.3 percent was significantly above that of the innovation countries, but below the objective of 20 percent and even still further below the RTI Strategy 2030's starting value. Austria is committed to the new European industrial policy and has therefore also defined the planned participation in five IPCEI as a goal of the RTI Strategy and has almost already achieved this, as Austria currently participates in four IPCEI.⁴⁰

The crisis-related challenges for companies and the reduction of R&D activities as one of the first reactions (see OECD 2020b; Reinstaller 2020) have resulted in numerous state countermeasures. Such measures are enabled with the investment premium, via the NextGenerationEU European Recovery Plan, for example, and at national level.⁴¹

Corporate RTI



⁴⁰ See section, Analysis of the objectives of the RTI Strategy 2030, goal 1, p. 18.

⁴¹ See I Introduction, p. 7.

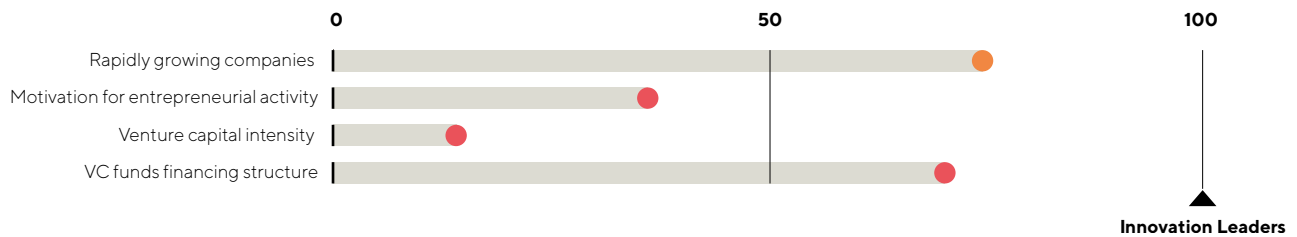


Figure 9: Strengths and weaknesses in the start-ups area compared with the innovation leaders

Direct goal assignment:

Goal 2: Focus on efficiency and excellence

- 2.2: Expansion of the venture capital pool to 0.1% compared to GDP
- 2.3: 100 % more economically successful academic spin-offs

Lever to goal achievement:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

- 1.2: Increase R&D-active companies by 20 %

Goal 2: Focus on efficiency and excellence

- 2.1: OECD top five with R&D rate



Start-ups



Start-ups, and here in particular research-based and rapidly growing companies, as well as their institutional, financial context and so on, are key elements of the innovation system's capability and catalysts of desirable transformation processes. The RTI Strategy 2030 considers this accordingly and also names two specific goals, whose achievement contributes to their overall implementation – the doubling of financially successful academic spin-offs and increasing the available risk capital to 0.1 percent of GDP.

The Start-up area remains one of the biggest weaknesses of the Austrian innovation system

Figure 9 (see above) firstly illustrates how the entire Start-up area also continues to be one of the Austrian innovation system's greatest weaknesses. Despite slight improvements, Austria remains significantly behind the top three and the innovation leaders, and also behind the EU average. Nor does removal⁴² of the start-up regulation indicator, which to date was always especially negative for Austria, change anything here. Important for the evaluation this year is the fact that the start-up area is seriously affected by the effects of the COVID-19 pandemic and some countries were able to position themselves better at the level of individual corresponding indicators (comparatively), while others positioned themselves worse (see GEM 2022; ASM 2022).

The share of rapidly growing companies⁴³ with a corresponding increase in employment figures improved significantly, whereby the indicator remains significantly behind all comparison groups, so this is also a persistent innovation system weakness.

Outside of the objectives of the RTI Strategy, however, an improvement is seen in the Start-up dynamic in the overall economy, that is, not focussed on innovation-based or growth-strong start-ups. According to the corresponding WKÖ (Austrian Economic Chamber – see WKÖ 2022) Start-up statistics, the number of start-ups compared to 2020 increased significantly by 6.4% (carers in the home not included) and a trend of falling Start-up numbers since 2017 was reversed.

Start-ups



»

The percentage of rapidly growing companies has risen significantly, but remains clearly behind the comparison groups.

⁴² The *Startup regulation* indicator is no longer available, as the underlying analyses of the World Bank's global "Doing Business Ranking" are no longer performed.

⁴³ The definition was, however, changed so that the focus was no longer only on innovation-intensive sectors.

Risk capital in Austria also too low in 2021

As in the Start-up area, the Austrian risk capital market on the whole remains a significant Austrian innovation system weakness. Paradoxically the risk capital intensity in terms of investments made has slightly improved in the international comparison, despite an absolute deterioration by 0.01 percentage points. It must be assumed that, despite some excellent financing rounds (Go Student and Bit Panda, for example), the crisis-related fall in GDP “conceals” significantly reduced risk capital availability. The above-mentioned goal of risk capital intensity of 0.1 percent of GDP has therefore at least temporarily moved even further away. Although the distance to the innovation leaders has reduced slightly, the distance to the top three (the Netherlands, the United Kingdom and France) has also increased slightly. Compensating for the insufficiently available private venture capital with state measures does indeed have a stabilising effect on the overall available amount of risk capital, however at the same time it also has a negative effect on another indicator, the composition of the venture capital funds, because the focus has shifted from private providers to state venture capital. The negative development of the risk capital indicators is, despite all efforts, also a long-standing trend in the relation with the innovation leaders.

» The negative development of the risk capital indicators is a long-term trend despite all efforts.

Attitudes to and competencies for start-ups are especially adverse

Naturally enough the topic of the weak performance and dynamics of knowledge and growth-intensive start-ups in Austria must not be considered purely on its own. Key here too are attitudes and capabilities that in particular should be mediated via the education system. According to the Global Entrepreneurship Monitor (GEM) 2020/21 Austria is not only evaluated as relatively bad here, it has even deteriorated further. The experts surveyed say the entrepreneurial training and further training in the tertiary sector only takes Austria to place 14 (compared to place 7 in the GEM 2018) in Europe; in primary and secondary levels even only to place 17 (2018 place 8; GEM 2022: 35). In GEM 2020/21 there are also further pointers to the causes: the relatively high importance of intrapreneurship, the start-up opportunities that are perceived as relatively bad and the attitude towards a start-up as a career choice in itself (with a social status that entrepreneurs also feel is high) (GEM 2022: 39 and 44ff.). Future effects can quite probably also be expected from the anchoring of *entrepreneurship education* in the curricula of the (tertiary) education institutions recently mentioned in the RTI Package 2021-2023.

Start-ups



In the international comparison in particular, the issue of regulation with start-ups and the taxation of corporate profits and so on, is considered further leverage for the start-up dynamic. With the removal of the (methodical, however controversial) “Doing Business Ranking” there are, however, fewer comparison options here. The BMDW and the BMJ are currently working on simplifying the start-up regulations, on an own corporate law form for start-ups, for example. On the corporate service portal⁴⁴ you can already start up individual companies and one-person

44 usp.gv.at/

limited liability companies, innovative start-ups are however generally team start-ups. Digital start-ups were also made easier with the introduction of the electronic notarial act. For company taxation (see chapter 1.1), we can at least say that positive stimuli for start-ups can currently not be assumed here.

The Austrian start-up dynamic pays directly into the RTI Strategy's goal of increasing the number of R&D-active companies by 20 percent. In view of the current start-up dynamic, on one hand determined by the crisis, on the other hand a continuing weakness anyway, a significant contribution in this respect currently appears questionable, not least of all because the percentage of knowledge-intensive start-ups is not growing accordingly. A measurable increase in the R&D rate caused by this cannot be expected from start-up activities.

Academic spin-offs

In the start-up context, the objective of doubling the number of financially successful academic spin-offs by 2030 is highly relevant, but such start-ups (with the requirement of their scaling) are of course linked with justified hopes for significant positive effects on the national economy. The difficulty of recording and measuring the development is due, however, to the absence of an appropriate database and a standardised definition. In the preliminary stage of this year's performance report a substantive discussion was held with various stakeholders, and on the basis of the Austrian Start-up Monitor (ASM) a definition, which from 2023 enables monitoring of this goal indicator, was worked out.

Start-ups



The companies defined by the ASM as "research spin-offs" are recorded here, that is, those with which the idea for the new product/business model emerged during and in the thematic context of a working relationship at a university, technical college or research institution. Also included in the monitoring are the aptly-named "training spin-offs", so start-ups with which the idea for the new product/business model (idea development as part of a course or further offering on the start-ups topic, for example) emerged during and in the causal context of a training relationship at a university or technical college.

It also applies that academic spin-offs will be dealt with as a subgroup of start-ups, that is, companies that are highly innovative and not older than 10 years and also commit to and target significant turnover or employment growth. The issue as to whether or not financial success beyond the scope of traditional growth indicators can be mapped was also considered in the respective discussions. Figures for mergers and acquisitions are therefore also considered for the analyses beginning in the coming year.

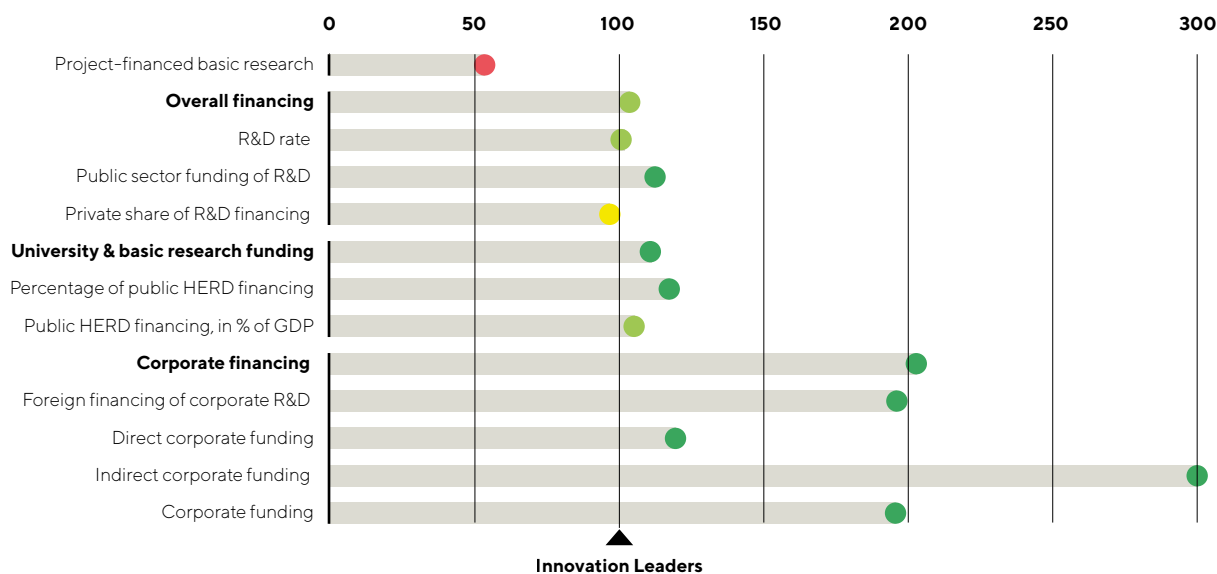


Figure 10: Strengths and weaknesses in the financing area compared with the innovation leaders

Direct goal assignment:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

1.3: Participate in three more IPCEI

Goal 2: Focus on efficiency and excellence

2.1: OECD top five with R&D rate

2.5.1: Strengthen participation in Horizon Europe

2.5.2: Top 3 ranking in Horizon Europe (or Horizon 2020) success rate

Lever to goal achievement:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

1.2: Increase R&D-active companies by 20 %

Goal 2: Focus on efficiency and excellence

2.2: Expansion of the venture capital pool to 0.1% compared to GDP

2.3: 100 % more economically successful academic spin-offs

2.4: Top 10 placing with European Research Council (ERC) grants

Goal 3: Promote knowledge, talents and skills

3.3: Two universities in top 100 (THE World University Ranking)



Financing

Composite indicator

154

↓
downward
trend

The area of RTI financing is the subarea of the RTI system, with which Austria shows by far the best performance compared with the innovation leaders. Belgium (as a new innovation leader) does indeed stand out compared with the Netherlands (no longer in the comparison sample), among other things with its higher corporate funding (especially with tax-based funding), nevertheless Austria remains far ahead of the leading innovation countries with the RTI financing in companies in particular, and especially with the tax-based funding and foreign financing of R&D, but indeed also with direct R&D corporate funding.

R&D financing is above-average in wide-ranging areas, nevertheless there is potential for improvement

The public sector financing of R&D at Austrian universities, on the other hand, is significantly lower than the average of the leading innovation countries, whereby, however, the level of core financing compared with project-based research funding in Austria is extremely high. An indicator on the raising of the share of Austrian Science Fund-similar funds to promote basic research is, however, only available for very few countries and therefore not included in the overall value of the financing area either.

Financing



Austria's R&D rate is currently just barely above the level of the leading countries, among other things because Belgium exhibits a significantly higher R&D rate than the Netherlands and in recent years rapidly caught up with the Austrian level of 3.2 percent. And ultimately the private share of R&D financing in Austria also remains slightly below average, while the public sector share is above average high.

» Private R&D funding remains below average, while the public funding is significantly above.

As did its predecessor document, the RTI Strategy 2030 also includes an R&D rate target, but this is no longer fixed absolutely with one figure, but rather relative to a group of leading countries. The rate target now also has numerous other goals, including output-oriented ones, so that there is basically no one-sided fixing on an input goal. The challenge in the area of R&D financing in Austria also affects the overall amount of the available public and private funds less, and more so the kind of awarding of such funds and the question as to what the public funding is provided for and what effect is achieved herewith.

In the universities area, for example, the Council has already long been referring to the low share of project-based financing of basic research, while the share of core financing in the international comparison is high (see figure 10, Project-financed basic research indicator).

On the whole open-theme research financing and funding predominates in Austria. The Austrian Science Fund therefore basically funds open-theme, but in corporate financing open-theme financing also predominates in direct funding. The research premium is open-theme *per definitionem*. The share of thematically open financing is therefore very high in both the university area and the corporate area, whereby that of the competitive theme-oriented financing on the other hand is comparatively low. In view of the current pressing challenges, such as climate change or digitalisation, for example, the question arises as to whether or not Austria is appropriately equipped to meet them. The OECD (OECD 2018) also referred to this problem in its review of the Austrian innovation policy.

Specific, data-based analyses to place the evidence of the financing's effect on a recent basis are recommended for the further development of the Austrian R&D financing structure, whereby not only will the traditional input and output additionality of funding be examined here – so, too, will its contribution to overcoming pressing challenges. With the adopted Austrian Micro Data Center hopefully new data sources will also soon be available for this, which should be used to examine the respective correlations. The systemic interaction must in particular be examined, in the universities area that of core financing and project-based financing, for example, and in the corporate area that between direct and indirect funding.

»

The share of funds awarded in competition is still comparatively low

Financing



Recommendations for action

B.5 Tertiary education

—> To meet the future requirement for STEM graduates, the RTI goal to increase the number of STEM graduates by 20 percent by 2030 should be exceeded. On one hand, the investments in the expansion of STEM study places at the universities must be increased for this and on the other hand increased funds must be provided to accelerate further measures to enrol students in STEM subjects. To create the required capacities for relevant study places the recommendation to increase the share of students in the technical college sector to 40 percent by 2040 remains unchanged.

—> To be able to achieve the RTI Strategy goal of placing two universities in international rankings among the top 100, the framework conditions for teaching and research at the universities must be further improved. An additional improvement of the supervision ratio and increase in the number of researchers/doctoral students as well as a quantitative and also qualitative improvement of the research output (especially the number and output of publications) in particular provide the necessary conditions for this. To enable the public universities to perform these tasks and to compete in international competition with the best universities, sustainable investments must be made in the recruitment and development of excellent scientists. To further increase the quality in teaching, research and the “Third Mission”, the entire higher education sector must be provided teaching and research funds at the level of the leading countries.

B.2 Academic research

—> A significant increase in investments in basic research funding awarded in competition at the level of the leading research nations, as well as a substantial beefing up of the funds for modern research infrastructures and participation in international collaborations (ESFRI, for example) are necessary framework conditions to enable improved performance at the universities and research institutes. For this, the “Fund excellent basic research” RTI Strategy 2030 goal requires a balanced funding policy to sustainably pursue basic research, industrial research and experimental development.

—> The universities’ task to intensify the exchange with society and the body politic increases in importance. Good science communication as part of the Third Mission and as a relevant policy area are a necessary condition in this respect. To professionally, transparently and comprehensively transpose findings from science and research for society in general, the conditions (funding) for science journalism in Austria must be improved accordingly. Resources must also be provided to enable and motivate scientific organisations to successfully implement evidence-based science communication in the dialogue between science, society and the body politic.

B.3 Corporate RTI

—> With the recent decisions on financing research and development, the National Foundation (and the Future Fund Austria) and the already agreed funds for participation in the Important Projects of Common European Interest (IPCEI) are important steps to secure the financial means required for the Austrian RTI policy. This will of course also require a financial growth path, especially for technologies with high innovation and transformation potential. A requirement in this respect, however, is an improvement, for example, of the input to output ratio with an integrated RTI policy (that is, linking with demand-oriented instruments such as procurement).



—> For participation in current and future IPCEI significantly more resources than before should be provided (including for administration), and agile governance across and beyond departmental boundaries must also be established. Both would also be a suitable basis to participate even better in the development and shaping of future IPCEI.

—> Innovation-promoting public sector procurement combined with sustainable procurement is an option to strengthen Austrian companies' innovation-based output. Austria is already well positioned with its initiatives for innovation-promoting public procurement and sustainable procurement. The implementation of strategic public procurement that unites both aspects, which is in particular based on an obligation to implement appropriate procurement processes (formulation of ambitious quantitative goals) and the cushioning of the increased technological and awarding risk of the procuring organisations with appropriate and sufficiently equipped co-financing programmes of the federal government, is recommended.

B.4 Start-ups

—> Although attitudes and educational offers for entrepreneurship are changing, a start-up as a career option or similar in Austria continues to be significantly less favourable than in other countries. The implementation of plans to establish entrepreneurial skills and capabilities at all education levels and in any case as part of tertiary education, should therefore be treated as a priority and equipped with the necessary resources. Entrepreneurship should also play a key role in the context of the much called for education offensive for the STEM area.

—> The strengthening of the domestic risk capital market is important for Austria's start-up dynamic (see chapter, "Regulation, taxes, financing"). Key in this respect would be the creation of an appropriately equipped umbrella fund provided by institutional investors.

B.5 Financing

—> Setting up a comprehensive, systematic analysis of the effects and correlations in the area of the Austrian R&D financing structure, both with the goal of increasing efficiency and impact and in terms of overcoming major social challenges – is the financing structure fit for the transformation? New available microdata sources in the Austrian Micro Data Center should be used for this.

—> In view of the pressing challenges, in the climate or digitalisation area, for example, the very high in all areas thematically open funding and financing share or the low share of financing provided in competition should also be discussed. A realignment of the Austrian R&D financing structure oriented on this would be a suitable option.

—> Specific, data-based analyses to place the evidence of the financing's effect on a recent basis are recommended for the further development of the Austrian R&D financing structure, whereby not only will the traditional input and output additionality of funding be examined here – so, too, will the contribution to overcoming pressing challenges.



RTI cross-cutting issues

The cross-cutting issues areas exhibit a specific specialist and/or thematic alignment, in which theme-specific indicators for universities, companies and R&D financing and other areas are addressed. These reflect social challenges, on one hand **digitalisation** (C.1) with the important broadband infrastructure framework condition, **climate and environment** (C.2), as the biggest global challenges of the day, and on the other hand, **location attractiveness** (C.4) and **gender equality** (C.5), which are structurally relevant issues for Austria.

This year, the report incorporates the **circular economy** (C.3) as a new area. The concept of a circular economy follows a closed process, which reduces the use of resources, takes toxic substances out of circulation and minimises waste.

Digitalisation



Climate and
environment



Circular economy



Location attractiveness



Gender equality





Figure 11: Strengths and weaknesses in the digitalisation area compared with the innovation leaders

Direct goal assignment:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

1.1.2: Digital Economy and Society Index (DESI)

1.4: Increase digitalisation

Goal 3: Promote knowledge, talents and skills

3.1.1: Increase STEM graduates by 20 %



Digitalisation



A high level of digitalisation is one of the necessary basic conditions for participation in appropriate welfare gains and productivity increases, as well as general competitiveness. The requirements for achieving a high level of digitalisation are very wide-ranging here, and among other things include the required infrastructures, well-trained specialists, inventions and innovations and operational implementations in various areas of application.

On the whole, the findings in this area do not look particularly good for Austria. With the indicators Austria lags behind the innovation leaders, and the overall performance in the EU comparison is also only below-average. Although an upward trend was observed in the past two years, a longer-term consideration of the development of digitalisation in Austria, however, only shows a small closing of the gap to the EU average – from today's point of view, the innovation leaders' mean value can no longer be achieved in this decade.

In the infrastructure area, the increasing speed of the fibre optic network expansion must be positively emphasised. Along with the absolute increase, relative growth compared with all three comparison groups was also achieved here. The starting point was however at a very low level, and with regard to the share of fibre optic connections, Austria currently occupies the last but one position among the OECD countries.

The indicators considered for this report were adjusted in the area of the use of innovative information and communication technologies (ICT) in companies. Data on the use of ERP systems, social media and the national online trade was removed; added were surveys on the use of artificial intelligence (AI), the Internet of Things (IoT) and 3D printers and robots. While cumulatively Austria is above the EU average here, the distance to the innovation leaders and the top three countries remains considerable. In the cloud computing and big data analyses areas in particular there is significant development potential and high catch-up requirement.

Even higher catch-up requirement in the entire digitalisation area

Only 7 percent of all companies run big data analyses; in Germany it is 17 percent, in Denmark 24 percent and in the Netherlands it is even 26 percent. We can assume that this circumstance with regard to the competitiveness of Austrian companies is not a good starting point for future developments. In the cloud computing area, Austrian com-

» From today's perspective, the average score of the innovation leaders does not seem achievable in the current decade.

Digitalisation



panies are about the same as European competitors when it comes to buying various online services. In recent years, a very clear upward trend has indeed been seen here. Nonetheless, the distance to the innovation leaders and the top three remains considerable.

The cumulative strength of Austrian companies in the Internet of Things area is encouraging. However, closer consideration is required here, too. The strength with regard to the use of sensors for automated production processes, smart meters and accompanying energy management, as well as security applications, is countered by weaknesses, with the use of the Internet of Things in production processes and logistics management, for example. This digitalisation potential must also be increasingly leveraged with regard to the competitiveness of Austrian industry in the years ahead.

In the future area Artificial Intelligence, Austrian companies are perhaps slightly above the EU average, however the deficit to the innovation leaders and the top three is still substantial. Combined with the relative weakness in the big data area there is the danger that process optimisations and automations that are consequently ruled out, will result in reduced competitiveness for Austrian companies. Positive here is the fact that the Austrian Government's strategy for artificial intelligence, which describes the main options for strengthening the AI ecosystem in Austria, was completed in 2021 (BMK 2021a). Unclear, however, is the specific approach to the proposed 64 measures – with what priority, with which financial means, with which timetable and by which stakeholders will these be implemented?

In the 3D printing area, Austrian companies are also on the whole slightly above the EU average, but they lag far behind the innovation leaders and the top three. Medium-sized and large-scale companies in Austria are significantly better represented here than small companies. With the use of robots in the entrepreneurial environment, Austrian companies are somewhat below the EU average, with both service robots and industrial robots. An upward trend is indeed seen in contrast to the 2018 survey, however the potential for development is considerable. Austrian manufacturing companies not only increase their own efficiency with the use of modern robot systems – they also contribute to making location Austria more attractive for robot experts.

The right specialists are required for successful digitalisation. STEM graduates (especially those in the ICT disciplines) are therefore an indicator for the development of human resources. The RTI Strategy goal of increasing the share of STEM graduates by 20 % can therefore have a positive effect on the number of ICT graduates. With the corresponding indicator (ICT graduates), Austria is currently below the EU average, far behind the innovation leaders, and very far behind the top three.

Digitalisation is also an important cornerstone with regard to the circular economy. The technological transition therefore offers a multitude of

» Digitalisation is an absolute requirement for competitiveness

Digitalisation



specific options to improve the circularity of the economy, because new technologies such as artificial intelligence, additive manufacturing or the Internet of Things play a decisive role in this transformation by enabling a high level of data transparency and improved manufacturing methods (MacArthur/Morlet 2020; Lacy 2020). Digitalisation consequently offers a multitude of opportunities on the path to a circular economy. The actual effects of these new technologies on climate change will ultimately depend on their specific implementation, as well as on indirect rebound effects, such as increased demand for ICT services due to higher quality and new services, for example.

» Technological change can improve the circularity of the economy.

Digitalisation





Figure 12: Strengths and weaknesses in the climate and environment area compared with the innovation leaders



Climate and environment

Composite indicator

113



upward trend

Along with digitalisation, combatting climate change is the key social challenge of the day. The European Green Deal is currently in the implementation phase, the Austrian Government has set itself an ambitious goal with climate neutrality by 2040 and with the eco-social tax reform has already adopted an important measure (see Austrian Government 2020: 73).⁴⁵ Anchored herein are indeed low at first, however then clearly rising price paths for CO₂ emissions, which will ensure incentives for appropriate RTI activities in the entire innovation system.⁴⁶

Along with projects to achieve climate neutrality by 2040, studies have been and will be commissioned to determine the costs of not acting in terms of the climate policy, such as the following projects, for example: PACINAS (see Wegener 2017) or COst of INaction (see CCCA 2020), both managed by the Wegener Center at Graz University, to name just two by way of example. In conclusion, not acting results right now in costs for the public budget running to several billion euro per year, and these costs will increase significantly until 2050, in the area of climate change impacts and adjustment, at the very least. (See Steininger et al. 2020) In a study on Austrian industry's contribution to climate neutrality, a consortium consisting of the University of Leoben, the Austrian Institute of Technology, the Johannes Kepler University Linz and the Energy Agency examined the status quo of Austrian industry in the international comparison, identified decarbonization strategies for individual industry sectors and also estimated the investment costs with regard to the implementation of new technology routes (see Diendorfer et al. 2021).

The RTI policy itself can also provide important stimuli to combat climate change, by funding scientific research and the technological bases for new products or manufacturing processes, which are more CO₂-efficient than before, for example. With the R&D financing for environment and energy anchored in the federal budget, since the last performance report we can see a clear leap in the environment area from 0.7 percent to 2.7 percent of the R&D federal spending and in the energy area from 2.7 percent to 3.5 percent. Austria is therefore actually still relatively

Climate and
environment



⁴⁵ A series of further documents, which will not be named in detail in this report (but are nevertheless extremely important), deal with the interaction between environment, economy, climate and so on. These include Agenda 2030 and the Sustainable Development Goals, among others. With regard to the latter the UniNEtZ options report, which the science community recently provided it to the Austrian Government, must also be mentioned.

⁴⁶ See section A.1. Regulation and taxes, p. 26.

far away from the leading EU countries in this respect, such as Latvia, Slovenia and Romania, for example, which spend more than 5 percent of their research financing on achieving environmental goals. This year Austria will, however, surpass the EU average and the leading innovation countries for the first time.

The direct RTI output, which is targeted with this expenditure, is still a harbinger of bad news – with the relevant findings, Austria achieves neither the level of the EU nor that of the leading countries. Increased financing can, however, at first also negatively affect the RTI performance in the medium term, as output indicators (development of patents, for example) are always only available after some delay. With the “Exports of environmental products in % of GDP” indicator the figure shows a far above-average performance, in particular because Austria is so densely forested. The raw materials from forests are the basis for all products that are traded on international markets as export goods (raw wood types, energy resources and various ancillary uses). It must be stated, though, that Austria’s forest wealth is in particular the result of natural factors rather than intentional innovation efforts. And with perhaps the most important indicator for measuring the impact of the RTI policy in the climate and environment area, the reduction of greenhouse gases measured on the EU goal, Austria also remains behind the EU’s results and the innovation countries. The increase in R&D expenditure and the implemented eco-social tax reform are not negatively affected here yet either. Additional RTI policy measures, but also measures in other areas, will however without doubt be necessary in the coming years to ensure Austria’s CO₂ emissions are put on a clearly falling path. The Austrian Recovery and Resilience Plan (RRP) is an extensive bundle of measures in this respect (see BMF 2021).

The European Commission has the transformative effect of every national RRP based on the share of the investments evaluated, which flow into climate and digital goals. To apply as a climate investment, the member states must, among other things, explain how these projects will contribute to the green transformation. The European Commission rated Austria’s RRP, which includes the EU-wide third highest share of climate goals, as very good. (See Dachs/Weber 2022: 22.) Specifically for RTI in the climate and environment area the RRP includes, for example, funds for Austria’s participation in the Hydrogen IPCEI, which is designed to promote the use of hydrogen in the EU.

Austria’s RRP and that of three of four leading innovation countries, namely Belgium, Finland and Sweden, exhibit comparable volumes (see Dachs/Weber 2022: 23).⁴⁷ In the climate and environment area Belgium invested in public transport, as did Austria. By contrast, the innovation priority of the Finnish RRP is on renewable energies and energy efficiency, as well as green tech innovations. Sweden also focuses in its RRP on

»

A realignment of the political decision-making and a debureaucratisation of the energy transition is required if the green transformation is to be swiftly implemented.

Climate and
environment



⁴⁷ Bruegel also lists a detailed breakdown of the RRP investment projects of all EU member states, bruegel.org/publications/datasets/european-union-countries-recovery-and-resilience-plans/ [1.3.2022].

mobility, however in contrast to Austria, in Sweden investments mostly flow into electromobility, including charging stations for e-vehicles (see Dachs/Weber 2022: 26).

To achieve the climate goals, further increased stimuli will also remain prioritised on all levels of the RTI policy in the climate and environment area. The most recent positive signals with regard to the increased public sector financing for climate and environment as well as the adoption of an eco-social tax reform are, however, important steps on the path to achieving the goal of climate neutrality by 2040.





Figure 13: Strengths and weaknesses in the circular economy compared with the innovation leaders



Circular economy

91

Composite indicator

The importance of and interest in circular economy concepts are in particular rooted in the fact that solutions for climate and environment policy issues are developed on their basis, and also open up new economic scope and place key economic principles, such as the efficient use of resources, front and centre (see Reinstaller et al. 2022: 3). Resource efficiency increased by a circular economy essentially means endeavouring to achieve higher value creation with lower natural resources use, which in turn results in increased independence from primary raw materials (see Reinstaller et al. 2022: 48). Three key pillars of the green transformation on the way to a circular economy are (1) more efficient use of resources, (2) the extension of product lifecycles and (3) the reduction of production output and waste minimisation. Quantifying relevant innovation efforts for Austria in this respect clearly shows that circular-oriented innovation activities to date only play a lesser role both in absolute figures and pro rata in the Austrian innovation system.

In the European Union, with the circular economy topic the Green Deal focuses on close interaction with the industrial policy. In 2019, the European Commission therefore placed the “Industry mobilisation for a clean and circular economy” at the centre of its considerations (see European Commission 2019: 4f.). In the year that followed the “New industry strategy” and the “New action plan for the circular economy” were adopted as a double pack. (See European Commission 2020a, b) Included here are a multitude of strategy lines, instruments and measures, in line with a modern industrial policy (see Polt et al. 2021). Examples here are initiatives to strengthen, (i) research and technological developments, (ii) qualification and human resources, (iii) public demand, (iv) transparency and information and (v) awareness with companies and consumers, which are required for the circular economy.

» Circular economy increases resource efficiency and reduces dependence on primary raw materials.

Austrian agenda

In the chapter on location and industry policy, the 2020-2024 Austrian government programme announces the development of a strategic measures plan for environmental technologies and for the circular and recycling economy for the first time (see Austrian Government 2020). The specific projects are then listed in more detail in the chapter on environment and nature protection. They range from tax breaks for small repair services to the expansion of multiuse systems, forbidding the disposal of fit for consumption products in the food retail trade, improving the data basis and transparency of material flows, financial incentives and the removal of regulatory obstacles for the use of secondary raw

Circular economy



materials in industry, deposit systems for batteries and small devices, amendment of the Act on the Remediation of Contaminated Sites, through to the expansion of funding programmes and supporting model regions for the circular economy.

Unlike the European Union, in Austria there is no independent industrial policy strategy, which is why it does not interact directly with the objectives of the circular economy either. In its recommendation for “Austrian industrial policy realignment”, the Austrian Council does however see the transformation into a circular economy as one of three overriding goals (see Austrian Council 2021b).

Following extensive preparations and with the inclusion of more than 400 stakeholders, the BMK presented an Austrian circular economy strategy, which defines the guiding framework for the years ahead (see BMK 2021b). Numerous points of reference and interfaces to already existing programmes and strategic documents and the like, which are still being prepared, are identified here.

Set of indicators for the circular economy in Austria

In this section, on the basis of the Austrian circular economy strategy and the support in line with a suitable monitoring included in it (see BMK 2021b: 40), the quantification of innovation activities in the circular economy area was initiated for the first time. This results in two methodical restrictions, which must be considered when interpreting the results.

The first restriction applies to the fact that the transformation of the economy on the basis of circular economy principles requires extensive social, institutional and societal innovations, as well as company-wide innovations and investments in infrastructure, which can result in coordination failures and therefore necessitate public sector interventions. Innovations in business models, organisation or logistics and other areas are required on an individual company level. New technological innovations are indispensable in this context, but are not sufficient for a successful transformation process. The restriction of the presented set of indicators on R&D, inventor activity and trade in goods in the area of circular economy technologies and products therefore only enables a rather limited set-up. (See Reinstaller et al. 2022: 35)

The second restriction applies to the precise statistical delimitation of inventor activity and trade in goods, which must be attributed to circular economy-relevant technologies. This is on one hand due to the fact that even among researchers and practicing professionals, there is no clear definition of “circular economy”. On the other hand, existing classifications of environmental technologies and environmental products also cover key, generally accepted circular economy principles, whereby in many cases environmental technologies and circular economy-relevant technologies coincide. For a more precise delimitation, even more detailed analyses of individual technology classes or product categories would be required. (See Reinstaller et al. 2022: 35)

» Transformative objectives require a new kind of policy-making and a binding timeline for implementation.

Circular economy



While considering these restrictions, the analysis of the indicators used for the circular economy produces a thoroughly positive overall picture for Austria, even if the circular economy overall indicator is below the innovation leaders' level (see figure 13). The overall result is driven by the weak results in the areas of trade balance, circular economy and patents. The existing gap shows there is still catch-up requirement.

If we consider the overall costs funded by the Austrian Research Promotion Agency (FFG), we see that these are only a very low percentage of the overall R&D total costs funded by the FFG (between 3 and 4.5 per cent). Figure 14 shows these R&D projects over the period between 2016 and 2020 as a percentage of the funded total costs. The total funding includes cash values of the funding and securities and is therefore higher than the actual benefits (the cash values of the funding) that went to the funding recipients (see Reinstaller et al 2022: 20).



Figure 14: Circular economy share over all industries in percent

—●— Total costs - - -●- - - Total funding ●..... Cash values

A similar situation also emerges with the analysis of the patent applications by Austrian inventors in the relevant technology areas. Austria, however, introduces technologically and commercially relevant inventions into the circular economy and supporting technologies areas (Industry 4.0, industrial biotechnology) – even if they are not so important in the Austrian innovation system. This also appears to have a negative effect in trade in goods, where there is a trade balance surplus in the area of circular economy-relevant goods and services. A causal correlation between the importance of inventions and the success in international trade cannot, however, be established on the basis of these analyses. This would require in-depth analyses (see Reinstaller et al. 2022: 35).

Circular economy



In its most recent Austria economic report, the OECD highlights the importance of the transition to a *green economy* and an appropriate budgetary equivalent (see OECD 2021e: 62). A specific implementation plan for financing a *green economy*, according to a “golden rule” model, for example, would also be important in this context (see Pekanov/Schratzenstaller 2020: 9f.). An appropriate approach here would be, for example, for the European Commission to make a recommendation with the fiscal rules with regard to country-specific benchmark percentages of the state spending in each country, which is to be used for green public sector investments.⁴⁸

Digitalisation and circular economy on the path to the *twin transition*

While many goals and concepts of the circular economy are still extremely visionary, the technological transition offers a multitude of specific options to improve the circularity of the economy. Digitalisation in particular is an important pathfinder, because new technologies such as artificial intelligence (AI) or the Internet of Things (IoT) can play a decisive role in this transformation, by enabling a high level of data transparency and improved manufacturing methods (see MacArthur/Morlet, 2020; Lacy/Spindler, 2020).

- Cloud services and the Internet of Things enable the increasing networking of various players and activities via the Internet. Storing and sharing data in the cloud, for example, then enables processes and procedures to be shaped more efficiently and industrial environments are optimised or new waste management strategies are implemented in smart cities. An example here are digital product passports, which record the material flow over especially sensitive value creation chains as seamlessly as possible. (See Reinstaller et al. 2022: 8)
- Big data analyses better identify patterns, trends and interactions, which can also be used, among other things, for better circularity of industrial processes. An example would be more accurate forecasts for requirement planning and the predictive maintenance of plant and machinery. (See Reinstaller et al. 2022: 8f)
- With machine learning algorithms are trained on the basis of historical data records, so that computers, robots and other smart devices work automatically and can perform new tasks independently. Their performance increases here with the ability to extract, record and process relevant data (digital images, for example) from the real world. Examples from the circular economy affect, for example, the use of robots for waste sorting (machine vision) or the optimization of incineration processes. (See Reinstaller et al. 2022: 9)
- In additive manufacturing, the computer-controlled formation of consecutive material layers produces three-dimensional objects (3D

Circular economy



⁴⁸ The Austrian Council made a similar proposal in an earlier recommendation (Austrian Council 2020b), and that in the form of a “golden rule for the RTI policy”, that is, to calculate RTI investments from corresponding deficit rules, in order to fund this type of investments. The golden rule is essentially based on the principle that new borrowing as this kind of public investment is justified, as to some degree it finances itself due to its positive long-term returns and similar GDP effects. This principle applies all the more so for RTI investments.

printing). For the circular economy this opens up the opportunity to also reduce both waste and the overall material requirement in manufacturing. (See Reinstaller et al. 2022: 9)

The circular economy and digitalisation also offer a multitude of new opportunities on the path to the *twin transition*. The actual impacts of the digital technologies on climate change will, however, ultimately depend on their specific implementation, as well as on indirect rebound effects, such as increased demand for ICT services due to higher quality and new services, for example (see Reinstaller et al. 2022: 9). A recent study, for example, thus confirms positive climate effects for Germany with digitalisation, but estimates these to be significantly lower than previously assumed and warns accordingly against unrealistic expectations (see Clausen et al. 2022).

How can the transformation to the circular economy be driven forward in Austria?

Generally speaking, the transition to a circular economy requires extensive innovation activities, both in adopting and in developing suitable technologies and new business models, but also regulatory further developments and social awareness raising and appropriate training measures (see Reinstaller et al. 2022: 48). This is both a challenge and a major opportunity for companies and society in general.

A specific case example of the challenges for establishing a circular value creation chain in the area of lithium ion batteries (LIB) by way of example illustrates the broad economic, social and RTI policy approaches, which are required for a transformation towards the circular economy (see Reinstaller et al. 2022: 36F) – introducing individual instruments and twisting and turning on the individual fine tuning points, such as *just* to establish a higher CO₂ tax, for example, or *just* to set up a general R&D funding programme for the circular economy, is insufficient to swiftly drive the transformation forward (see Reinstaller et al. 2022: 49). A systemic approach, that is, an extensive set of measures harmonised with individual industries and material flows is required, including regulatory specifications, R&D funding, new business models, training paths, awareness raising and so on. Furthermore, the European framework conditions must also be considered. Efforts in this area are especially important to achieve climate goals, as a globally concerted effort would mean a quadrupling of the raw material requirements for cleaner energy technologies by 2040. Battery storage systems generally require far more raw materials than their fossil fuel-based equivalents. A typical electric car thus requires approximately six times more mineral raw materials than a conventional car would. The energy system transformation is therefore accompanied by a change in the demand for raw materials – from fossil resources to metals. (See Reinstaller et al. 2022: 49)

» A reliable supply of the raw materials required for an energy transition is an essential requirement for a successful climate protection strategy.

Circular economy



Specific implications for the Austrian RTI policy

1. The RTI policy can only be one aspect with the transformation towards the circular economy. This requires a, holistic approach, that is, more intensive coordination of various players, stakeholders or ministries, for example, to be able to introduce effective measures both within Austria and at European level. Transformation requires coordination. An example here is the embedding of a thematic funding programme for the circular economy in a broad concept, which also incorporates foresight, business models, regulation, awareness raising and so on, and ideally also proceeds sector-specific, so the respective challenges can differ depending on the sector, industry or product. For each sector/industry, for different value creation chains or for specific location-bound systems, such as urban spaces, the most important levers of the transformation must also be identified, and measures to apply these levers must be developed. These will not always be purely technological problems here. Rules or regulations, market structures, production technologies, financing problems or established norms of behaviour can also stand in the way of a transformation. (See Reinstaller et al. 2022: 49)

Coordination with other structure policy measures is also important. The circular economy requires a specific support infrastructure, which individual companies cannot provide profitably and therefore results in coordination failure. An example here are digital networks with high security standards and communication technologies. Tracing components, materials and products is an important part of circular economy technologies and establishing new business models. There are therefore overlaps with structure policy areas of action here, such as the funding of Industry 4.0 technologies and the corresponding support infrastructure, for example. So it is important to develop portfolios of measures, which incorporate various structure policy areas, and to coordinate their implementation across departments. (See Reinstaller et al. 2022: 49f)

2. As the analysis shows, RTI activities can be expanded both on the funding side and on the performance side, whereby provision of higher financial resources would also be a priority. This is shown both generally for circular economy activities and for lithium ion batteries, with which the Austrian value creation share in the automotive area, for example, is especially high and where therefore in industrial policy terms a priority setting would also have to be considered. *Picking the winner* risks are reduced here, because it's not about strengthening individual companies, but rather about solving problems on the basis of the most convincing applications. (See Reinstaller et al. 2022: 50)

Circular economy



3. Traditional thematic funding approaches in Austria are generally based on a bottom-up approach – under an umbrella topic, for example, companies can submit their applications freely. In harmony with the considerations for implementing missions,, we must consider formulating specific goals for funding activities and to actively address and network potential funding recipients for this, to achieve specific advances with regard to defined technological goals. This also corresponds with the trend of ARPA-oriented funding agencies, such as the European Innovation Council, or the Wellcome Leap Fund. The smaller Austrian environment must also be considered here, in terms of a test to see if there is enough potential in the country itself to truly make technological advances with regard to a goal, or if this activity would be better domiciled at European level from the outset. (See Reinstaller et al. 2022: 50)
4. In Austria COMET centres are funded theme-open. One consideration would be to consciously set up COMET centres in the future to meet specific scientific-technological challenges. Such considerations must, however, as previously handled in COMET, be oriented on Austrian strength areas and existing competencies, to enable research and development at EU level at the least. (See Reinstaller et al. 2022: 50f)



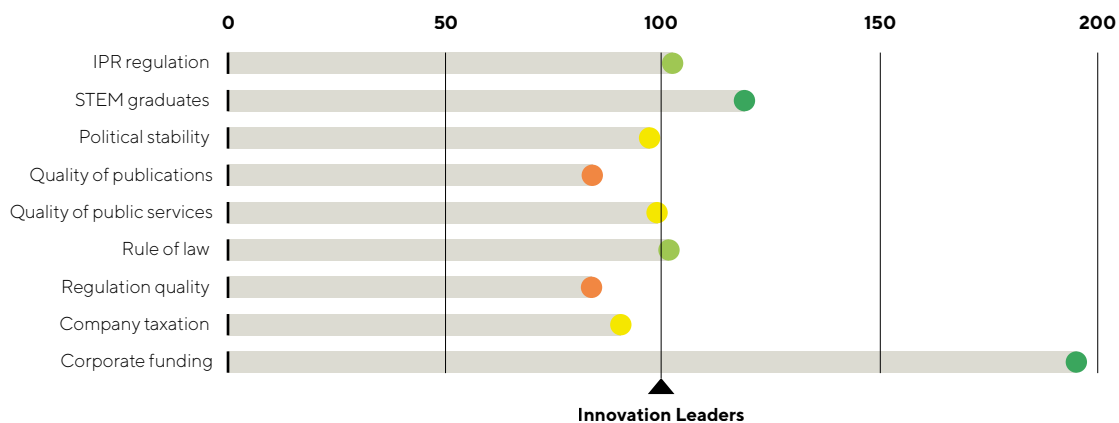


Figure 15: Strengths and weaknesses in the location attractiveness area compared with the innovation leaders



Lever to goal achievement:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

1.2: Increase R&D-active companies by 20 %

Location attractiveness

Composite indicator

112



downward trend

The location attractiveness for innovation-intensive companies and highly qualified specialists plays a major role for small, open national economies such as Austria's in particular, which are heavily integrated in global value creation chains. Attractiveness here is firstly measured on general factors such as political stability, quality of public services, regulation and rule of law. For such companies in particular the proximity to research-intensive institutions is essential for location decisions, to benefit, for example, from knowledge transfer, research collaborations and well-trained graduates and to create an attractive knowledge-intensive ecosystem. Corporate taxes and funding ultimately have an effect on the financing and revenue of innovation activities (see Keuschnigg et al. 2017).

Despite the higher company funding in Belgium, Austria remains far above the average of the leading countries. The availability of STEM graduates contributes to the location attractiveness – primarily due to the numerous graduates from the higher technical institutes, which are statistically recorded as university graduates. ICT specialists and university graduates are, however, well above-average in the digitalisation area compared with the leading countries, so that the indicator for general STEM graduates must be considered with caution.

The remaining indicators, among them political stability as well, are just about on par with the average. Securing location attractiveness with diversification of the location benefits as a medium-term undertaking appears important in any case – foreign R&D financing is high in Austria. If big companies decide to emigrate, this would quickly have significant effects on RTI activities. First and foremost for a diversification are the quality of universities and the availability of specialists (ICT) – for this, see A.2 Education, B.1 Tertiary education, B.2 Academic research and D.1 Digitalisation. A diversification would even have the potential to contribute to efficiency (see C.2 Efficiency), if the amount of corporate funding is no longer primarily decisive for location attractiveness.

» Diversification of the location advantages appears important in any case.

Not only is it also important for companies to be attractive abroad, the conditions for rapid growth of young innovation-intensive companies in Austria must be improved as well, that is, the RTI dynamic in the country must be strengthened autonomously (see B.4 Startups and B.5 Financing).

Location attractiveness





Figure 16: Strengths and weaknesses in the gender equality area compared with the innovation leaders



Direct goal assignment:

Goal 3: Promote knowledge, talents and skills

3.1.2: Increase the percentage of women with graduates in technical subjects by 5 %

Gender equality



Valuable potential is still being lost in Austria, as too few highly qualified women work in science and research. Both Austrian industry⁴⁹ and the economy on the whole require specialists, especially in technology and in the ICT area, which is why it is urgently necessary to encourage more women to seek careers in these professions. Also to be positively evaluated is the fact that the “STEM graduates” indicator, which represents the tertiary education of female graduates in scientific and technological disciplines per 1,000 inhabitants aged 20 to 29, shows a value that is comparable with that of the innovation leaders. At the same time, however, the “Female graduates in scientific studies” (that is, the share of female STEM graduates as a percentage) and “Female ICT specialists” (that is, the share of women among ICT specialists including professions such as ICT service managers, ICT technicians, ICT service providers and so on) indicators show below-average values.

» Female researchers in companies and ICT graduates are clearly underrepresented in Austria.

It is especially poor with the “Female researchers in companies” indicator, which shows the share of women in scientific research staff, and with “Female ICT graduates”. The latter measures the share of women among graduates of ICT study courses per 1,000 inhabitants and is not only far behind the innovation leaders, but rather is also significantly below the EU average.⁵⁰

Heterogeneous, however on the whole problematic situation in the “gender equality” area

The “gender equality” area provides a heterogeneous view of the situation; however, the cumulative value for gender equality in Austria on the whole shows a significant deficit compared with the innovation leaders. Although the “glass ceiling index”, which shows how likely it is that a woman will make the leap from scientific staff at a university to an executive position, is thankfully comparable with that of the innovation leaders, at the same time the below-average values with the “Female researchers in companies” and “Female researchers not working in companies” indicators show that both in Austrian companies and in the state and universities sectors the share of women in scientific research staff is significantly lower than that with the innovation leaders. Austria also scores especially poorly with the “ICT graduates” indicator, where

Gender equality



⁴⁹ Since 2009, the Federation of Industry has performed regular surveys to sound out the importance of STEM qualifications and the respective staff situation in leading Austrian companies. For the most recent results see IV, STEM factsheet, January 2021, online at iv.at/-Dokumente-/Publikationen/399-20-pm-mint-factsheet-v8.pdf [1.3.2022].

⁵⁰ See “Strengths and weaknesses analysis: Gender equality”, fti-monitor.rfte.at/C/C.5 [1.3.2022].

it is significantly below the EU average and the innovation leaders, and dramatically behind the top three.

To therefore actually be able to achieve the goals formulated in the RTI strategy – (i) Increase the percentage of female STEM graduates by 20 percent (ii) Increase the percentage of women with graduates in technical subjects by 5 percent – further efforts to improve gender equality are also required. Initiatives such as the “MINTality” Foundation started at the beginning of 2022 by several companies, the Federation of Industry, the Economic Chamber and the Innovation Foundation for Education are indeed extremely important here, however even more important would be the funding of girls and women in the STEM subjects over the entire education chain with corresponding didactic adjustments and a bundling⁵¹ of already existing schooling measures, concepts and activities. The “*Fachzirkel Geschlechtersegregation MINT*” (STEM gender segregation roundtable) workgroup set up by the BMB-WF, which by mid-2022 will work out a strategy complete with measures recommendation to attract more women/girls for training in the STEM area, is therefore very welcome. With initiatives such as the “STEM Girls Challenge”, together with the BKA and the Federation of Industry, the BMDW aims to strengthen the participation and visibility of girls and young women in future industries, so that old role models and stereotypes will finally be removed. The goal is to counter the scarcity of specialists at business location Austria, and a further goal is to not only increase the share of women in STEM professions and to promote women within the company itself in these areas, but rather to also increase the share of women in management positions in the medium to long term.

The education system must also play a key role here, but role models and social values in particular will also be illustrated. The education system above all has the task of equipping students with the basics of 21st century skills. But, as already shown in A.2 Education, Austria has long since exhibited a high performance difference between girls and boys in the mathematics subject. And the basically positive findings on the high share of work-related graduates⁵² are also somewhat clouded by the fact that only just under 10 percent of girls and boys complete an upper secondary level vocational course of education in the “engineering, manufacturing industries and construction industry” subjects, whereby Austria, however, is at a level comparable with the innovation leaders.⁵³ This situation continues with the graduates of tertiary courses of education in the “engineering, manufacturing industries and construction industry” subjects, where Austria is also on a par with the innovation leaders.

51 For this, see also resolution proposal 2305/A(E) of 23 February 2022 (XXVII.GP) by Representatives Dr.in Maria Theresia Niss and Mag.a Sibylle Hamann with regard to the promotion of women in the STEM area.

52 For this, see section A.2 Education and “Strengths and weaknesses analysis: Education”, fti-monitor.rfte.at/B/A.2 [1.3.2022]

53 In Sweden, it is 8.5%, in Denmark 9.6% and in Finland 8.3%; at this time, no value is available for Belgium. (See para. B3.2 in OECD 2021b.)

COVID-19 pandemic as a step backwards for gender equality

The effects that the COVID-19 pandemic will have in the area of gender equality cannot yet be conclusively evaluated. There are, however, clear indications that existing inequalities have worsened, and additional challenges in particular have also emerged for women, especially with supervision responsibilities, which obstruct many women in the research area in maintaining their research productivity.

As at the same time we can assume that with the end of the pandemic the briefly attenuated STEM staff issue will once again give way to a significant growth trend in the technical area,⁵⁴ and therefore there will also again be high demand for graduates of higher technical education from technical colleges, higher technical institutes and universities, it is all the more urgent that women be motivated to seek careers in STEM subjects.

⁵⁴ For this, see the companies' survey in IV, STEM factsheet, January 2021, online at iv.at/-Dokumente-/Publikationen/399-20-pm-mint-factsheet-v8.pdf

Recommendations for action

C.1 Digitalisation

—> Digitalisation plays an important role with regard to the alignment on a circular economy, because new technologies such as artificial intelligence or the Internet of Things can play a decisive role in this transformation, by enabling a high level of data transparency and improved manufacturing methods, among other things. Measures that establish the digital transformation in companies (especially SMEs) are therefore necessary and important.

—> Successful digitalisation requires high quality trained specialists, who are currently not available in sufficient numbers in Austria. Initiatives, which at the latest begin in secondary level I and ensure that, on one hand a sound digital basic education is achieved and on the other hand interest in appropriate vocational training courses and studies is incentivised, must be increased here.

C.2 Climate and environment

—> The eco-social tax reform just recently adopted by the Austrian Government is an important cornerstone in achieving climate goals and in steering towards consumers' sustainable behaviour, but the arrangement in its current form is simply not extensive enough. The systemic view of the circular value creation chain is missing. A significantly further-reaching implementation of a concept of the eco-social tax reform while considering the principles of the circular economy would therefore also be important with regard to their implementation. The latter must not be impeded by too many standards and regulations, which vary from state to state.

—> The RTI policy should provide its support to combat climate change by increasing additional stimuli even further, by funding scientific research and the technological bases for new products or manufacturing processes, which are more CO₂-efficient than before, for example.

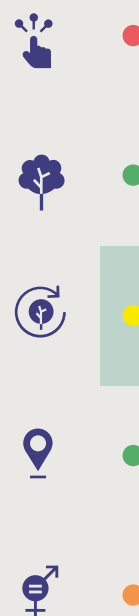
C.3 Circular economy

—> The creation of a specific implementation plan to finance a green economy, while considering the principle of a "golden rule", for example, would be required here. An appropriate approach here might be for the European Commission to make a recommendation with the fiscal rules with regard to country-specific benchmark percentages of state spending in each country, which is to be used for green public sector investments, and these percentages would then be correspondingly deficit ineffective.

—> With the implementation of the measures for a circular economy its systemic nature must also be considered, such as with the example of the strategic measures plan for environmental technologies and for the circular and recycling economy, for example (see Austrian Government 2020). This means the introduction of individual instruments and twisting and turning on individual fine tuning points will not be sufficient to drive the transformation forward. Due to the high complexity and causal relations, a successful implementation requires more than an ex-post-oriented success measurement (see Lindner et al. 2021).

C.4 Location attractiveness

—> A diversification of the location benefits should reduce the dependency on corporate funding as a special location feature. Further strengthening of the internationally visible excellence of research at universities and increasing the availability of highly qualified specialists (see A.2 Education, B.1 Tertiary education, B.2 Academic research, D.1 Digitalisation).



—> Improvement of the conditions for the growth of young, innovation-intensive companies, to contribute with home-made entrepreneurial dynamics to location attractiveness and RTI output (see B.4 Startups, B.5 Financing)

C.5 Gender equality

—> Although numerous measures have already been introduced to improve gender equality and in particular with the “glass ceiling index” have also been effective, the traditional understanding of roles is still very pronounced in Austria. Gender-specific role expectations should therefore already be critically questioned in early childhood education and, among other things, more men should be recruited as teaching staff for the early childhood and primary education area by creating appropriate incentives.

—> Further specific promotion measures should also be introduced to remove the performance differences in the mathematics subject. In this context, whether or not further training measures to sensitise teachers with regard to the importance of gender-balanced classes are required should also be checked. Only when classes are taught gender-balanced at school level can significant progress also be expected in the tertiary area and the RTI area.

—> To make the STEM subjects attractive it is recommended the mediation and teaching of these subjects be oriented more intensively on problem-centred learning. Not the “how”, but rather and in particular the “why” should be front and centre here. The content of the STEM subjects should not be taught as a purpose, but rather as a means for solving problems.



Impact

The **Effectiveness** and **Efficiency** chapters do not describe any additional areas of the RTI system, but rather correlate already discussed input indicators with the output (efficiency analysis). Overriding impact indicators of the economic and social, health and environment areas are clustered in the effectiveness area (national economy and social). They are therefore primary goals of various economic policy measures. A causal relation is not, however, established here between RTI performance and the contribution of these impact indicators. The indicators are descriptive and are influenced by many other determining factors outside of RTI. They can however support the RTI policy's prioritisation and decision-making – with regard, for example, to choosing the type of innovation activities, which can either focus on specific topics or in a more general way are oriented on competitiveness and economic growth.

Effectiveness



Efficiency



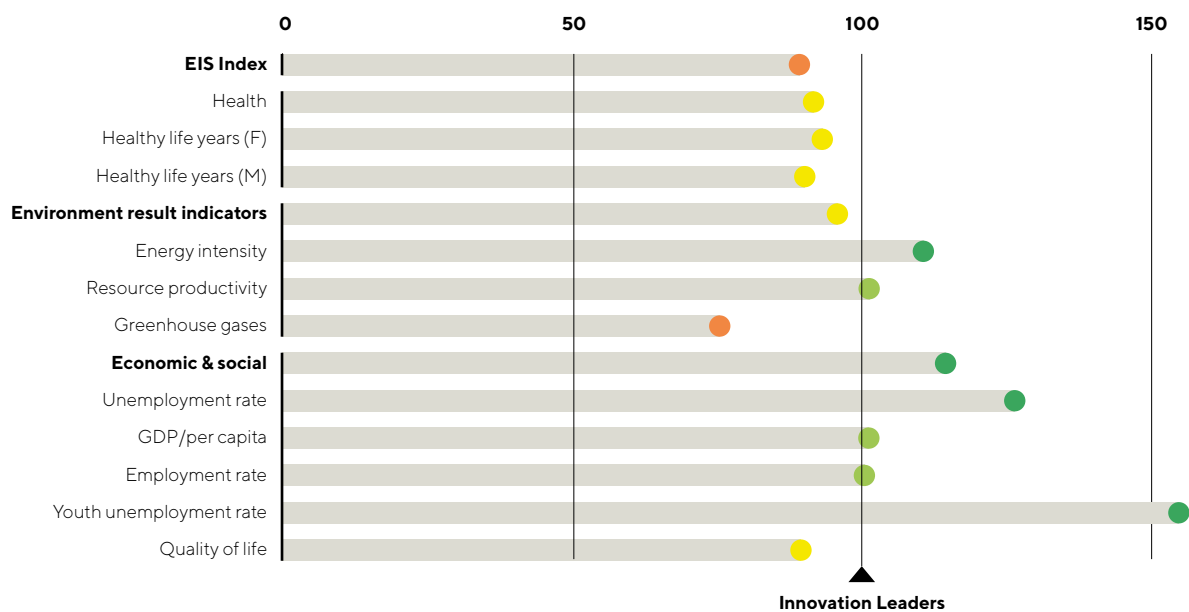


Figure 17: Strengths and weaknesses in the effectiveness of RTI activities area compared with the innovation leaders



Direct goal assignment:

Goal 1: Become an international innovation leader and strengthen Austria as an RTI location

1.1.1: European Innovation Scoreboard Index (EIS)

1.1.3: Global Innovation Index (GII)

Effectiveness



The effectiveness illustrates Austria's capability with key indicators in the three dimensions, economic & social, environment and health. These form the overriding impact goal of efforts in the RTI system, well-being, health and sustainability of the Austrian economy and society. Due to their multi-causal development, RTI system impacts are, however, not directly observable. The available indicators therefore do not map causal explanations, but rather instead provide indications on whether or not there are areas with a special RTI policy need for action. A low per capita GDP or a high unemployment rate, for example, would therefore indicate that RTI activities must focus more intensively on companies' growth opportunities and competitiveness.

As shown in figure 17, on the whole Austria is just ahead of the leading innovation countries, primarily because of Luxembourg's absence with its enormously high per capita GDP and with consideration of the youth unemployment rate indicator for the first time compared with last year's report. In general, the performance in the economic & social dimension is significantly better than in the environment and health areas. Consistently with all relevant indicators (with the exception of quality of life), but with the unemployment and youth unemployment rate in particular Austria scores significantly better than the comparison countries. The low youth unemployment rate is attributable to the vocational training system – with the percentage of work-related graduates Austria takes first place among the available countries (see A.2 Education). With the employment rate Austria is on a par with the leading countries, the not presented employment rate of older people would, however, be lower in Austria. This performance characteristic – high economic performance, lower with environment and health – can be used as motivation for an extensive analysis of the R&D financing structure (see B.5 Financing). General economic goals can benefit from every RTI activity, whatever the direction; specific efforts are however required for improvements with environment and health.

» In general, the performance in economy & social is significantly better than in the areas of health and environment.

In conclusion, there is significantly greater potential effectiveness of Austria's RTI activities in comparison with the EU average, but not with the top three. Notable, however, is the deficit in the health area itself compared with the EU average. Not yet fully mapped in the data are the effects of the Covid-19 crisis, which could worsen the situation, with, for example, a higher fall in GDP compared with other countries that have a lower tourism share.

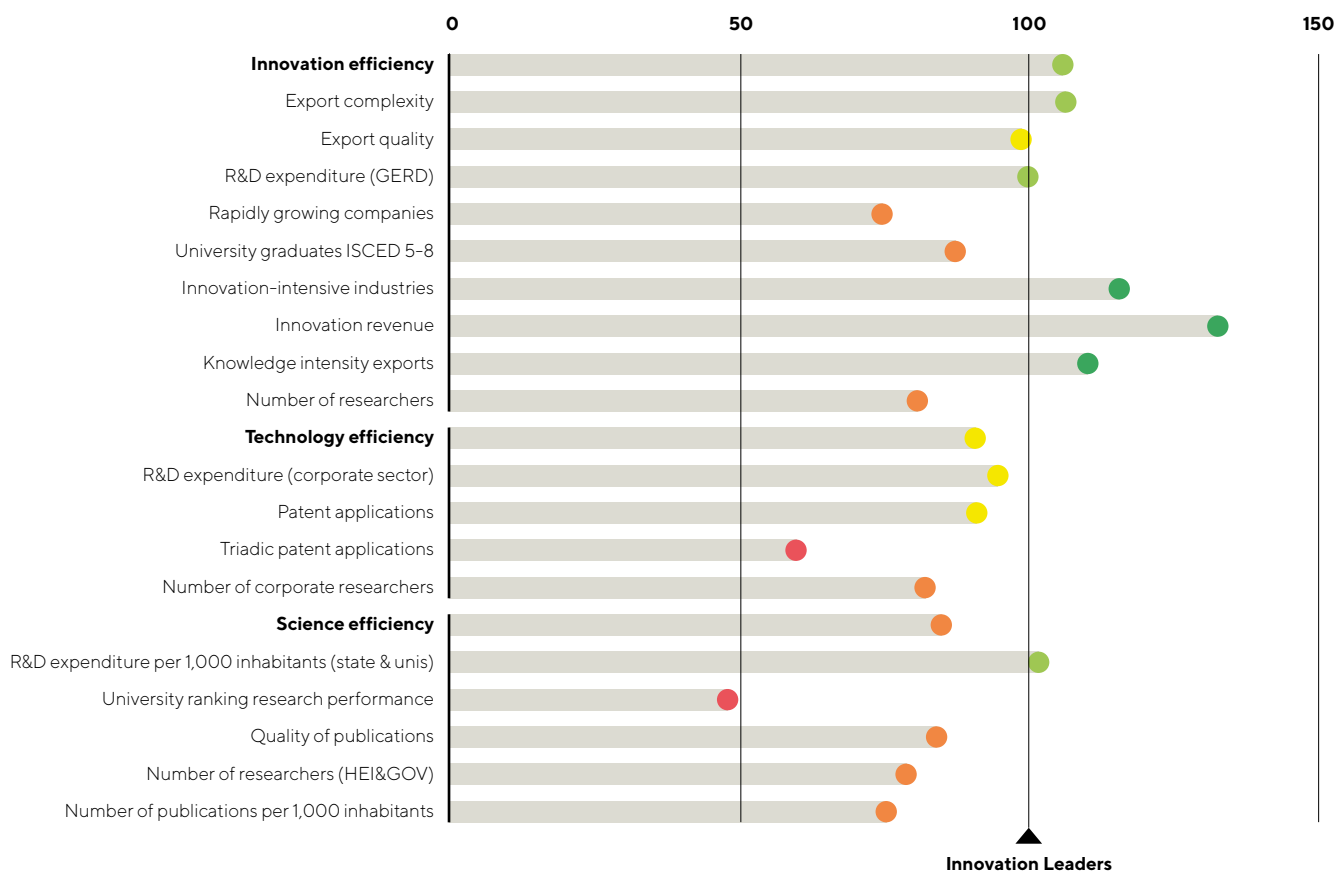


Figure 18: Strengths and weaknesses in the efficiency of RTI activities area compared with the innovation leaders



Efficiency



Efficiency correlates input (R&D expenditure, number of researchers, among other factors) with output in the three performance dimensions, science (publications), technology (patents) and innovation (high-tech sectors, innovation revenue, export quality, among other factors) based on statistical analyses (see Janger/Kügler 2017). The indicator is not only influenced by innovation processes within the core RTI system, but rather also by the quality of the RTI framework conditions (see A.1-A.3).

With regard to the efficiency of RTI activities, in relation to the leading innovation countries there continues to be improvement potential, such as in science or technology, for example, where the delivered input results in relatively lower output than with the leading innovation countries. In the innovation dimension, Austria's value is slightly above-average (see figure 18), this dimension is however also the most difficult to measure, while R&D expenditure and patents as well as publications are clearly delimited and statistically more reliable – Austria's narrow advantage should therefore be interpreted with caution.

The Austrian Council has already discussed the lack of efficiency in individual areas of the RTI system several times (see Austrian Council 2018: 18ff.). Despite somewhat improved values in the science and technology area in the "science efficiency" composite indicator compared with the previous year, Austria could not catch up and is behind the top three (Switzerland, Japan, Germany); the same applies for the technology dimension.

With the input indicators, with the exception of the R&D expenditure indicator (state sector and higher education and GERD), Austria is on a par or just ahead of the innovation leaders; with R&D expenditure in the corporate sector it is significantly below these countries in places. In last year's report, the efficiency analysis presented yet another situation. Three input indicators in R&D expenditure here were above the level of the innovation countries (see Austrian Council 2021d: 67). This is attributable to the fact that in 2022, the Netherlands is no longer a leading innovation country and Belgium now is. Belgium is perhaps not as strong as the Netherlands with research expenditure for the higher education sector, it does however provide significantly more funding and tax incentives for companies. With exceptions that in particular affect innovation performance, as already in the previous year, the output indicators are however significantly behind the innovation leaders, especially in the area of technologically demanding triadic patents.

» The input in science and technology leads to less output than for the innovation leaders.





III

Prospects

Prospects

Crisis periods, such as that triggered by the Covid-19 pandemic, are also always periods of transition. This situation further intensified with Russia's invasion of Ukraine in February 2022. In addition to a genuine threat to our security there is also the threat of block building once again, an increase in the strategic use of technologies and ultimately a targeted decoupling. In any case, it can be expected that the dynamics of major changes in the years ahead will accelerate even further. Whether further geopolitical shifts, climate change or the digital transformation – the rate of resulting upheavals will increase significantly and incorporate education, science and economy, society and politics. (See Austrian Council 2021c) In such times in particular, countermeasures must always contribute to enabling reforms, to be able to meet future challenges and not simply reset systems to their initial state.

The RTI policy must therefore not only be aligned future-oriented, but rather and in particular systemically as well. Future-oriented means that pending changes caused by an appropriate alignment are anticipated, accompanied and supported as best they possible can be. Systemically means that only the combination of numerous fine tuning points can have the desired effect – a consideration of and dealing with challenges according to policy areas or similarly isolated will therefore be unsuccessful. Essential issues must also be dealt with today already to be able to resolve future problems. This includes an Austrian industrial policy realignment, increased equal opportunity in the education system, modernising the universities, a people-centred digital transformation, increased technology sovereignty, combatting climate change and establishing a circular economy. Complex causal relations must not only be identified – they must also be dealt with in a specifically coordinated manner. RTI stakeholders therefore require a clear understanding of causal relations and a cultural change, which drives collaboration and cross-sector cooperation. Addressing the *grand challenges* requires the interaction of various levels of policy action. Only an appropriate adaption of pending changes and current challenges will also result in sustainable improvements in Austrian growth potential (see OECD 2021e: 83ff.). Strengthening the resilience of critical infrastructures and reducing one-sided strategic dependencies must also be an essential part of a future-oriented integrated RTI policy, with investments in cybersecurity, for example, or alternative forms of sustainable energy supply (hydrogen, for instance).

With the redefined framework conditions in the research funding act (FoFinaG), the RTI Strategy 2030 and the current RTI package the development of a new mode of governance for a changed intervention culture in terms of the requirements discussed here can already be seen. The urgency of the challenges, however, now also means there will be further institutional and structural consequences. An integrated RTI

policy with guiding principle missions and strategic visions is key here. A system of critical questioning and agile responsiveness must also be established to enable faster coordination between the responsible ministries and the various interest groups. Embedding national activities in international and European processes is strategically important here. The global cooperation between science, industry and the body politic of various countries in the development of vaccines for SARS-CoV-2 is a positive example of the swift and effective coordination of private economy and state ideas and initiatives (see Kreiling/Paunov 2021).

A transformative innovation policy is not primarily restricted to economic goals such as competitiveness and economic growth, but rather must also deliver specific activities and a binding timeframe for social problem solutions (see Lindner et al. 2021). This requires strong, clear and credible signals to those active in the economy and to society in general. National crisis-related measures must therefore not only address the immediate consequences of crises, but rather must also be developed in terms of their interaction and seen as part of an integrated macrosocial future strategy. The basic idea of a transformation that goes beyond the scope of the current crisis is included in the RRP in accordance with the specifications of the RRF. The national COVID-19 aid measures, on the other hand, do not have any comparable transformative stimuli. (See Dachs/Weber 2022). It is also important that transformative initiatives, such as those set out in the RRP are proactively defined and further developed with the aid of foresight processes or similar measures.

Bibliography

ASM (2022): *Austrian Start up Monitor 2021*, austrianstartupmonitor.at/wp-content/uploads/2021/05/Austrian-Start-up-2020.pdf [1.3.2022].

Austrian Council (2017a): *“Recommendation for the further development of the technical colleges sector in the Austrian education and science system”*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/einzelempfehlungen/2017/170530_Empfehlung_Weiterentwicklung_FH.pdf [1.3.2022].

Austrian Council (2017b): *“Recommendation for policy prioritisation for the tertiary education sector (especially universities)”*, Vienna: Austrian Council for Research and Technology Development, rat-fte.at/files/rat-fte-pdf/einzelempfehlungen/2017/170914_Empfehlung_politische%20Schwerpunktsetzung_Universitaeten.pdf [1.3.2022].

Austrian Council (2017c): *“Recommendation on the way to the forefront of innovation”*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/einzelempfehlungen/2017/171130_Empfehlung_Der%20Weg%20zur%20Innovationsspitze.pdf [1.3.2022].

Austrian Council (2018): *Report on Austria’s Scientific and Technological Capability 2018*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/leistungsberichte/Leistungsbericht%202018.pdf [1.3.2022].

Austrian Council (2019): *Report on Austria’s Scientific and Technological Capability 2019*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/leistungsberichte/Leistungsbericht%202019.pdf [1.3.2022].

Austrian Council (2020a): *“Recommendation on the implementation of a ‘Future Fund Austria’ for research, development and innovation”*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/einzelempfehlungen/2020/200826_Empfehlung_Fonds%20Zukunft%20Österreich.pdf [1.3.2022].

Austrian Council (2020b): *“Recommendation for the RTI policy during and after the COVID-19 crisis”*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/einzelempfehlungen/2020/200618_Empfehlungen%20für%20die%20FTI-Politik%20nach%20COVID-19.pdf [1.3.2022].

Austrian Council (2021a): *“10 theses on technology sovereignty”*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/publikationen/2021/RFTE_Neujahrsempfang_2021_Thesenpapier.pdf [1.3.2022].

Austrian Council (2021b): *“Recommendation for Austrian industrial policy realignment”*, Vienna: Austrian Council for Research and Technology Development, rat-fte.at/files/rat-fte-pdf/einzelempfehlungen/2021/211020_Empfehlung_Industriepolitik.pdf [1.3.2022].

Austrian Council (2021c): *“Recommendation, ‘Sense of Urgency’ in the RTI Policy”*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/einzelempfehlungen/2021/211108-Empfehlung-Sense-of-Urgency.pdf [1.3.2022].

Austrian Council (2021d): *Report on Austria’s Scientific Capability 2021*, Vienna: Austrian Council, rat-fte.at/files/rat-fte-pdf/leistungsberichte/Leistungsbericht%202021.pdf [1.3.2022].

Austrian Economic Chamber (2022): *Startups 1993 – 2021. Preliminary results*, wko.at/statistik/ng/ng2021v-gesamt.pdf

Austrian Government (2020): *Aus Verantwortung für Österreich. Government programme 2020-2024*, bundeskanzleramt.gv.at/dam/jcr:7b9e6755-2115-440c-b2ec-cbf64a931aa8/RegProgramm-lang.pdf [1.3.2022].

BKA (2020a): *RTI Strategy 2030. Strategie der Bundesregierung für Forschung, Technologie und Innovation*, bundeskanzleramt.gv.at/dam/jcr:1683d201-f973-4405-8b40-39dded2c8be3/FTI_strategie.pdf [1.3.2022].

BKA (2020b): *RTI Package 2021-2023*, Vienna: Federal Chancellery, bundeskanzleramt.gv.at/dam/jcr:d238ee64-dddf-4ae1-8067-fe1a5f8a9f48/FTI_pakt.pdf [1.3.2022].

BMBWF (2018): *“71. Ordinance, which amends the ordinance on the curricula of the new secondary schools and the ordinance on the curricula of the secondary schools of general education”*, Vienna: Federal Ministry of Education, Science and Research, ris.bka.gv.at/eli/bgbll/II/2018/71/20180419 [1.3.2022].

BMBWF (2020): *National university mobility and internationalization strategy 2020-2030*, Vienna: Federal Ministry of Education, Science and Research.

BMBWF (2021a): *National education report, Austria 2021*, Vienna: Federal Ministry of Education, Science and Research.

BMBWF/FWF (2021b): *“Financing agreement excerpt (FV) 2021-2023”*, Vienna: Federal Ministry of Education, Science and Research, bmbwf.gv.at/dam/bmbwfgvat/Forschung/Forschung-in-%C3%96sterreich/Forschungsf%C3%B6rderungseinrichtungen/FWF-FV-barrierefrei.pdf [1.3.2022].

BMF (2021): *Austrian Recovery and Resilience Plan 2020-2026*, Vienna: Federal Ministry of Finance, Vienna: Federal Ministry of Finance, oesterreich.gv.at/dam/jcr:ecf30896-0861-4107-8ed9-b589a79bd623/Österreichischer%20Aufbau-%20und%20Resilienzplan%202020-2026.pdf [1.3.2022].

BMK (2021a): *Austrian Government’s strategy for artificial intelligence*, Vienna: Federal Ministry of Climate Protection, Environment, Energy, Mobility, Innovation and Technology, bmk.gv.at/dam/jcr:93f327ac-b69c-4ac7-a9aa-30eee51cc221/AIM_AT_2030_UA.pdf [1.3.2022].

BMK (2021b): *The Austrian circular economy. Austria on the path to a sustainable and circular society*, Vienna: Federal Ministry of Climate Protection, Environment, Energy, Mobility, Innovation and Technology, bmk.gv.at/dam/jcr:ccbbe6aa-d0eb-4dbb-ae50-cab89e251cd5/Kreislaufwirtschaftsstrategie_Begutachtungsentwurf.pdf [1.3.2022].

Bock-Schappelwein, Julia/Famira-Mühlberger, Ulrike (2021): *Extent and effects of school closures. Austria in the international comparison*. WIFO Research Briefs 15/2021, Vienna: WIFO, wifo.ac.at/news/ausmass_und_effekte_von_schulschliessungen [1.3.2022].

- Clausen, J./Niebel, T./Hintemann, R./Schramm, S./Axenbeck, J./Iffländer, p. (2022). *Climate protection with digital transformation: Realistische Perspektive oder Mythos?*, Berlin: Borderstep Institute for Innovation and Sustainability (in cooperation with ZEW and KDO).
- Dachs, Bernhard/Weber, Matthias (2022): *National recovery packages, innovation, and transformation, study commissioned by the Austrian Council*, Vienna: Austrian Institute of Technology, rat-fte.at/files/rat-fte-pdf/publikationen/2022/RFTE-2022-National-recovery%20packages-innovation-and%20transformation.pdf [1.3.2022].
- KOF Swiss Economic Institute (2021): *"KOF Globalisation Index. Ranking 2021"*, Zurich: ETH Zurich, ethz.ch/content/dam/ethz/special-interest/dual/kof-dam/documents/Globalization/2021/KOFGI_2021_ranking.xlsx [1.3.2022].
- European Commission (2014): *"Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest 2014/C 188/02"*, Brussels: European Commission.
- European Commission (2019): *"The European Green Deal"*, COM(2019) 640, Brussels: European Commission, ec.europa.eu/info/sites/default/files/european-green-deal-communication_de.pdf [1.3.2022].
- European Commission (2020a): *"A New Industrial Strategy for Europe"*, COM(2020) 102, Brussels: European Commission, eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0102 [1.3.2022].
- European Commission (2020b): *"A new Circular Economy Action Plan For a Cleaner and More Competitive Europe"*, Brussels: European Commission, ec.europa.eu/environment/strategy/circular-economy-action-plan_en [1.3.2022].
- European Commission (2021): *"Updating the 2020 New Industrial Strategy: Building a Stronger Single Market for Europe's Recovery"*, COM(2021) 350, Brussels: European Commission.
- European Commission (2021b): *"Special Eurobarometer 516 – April-May 2021: European citizens' knowledge and attitudes towards science and technology"*, europa.eu/eurobarometer [1.3.2022].
- University Conference (2022): *"UC position on technical colleges development and funding plan from 2023/2024"*, fhk.ac.at/wp-content/uploads/2022/02/FHK_Positionspapier_O222.pdf [1.3.2022].
- GEM (2022): *Global Entrepreneurship Monitor 2020/2021*, Graz: Johanneum UAS, gemconsortium.org/file/open?fileid=50900 [1.3.2022].
- Hanushek, E.A./Woessmann, L. (2020): *"Education, knowledge capital, and economic growth"*, in: Bradley, S./Green, C. (Hg.): *The Economics of Education. A Comprehensive Overview*, London: Academic Press, p. 171-182.
- Hranyai, Kathrin/Janger, Jürgen/Strauss, Anna (2013): *Research rate goals 2020, study commissioned by the Austrian Council*, Vienna: WIFO, rat-fte.at/files/rat-fte-pdf/publikationen/2013/131010_Forschungsquotenziele2020_2013_WIFO.pdf [1.3.2022].
- Janger, Jürgen/Kügler, Agnes (2017): *Innovation efficiency. Austria in the international comparison (Innovation Efficiency. A Cross-country Analysis)*, Vienna: WIFO, wifo.ac.at/pubma-datensätze?detail-view=yes&publikation_id=61111 [1.3.2022].
- Janger, Jürgen/Strauss-Kollin, Anna (2020): *Analysis of the Austrian innovation system's performance*, study commissioned by the Austrian Council, Vienna: WIFO, wifo.ac.at/jart/prj3/wifo/resources/person_dokument/person_dokument.jart?publikationsid=66555&mimetype=application/pdf [1.3.2022].
- Keuschnigg, Christian/Ecker, Brigitte/Sardadvar, Sascha/Reiner, Christian (2017): *Innovationsland Österreich: F&E, Unternehmensentwicklung und Standortattraktivität*, study commissioned by the Austrian Council, St. Gallen: WPZ, rat-fte.at/files/rat-fte-pdf/publikationen/2017/170606_Innovationsland%20Oesterreich_WPZ.pdf [1.3.2022].
- Keuschnigg, Christian/Sardadvar, Sascha (2019): *Venture capital for financing innovation and growth*, study commissioned by the Austrian Council, Vienna: WIFO, rat-fte.at/files/rat-fte-pdf/fti-dokumente/RFTE_Wagniskapitalfinanzierung_20190604.pdf [1.3.2022].
- Kreiling, L./Paunov, C. (2021), *Knowledge co-creation in the 21st century: A cross-country experience-based policy report*, OECD Science, Technology and Industry Policy Papers, No. 115, Paris: OECD Publishing, doi.org/10.1787/c067606f-en [1.3.2022].
- Lacy, P./Long, J./Spindler, W. (2020). *The Circular Economy Handbook*. London: Palgrave MacMillan.
- Lindner, R./Edler, J./Hufnagl, M./Kimpeler, S./Kroll, H./Roth, F./Wittmann, F./Yorulmaz, M. (2021): *"Missionsorientierte Innovationspolitik" ("Mission-oriented innovation policy")*, policy brief. Fraunhofer ISI (2021), isi.fraunhofer.de/content/dam/isi/dokumente/policy-briefs/policy_brief_missionsorientierung.pdf [1.3.2022].
- Loretz, S./Pitlik, H./Schratzstaller, M. (2021): *"Federal budget and public debt in the COVID-19 crisis. Estimated budget 2021 and medium-term financial framework 2021 to 2024"*, WIFO monthly reports 94 (1), p. 53-65.
- Ellen MacArthur Foundation (EMF), (2013). *Towards the Circular Economy: Opportunities for the consumer goods sector*. Ellen MacArthur Foundation, 1-112. mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/pdfs/towards_the_circular_economy.ashx [1.3.2022].
- MacArthur, E./Morlet, A. (2020): Foreword, in: Lacy, P., Lacy, P./Long, J./Spindler, W. (2020). *The Circular Economy Handbook*, London: Palgrave MacMillan.
- OECD (2020a): *"Coronavirus (COVID-19): Joint actions to win the war"*, Paris: OECD Publishing, oecd.org/about/secretary-general/Coronavirus-COVID-19-Joint-actions-to-win-the-war.pdf [1.3.2022].
- OECD (2020b): *"Science, technology and innovation in times of COVID-19. What policy responses for the recovery"*, Paris: OECD Publishing.
- OECD (2021a): *"Education at a Glance 2021"*, Paris: OECD Publishing.

- OECD (2021b): *“Education at a Glance 2021: OECD Indicators”*, wbv Media, Bielefeld. Indicator A5 doi.org/10.3278/6001821ow [1.3.2022].
- OECD (2021c): *“Education at a Glance 2021. OECD Indicators, Table A1.1. Educational attainment of 25-64 year-olds (2020)”*, stat.link/fvdtr4 [1.3.2022].
- OECD (2021d): *“Education at a Glance 2021. OECD Indicators – Austria”*, Paris: OECD Publishing, oecd-ilibrary.org/sites/d2c43767-en/index.html?itemId#content/component/d2c43767-en [1.3.2022].
- OECD (2021e): *OECD Economic Surveys: Austria 2021*, Paris: OECD Publishing, doi.org/10.1787/eaf9ec79-en [1.3.2022].
- OECD (2018): *OECD Reviews of Innovation Policy: Austria 2018*, Paris: OECD Publishing, oecd.org/publications/oecd-reviews-of-innovation-policy-austria-2018-9789264309470-en.htm [14.4.2022].
- Pekanov, Atanas/Schratzenstaller, Margit (2020): *The role of fiscal rules in relation with the green economy*, Brussels: European Government Economic Governance Support Unit and Policy Department, [europarl.europa.eu/RegData/etudes/STUD/2020/614524/IPOL_STU\(2020\)614524_EN.pdf](https://europarl.europa.eu/RegData/etudes/STUD/2020/614524/IPOL_STU(2020)614524_EN.pdf) [1.3.2022].
- Polt, Wolfgang/Peneder, Michael/Prem, Erich: *New European industry, innovation and technology policy (NIIT), a discussion of key aspects with a view to Austria*, study commissioned by the Austrian Council, Vienna: WIFO/eutema/Joanneum Research, rat-fte.at/files/rat-fte-pdf/publikationen/2021/2106_Endbericht%20NIIT.pdf [1.3.2022].
- Reinstaller, Andreas/Meyer, Ina/Peneder, Michael (2022): *Transformation to the circular economy – capability, industry and RTI policy funding*, study commissioned by the Austrian Council, Vienna: WIFO.
- Reinstaller, Andreas (2020): *“Effects of the COVID-19 crisis on the research and development tasks of the corporate sector in Austria”*, WIFO monthly reports 6/2020, Vienna: WIFO.
- Reinstaller, Andreas (2022): *Effects of the COVID-19 pandemic on the innovativeness of companies in Austria*, study commissioned by the Austrian Council (work in progress)
- Reinstaller, Andreas/Reschenhofer, P. (2019): *Der Beitrag österreichischer Erfindungen zur Entwicklung von Schlüsseltechnologien. Ergebnisse auf der Grundlage eines neuen Patentanzeigers*, study commissioned by the Austrian Council, Vienna: WIFO.
- Schneider et.al. (2021): *Evaluation of the COVID-19 investment premium*, bmdw.gv.at/dam/jcr:533d5c21-7a88-4ee7-8715-2591c952889d/IWI%20P-IC%20Endbericht_Evaluierung%20COVID-19-Investitionspr%C3%A4mie%202021_bf2.pdf [1.03.2022].
- Statistik Austria (2021): *Global estimate: Gross domestic expenditure for R&D 2005-2020. Financing the research and experimental development implemented in Austria*, Vienna: Statistik Austria, statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/forschung_und_innovation/globalschaetzung_forschungsquote_jaehrlich/023703.html [1.3.2022].

Printing information

Publisher and media owner

Austrian Council for Research and Technology Development, 1010 Vienna, Pestalozzigasse 4

Members of the Council

Dr.ⁱⁿ Klara Sekanina, Chairperson

DIⁱⁿ Dr.in Sabine Herlitschka, MBA, Deputy Chairperson of the Austrian Council

Univ.-Prof. Dr. Jakob Edler

Dr. Hermann Hauser

Em. Univ.-Prof.ⁱⁿ Dr.in Helga Nowotny

Univ.-Prof.ⁱⁿ Dr.in Sylvia Schwaag-Serger

Secretariat

DI Dr. Ludovit Garzik, Managing Director of the Secretariat

DIⁱⁿ Mag.a Dr.ⁱⁿ techn. Alexandra Mazak-Huemer, Deputy Managing Director

Dr. Anton Graschopf

Mag.^a Bettina Poller

PD Dr. Gerhard Reitschuler

Sascha Ruhland, M.A.

Mag. Martin Wagner

Dr. Bernhard Wally, MSc

Project Manager and Editor

DIⁱⁿ Mag.a Dr.ⁱⁿ techn. Alexandra Mazak-Huemer

Mag. Martin Wagner

Data

Austrian Institute of Economic Research (WIFO), Mag. Dr. Jürgen Janger, MSc

English Translation

Translation Services Dr. Billaudelle & Partner, Kevelaer, Germany

Design and production

Extraplan GesbR, Vienna

© 2022 Austrian Council for Research and Technology Development