Rat für Forschung und Technologieentwicklung

Report on Austria's Scientific and Technological Capability

2023

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Preamble

The RTI system is becoming increasingly more complex and new topics, which influence strategic decisions or require such, become more important. Geopolitical conditions that change quicker all the time generate additional pressure to introduce the right measures at the right time – to coordinate stakeholders and to break down silos.

These circumstances apply to practically every country, but they certainly have special effects for small, open and interconnected national economies, such as Austria's. It is therefore all the more important to continuously, dynamically, reliably and comprehensibly evaluate the performance of the Austrian innovation system.

With the introduction of the RTI monitor in 2022, the Austrian Council took an important step in this respect – this digital instrument supports players, stakeholders and political appointees in making evidence-based decisions for the RTI system, to examine the effects of previous measures, and allows us to understand systemic dependencies better.

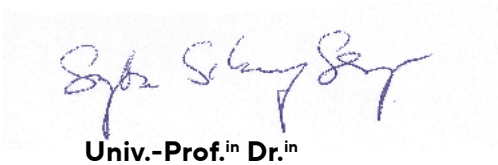
To comply with this requirement even more specifically, the analytical priority in 2023 is on the temporal development of the underlying indicators and their long-term contributions to change – so, how the individual aspects of the system have impacted over time on the performance of the respective areas and which trends and prospects of goal achievement this produces.

The RTI monitor is a data-driven instrument that uses, prepares and makes available a wide range of resources, so stakeholders can turn information into action.

The real value that the knowledge and common good-oriented use of data has, however, is also made clear with the Council's instrument linked with the RTI monitor: The ECTO Dashboard[1] uses a big data approach to create a knowledge-based product chamber model for Austria and to identify transformation opportunities in the Tech4Green area. Identified in it is the potential of green products and product groups, for which Austria already has the necessary capabilities for production and which therefore offer specific opportunities for an accelerated green transformation. The global market size for these products is also analysed and the dependence on critical primary raw materials is scrutinised.

1 "Economic Complexity and Green Transformation Opportunities" Dashboard, Complexity Science Hub (CSH) Vienna commissioned by the Austrian Council, URL: ecto.rfte.at. For this see chapter C.3 Environment & climate, "Transformation opportunities in the Tech4Green area" section, p. 75.

With the central RTI monitor and the new ECTO, the Austrian Council supports stakeholders, players and political decision makers in strategically and sustainably shaping the Austrian RTI system, at both national and European level, and in implementing the green and digital transformation, innovatively, securing prosperity, and fit for the future.



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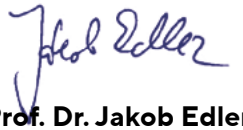

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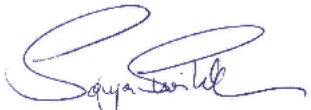


Dr.in Sonja Sheikh

The *Report on Austria's Scientific and Technological Capability 2023* and RTI monitor 2.0

This year the analyses primarily focus on the respective contribution to change of the individual indicators, which are used for measuring the performance of the RTI system, and consider them in and for the long term. This report is designed to analyse and evaluate the Austrian RTI system, systematically and data-driven – that is to say, evidence-based. The goals of the RTI Strategy 2030 and (new this year) those of the Circular Economy Strategy with the areas of the RTI system are correlated for this purpose on the inside of the jacket cover. Performance is pinpointed using the indicators on which the report is based on, which measure various performance aspects (areas).

The innovation leaders according to the European Innovation Scoreboard[2], are used as a benchmark to also position the performance of the Austrian innovation system in an international comparison. In 2023, these are Sweden followed by Finland, Denmark, the Netherlands and Belgium. In the RTI monitor, in addition to the innovation leaders, Austria's performance is also compared with the global top 3 and the EU average.

Comprehensive graphically prepared time series visualisations of all individual indicators in the international comparison are added as a new function of the RTI monitor.[3] It is then possible, in addition to the analysis of the current status at the time of reporting, to identify developments via long-term time series comparisons, to react accordingly and also to more efficiently predict the prospects of achieving the goals of the RTI Strategy 2030.

The content connection of the report with the RTI monitor shifts even more this year into the centre of focus, so this report must be considered an analogous addition to the digital RTI monitor[4].

Innovations in the RTI system

The RTI system consist of four subsystems (RTI framework conditions, core RTI system, RTI cross-cutting issues and impact analysis), containing sixteen areas. To emphasise the pressing challenges of the green trans-

2 European Innovation Scoreboard (EIS) 2022, research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en [1 March 2023].
3 Among other things, this enables visualisation of the impacts of the 2008-2009 financial and economic crisis, the 2012-2014 Euro debt crisis and the 2020-2022 COVID-19 pandemic on the developments of the indicators.
4 Austrian Council's RTI Monitor: fti-monitor.rfte.at.

formation, this year the "C.2 Climate and environment" and "C.3 Circular economy" areas have been consolidated into the "Green Transformation", the goals of the Circular Economy Strategy (BMK 2022a: 14ff) adopted by the Austrian Government have been referenced, and the indicators for C.3 Circular economy have been extended and specified. The funding forms (green finance) required for successful implementation of the measures are also examined in a first overview.

The RTI cross-cutting issues have also been expanded with an important geopolitical area: C.6 Sovereignty focuses on the technology sovereignty priority and analyses the level of sovereignty in EU-27 key technologies compared with China, Japan, South Korea, Switzerland and the USA.[5]

The indicators

The basis for the indicators of the report and the RTI monitor is provided by empirical data from the most important databases accessible to the general public, and in particular those of international organisations such as Eurostat, OECD, WTO, THE or the World Bank, for example. Both the input and output indicators of the Austrian RTI system compared with the innovation leaders (see section III, Strengths and weaknesses analysis) are presented in the bar charts of the respective areas. Financial and human resources are considered on the input side (public sector R&D funding, for example); on the output side (where available) both quantity and quality indicators are considered (the number and quality of patents, revenue achieved with innovations, among others).[6]

While the aggregated area indicators and the composite indicators only provide a rough overview, with their selection and structure the individual indicators enable detailed cause analyses and the later illustration of a chain of effects (see Janger/Strauss-Kollin 2020:5).

5 An analysis of the level of sovereignty, which is restricted to one individual member state of the European Union, must be considered unsuitable, as both positive and negative developments of individual countries have direct or indirect effects on the entire federation of states.

6 In the RTI Monitor in version 2.0, all indicators are classified in input and output using symbols.

Report structure

This report is structured in three key sections:

I Degree to which the goals of the RTI Strategy 2030 are achieved
The objectives and the respective goal values are mapped in an overall table here. The goals of the RTI Strategy 2030 (Goal 1. Join the international leaders and strengthen Austria as an RTI location; Goal 2. Focus on efficiency and excellence; and Goal 3. Promote knowledge, talents and skills) are then analysed aggregated and significant results are described in further detail. A detailed analysis of the individual objectives of the RTI Strategy 2030 with the corresponding time series visualisations and the outlook for the prospects of goal achievement is provided in the web-based RTI monitor 2.0.

II Degree to which the goals of the Circular Economy Strategy are achieved
Following the same logic, this section focusses on the four goals of the Circular Economy Strategy adopted by the Austrian Government in 2022. Indicators of the Eurostat database were used here to analyse the current findings for domestic material consumption (per capita), for material footprint (per capita), GDP per ton of material use, the usage rate of reusable materials and the amount of municipal waste per resident and to describe the goal distances (goal achievement).

III To analyse the strengths and weaknesses of the RTI system in the international comparison
The RTI system is illustrated in the report and RTI monitor 2.0 as follows:

Subsystem A: RTI framework conditions
A.1 Regulation and taxes, A.2 Education and A.3 International ties.

Subsystem B: Core RTI system
B.1 Tertiary education, Academic research B.3 Companies in which knowledge and innovations are generated and B.4 Start-ups, which are supported in their innovative projects by the research funding system (B.5 Financing).

Subsystem C: RTI cross-cutting issues
Includes specialised areas (C.1 Digitalisation, C.3 Circular economy, for example), which have effects on all subsystems of the core RTI system and are influenced by the rest of the innovation system, such as RTI framework conditions (A). C.2 Location attractiveness, which is an important component for innovation performance because of the high level of foreign financing for Austrian R&D expenditure, must also be highlighted here, as must C.5 Gender equality, with special focus on increasing the inclusion of women in RTI activities.

Subsystem D: Impact
Effectiveness and efficiency illustrate the interplay of all subsystems and stakeholders. D.1 Effectiveness incorporates overarching economic and social impact indicators, such as economic performance, health or environmental measures, for example. This potential effectiveness will highlight the RTI policy's overarching need for action, such as important environmental KPIs (for example the level of greenhouse gases).

The qualitative evaluation of the individual areas in this report is based on empirical data from sources mentioned at the beginning, which were compiled by WIFO as commissioned by the Austrian Council, as on 31 January 2023. This report also focusses heavily on the development of this data over the long term, as provided visualised in the RTI monitor in time series form.

The analysis is performed based on Austria's per annum growth rate (*compound annual growth rate*) and the difference with the innovation leaders. Colours form a traffic light system here: Green and bright green signal 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.

- Value ≥ 109.5
- 99.5 ≤ Value < 109.5
- 89.5 ≤ Value < 99.5
- 74.5 ≤ Value < 89.5
- Value < 74.5

A series of the indicators used is only available with an average delay of two to four years (see OECD, Eurostat). For better orientation the precise data source (Eurostat [rd_e_gerdfund], for example), is therefore given in the RTI monitor 2.0 with each individual indicator, along with a time series visualisation (Austria compared with the innovation leaders, top 3 countries and EU average). Also pointed out is the fact that some indicators are subject to sharp fluctuations because of method and data breaks, and a moving average was therefore used by WIFO for these indicators (see section III: Strengths and weaknesses of the RTI system at a glance).

Introduction

Last year's report focussed primarily on the transformation and the state support measures demanded by the COVID-19 pandemic and the systemic implications for the Austrian RTI system. The transformative content of both national and international, that is, in particular EU measures (NextGenerationEU, Recovery and Resilience Facility) were estimated and evaluated here (see Dachs/Weber 2022). The analysis showed that the transformative content of the state measures with regard to climate and digitalisation goals must be evaluated as positive, both relative to the EU average and even to the innovation leaders.

This year a series of further macroeconomic uncertainties have been added to the pandemic situation (now no longer primarily front and centre). These include the Russian war on Ukraine and the resulting energy crisis and supply chain problems, the supply shortages they entail and the highest price increases in seventy years. These developments must also be considered with higher priority for the near future, and in particular for the RTI system. Each country responds differently to the new challenges. The new international dynamism will have to be critically observed given the fact that the energy crisis has to date only marginally been used to drive forward both the green and the digital transformation with the required acceleration, even though some trends (realignment of the EU emissions trading scheme[7], for example) must be assessed as positive (see Dvorak/Hirtenstein 2022).

With its location-policy incentives and grants, the US American *Inflation Reduction Act*[8] (IRA) is also an additional challenge for location Europe. Within the scope of the IRA the USA specifically promotes the production and use of renewable energies with approximately $400 billion – if we add on the legislation to expand the infrastructure and chip industry, some €1.6 trillion will be provided to make industry ultra-modern, more resilient and CO_2-neutral. In addition to the promotion of investments in clean energy and incentives to accelerate emissions reduction and climate resilience, the USA also considers the social dimension of the transformation, to guarantee a socially just transition to a green economy with highly qualified workers.[9]

That companies only receive the grants provided for in the IRA when products are for the most part produced in the USA is a further highly critical

7 The new regulation foresees a tightening of the existing specifications – the number of existing emission allowances will be sharply curbed, whereby the current price of €85/t CO_2 will increase; the number of issued allowances is currently falling annually by 2.2 percent, and is expected to reach 4.2 percent. And there will be no more exceptions for certain industries.

8 United States Environmental Protection Agency (EPA), epa.gov/green-power-markets/inflation-reduction-act [24 February 2023]

9 An essential difference of the IRA compared with the European subsidy policy and the existing high funding is the fact that, unlike Europe, the USA is very consciously output-oriented subsidised. The IRA is therefore not research funding, but rather a specific form of production funding for companies and businesses.

aspect, which can negatively impact on the European – and therefore also Austrian – business location, in the form of companies relocating abroad, for example. Solution-oriented discussions are indeed already underway at diplomatic level to prevent a potential trade dispute between Europe and the USA, but also with China, however Europe must reconsider its own subsidy policy and make the framework conditions for investments (accelerated approval procedure, for example) as attractive as possible, as quickly as possible.

The *Net-Zero Industry Act* was adopted at European level as a first reaction to the IRA and China's subsidy policy for climate-neutral technologies with higher value creation. In this act, the European Commission now promotes comparable measures and the inclusion of the European sovereignty fund planned for the financing (see VertDE 2023). This will ensure that public monies are utilised to raise social standards, while simultaneously supporting European industry and reducing carbon emissions. We must, however, proceed with caution here to prevent any potential race for subsidies.

These international developments must also be considered in the Austrian RTI context. As part of the Climate and Transformation Offensive (CTO), the Austrian Government intends to drive forward the energy transition and climate action, and to a lesser degree the digital transformation as well, through the use of specific funding for Austrian industrial companies (see BMK 2022b). With an average of €834m per annum, extensive measures will be subsidised within the scope of the CTO from 2023 to 2026, while a further €590m per annum (approximately) are estimated for 2027 to 2030. In total, an industrial policy package of measures with some €5.7 billion is available for the CTO up to 2030[10] (see Reinstaller 2022). Added to this are the funds (some €300 million), which the BMAW[11] provides from the CTO in the 2023-2026 period to fund applied entrepreneurial research. Funded, on one hand, are transformative business projects, which will contribute to making the Austrian economy more sustainable, more crisis-resistant and more independent, and on the other hand projects that target a leading role in the implementation of new technologies and innovative business models.

The Package for Research, Technology and Innovation[12] (RTI Package) is an additional instrument for the operationalisation of the long-term applied RTI strategy goals and guarantees the connection with the European RTI agendas. €5.05 billion are agreed for the 2024-2026 period, representing the highest ever budget for science and research (see BKA 2022a). Compared herewith a total of €3.86 billion are available in the expiring 2021-2023 RTI Package (see BKA 2022b). The question as to whether or not a three-year period is basically sufficient to achieve the operationalised goals accordingly, nevertheless remains.

10 The Austrian Productivity Council sees this bundle of measures as an important step towards long-term securing the competitiveness of industry location Austria, however it also points out the need for accompanying measures and broader agreement with other policy areas.
11 See ffg.at/transformationsoffensive [4 April 2023].
12 For the RTI Package, see BKA 2020b and BKA 2022a.

The importance of the RTI Packages is in the guaranteed planning security and the clear allocation of the financial resources (UA 31.03, 33 and 34). The focus of the RTI Package is the sustainable transformation of the economy, the cooperation between science and business, R&D climate goals, technology sovereignty and openness, as well as young talent and equality. The commitment is centred on a transformative innovation policy with impact orientation, an inter-departmental focus on the holistic portfolio management of measures and the corresponding linking of the respective instruments (see BKA 2020a:6).

More financial resources in the RTI system (input), however, do not automatically mean increased innovation performance (output). With the additional allocation of funds, the agencies are confronted with higher administrative costs to process the wide range of new (on top) topics added on. With regard to the shaping of a transformation-oriented innovation policy, however, it is also important to not get bogged down in path dependencies and to force these through with new topics again and again, with the goal of achieving the most wide-ranging RTI policy approach possible. Such inefficient lock-ins result in the efficiency lead of new paths being overcompensated by the adoption lead of existing measures and instruments (old paths), and innovative transformation consequently tending to be inhibited rather than promoted (see Schwaag Serger et al. 2022:3).

With regard to overall sustainability (so, ecological, social and economic), Austria enjoys a position among the European and global leaders together with the two innovation leaders, Sweden and Finland. Relative to other countries Austria invests much in research and development and has caught up rapidly in various areas of the RTI system (see Schwaag Serger et al. 2022:7, 17). If the sustainability-oriented transformations are to successfully meet the multi-dimensional challenges presented, a number of different instruments and measures will have to be applied to begin the removal of existing practices and technologies (see Kivimaa/Kern 2016: 207). All these efforts must also be undertaken with a clear impact-oriented focus.

To be able to identify and better analyse interdependencies, the RTI monitor 2.0 and, of course (in condensed form), the analogous report provide information on the current capability of the Austrian RTI system in various areas in the international comparison. The data and indicators enable a purely data-oriented status quo analysis here, from which RTI policy measures can in turn be evidence-based. Both the development compared with the previous year (growth effect) and the level of each area (level effect) relative to the innovation leaders, Sweden, Finland, Denmark, the Netherlands and Belgium, are relevant here.

I

Analysis of the goals of the RTI Strategy 2030

RESULT OF THE ANALYSIS OF THE DISTANCE TO THE RTI STRATEGY 2030 GOAL VALUES		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)	**17**	**10**	**59**
1.2	Recruit 5-10 new RTI-intensive lead companies and expand existing ones	**3**	**10**	**60**
1.3	Increase number of R&Dactive companies by 20%	**3.872**	**4.646**	**83**
1.4	Participating in at least 3 additional IPCEI	**4**	**5**	**80**
1.5	Drive forward digital transformation	**77**	**100**	**77**
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	**0,22 %**	**0,1 %**	**100**
2.3	100 % more economically successful academic spin-offs			
2.4	Top 10 placing with European Research Council (ERC) grants	**6**	**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	**13**	**3**	**23**
2.6	Increase the corporate sector's success rate with Horizon Europe	**23,7**	**20**	**100**
3	**Promote knowledge, talents and skills**			
3.1.1	Increase STEM graduates by 20 %	**17.391**	**19.528,8**	**89**
3.1.2	Increase the percentage of women with graduates in technical subjects by 5 %	**29**	**31,5**	**92**
3.2	Top three place in the IMD World Talent Ranking	**8**	**3**	**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**
3.5	Double students of STEM who completed a semester abroad	**1971**	**4424**	**45**

* no concrete value

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

Goals 1.1.1 to 1.1.3 address Austria's development in the European Innovation Scoreboard (EIS), Digital Economy & Society Index (DESI) and Global Innovation Index (GII) international indices.

In the EIS Austria is ranked number 8 in the group of *strong innovators* (EU-27 and pre-Brexit EU-28) and number 10 (including "non-EU-countries" Switzerland [number 1] and Norway [number 7]) and therefore has achieved 50% of the goal of rising to rank 5 among the EU-27. With 118.3% of the EU average Austria is therefore above that of the *strong innovators* (114.5% – see European Commission 2022d). Although the Austrian development trend is rising slightly by 4.5%P, it is nevertheless below the EU growth rate of 9.9%P.[13]

In the DESI Austria remains at tenth place, but could catch up somewhat compared with Estonia (rank 9). A ranking improvement is possible, however countries that currently rank behind Austria (such as Germany, for example), also exhibit a very strong upward momentum. There is a need to catch up especially in the areas of connectivity, digital public services and human capital.[14]

In the overall index (GII), since 2018 Austria has improved from place 21 to place 17 in 2022 and therefore has achieved 59% of the goal of joining the top 10. Austria performs best in the sub-categories, *institutions* and *infrastructure*, weakest in *knowledge and technology outputs, creative outputs* and *market sophistication* – whereby it once again performs better with the inputs than with the outputs.[15]

Goals 1.2 to 1.5 apply to national goal values. With the "Acquire 5-10 new RTI-intensive leading companies and expand existing ones" goal the innovative transformation potential of these companies will be used for the location. Coordinated with the departments represented in the RTI Task Force (and the BMAW in particular) in a very first proposal, leading enterprises were defined as businesses whose investment volume (pure) in R&D exceeds €100 million and/or which create 100 new jobs. On the basis of the ABA media monitoring, five companies from the areas of automotive, pharma and microelectronics were identified.

A further goal of the RTI Strategy is to increase the number of R&D-active companies by 20%.[16] This is especially important as Austria cannot optimally exploit the potential of positive effects of the structure and technology transformation and recently added key technologies with already established companies alone. The number of R&D-driving businesses developed

affected areas of the RTI system

- A.1 Regulation and taxes
- A.2 Education
- A.3 International ties
- B.1 Tertiary education
- B.2 Academic research
- B.3 Corporate RTI
- B.4 Start-ups
- B.5 Financing
- C.1 Digitalisation
- C.4 Location attractiveness
- C.6 Sovereignty
- D.1 Efficiency

13 See RTI Monitor: 1.1.1 EIS, fti-monitor.rfte.at/Z/1.1.1.
14 See RTI Monitor: 1.1.2 DESI, fti-monitor.rfte.at/Z/1.1.2.
15 See RTI Monitor: 1.1.3 GII, fti-monitor.rfte.at/Z/1.1.3.
16 See RTI Monitor: 1.3 Increase R&D-active companies by 20%, fti-monitor.rfte.at/Z/1.3.

extremely positively up to 2019; the trend of this indicator and therefore an estimate of the prospects of goal achievement are, however, only possible at the earliest with the pending publication of the latest R&D survey. The current development trend with start-ups of innovative, growth-intensive companies, is however problematic, as it is regressive compared with the innovation leaders. Missing here above all are effective measures for the better availability of risk capital.

As a key element of the European industrial policy, Important Projects of Common European Interest (IPCEI) are considered in the Austrian RTI Strategy with the goal of participating in a total of five by 2030.[17] Austria currently participates in four IPCEIs[18] and can therefore already achieve the set goal in 2023, as approval for participation in a fifth is imminent (IPCEI Microelectronics II)[19].

The "Increase digitalisation" goal has already been achieved up to 77%.[20] The main part of this evaluation is allocated to the "Digitalisation" overall indicator, with which Austrian achieves 75% of the level of the innovation leaders (see section III: C.1). Further digitialisation indicators are also calculated in, but are not identified in the RTI monitor.[21] Massive improvement potential exists in the areas of infrastructure and specialists, which are required for an intensified implementation of the digital transformation. A specific, impact-oriented focus should therefore be placed on these topics (see section III: C.1).

17 See RTI Monitor: 1.4 Participate in 3 more IPCEI, fti-monitor.rfte.at/Z/1.4
18 bmk.gv.at/themen/innovation/internationales/ipcei/aktive_teilnahmen.html [1 March 2023].
19 bmk.gv.at/themen/innovation/internationales/ipcei/angestrebte_teilnahmen.html [1 March 2023].
20 See RTI Monitor: 1.5 Increase digitisation, fti-monitor.rfte.at/Z/1.5.
21 The four additional indicators are: (1) ICT for ecological sustainability – DESI, (2) Percentage of schools with regard to the rollout of digital terminal devices, (3) Participating schools in the area of digital school development and (4) Number of teachers that have taken part in the two MOOCs, "Distance Learning" and "digi.konzept".

affected areas of the RTI system

2 Focus on efficiency and excellence

Goals 2.1 to 2.6 are oriented on the internationally successful research nations. Austria must show an impressive catchup process with the R&D rate.[22] Austria attains third place in the EU here behind the innovation leaders Sweden and Belgium (comparison year 2020) and in the global ranking it is ranked seventh (along with Sweden and Belgium, Israel, South Korea, the USA and Japan are still ahead of Austria).

For goal 2.2 "Raise venture capital investments", risk capital availability and risk capital intensity are one of the critical variables for scaling as a prospect for growth and innovation and therefore must be established in Austria, indirectly as a motivator. Austria has not improved since 2007 in the long-term comparison with the innovation leaders and has even fallen further since 2014.[23] The average level of the risk capital intensity of the innovation leaders in 2014 was already at 0.42% and in 2021, it was 0.8%. The goal of increasing risk capital intensity in Austria to 0.1% of GDP is met based on the current (smoothed) data[24] in the time series visualisation of the risk capital intensity indicator[25]. This smoothing means the average level is now at 0.15%. Goal achievement in this area must not however belie the fact that the development in the VC area does not show any substantial increases, despite numerous RTI policy initiatives in recent years. The challenge of bringing about a genuine trend reversal is therefore still an absolute given.

For goal 2.3, Double the number of financially successful academic spin-offs by 2030, the spin-off of R&D and innovation-intensive, strong growth companies from universities and research institutions must increase sharply.[26] The finding is based here on an extrapolation of the data of the Austrian Startup Monitor (ASM).

Goal 2.4 To rank in the top 10 (applications per resident) with ERC grants, has been achieved almost continuously since 2009. In the current report period, Austria is ranked number 6.[27] The current goal achievement with the acquisition of ERC grants by Austrian researchers, however, is no long-term guarantee, so the distance to the leader group could not be reduced.

The participation in Horizon Europe is an essential component of the Austrian funding landscape. A participation of more than 2.9% is therefore targeted as a goal in all countries and according to the current status

- A.1 Regulation and taxes
- A.3 International ties
- B.2 Academic research
- B.3 Corporate RTI
- B.4 Start-ups
- B.5 Financing
- C.6 Sovereignty

22 See RTI Monitor: 2.1 OECD top five with R&D rate, fti-monitor.rfte.at/Z/2.1.
23 See RTI Monitor: 2.2 Raise venture capital investments to 0.1% of GDP, fti-monitor.rfte.at/Z/2.2.
24 Due to the retroactive smoothing of the data by WIFO to balance out the heavy data volatility, clearly different findings than those in previous years are found in this area.
25 See RTI Monitor: A.1. Regulation and taxes (individual indicator: risk capital intensity), fti-monitor.rfte.at/B/A.1.
26 See RTI Monitor: 2.3 100 % more economically successful academic spin-offs, fti-monitor.rfte.at/Z/2.3.
27 See RTI Monitor: 2.4 Top 10 placing with ERC grants, fti-monitor.rfte.at/Z/2.4.

affected areas of the RTI system

report is also achieved (FFG, 2023a). If we only consider the EU countries, with 3.5% the percentage is clearly above the EU average.[28] In the ongoing Horizon Europe Programme 2021-2027, with regard to the success rate Austria is ranked number 13 (11 with EU-27) and therefore cannot be considered with the result from Horizon 2020 (place 3), which is once again a targeted goal.[29]

The participation of Austrian companies in Horizon Europe has been increasing continuously since 2020 and with 23.7% in 2022 was more or less on a par with the innovation leaders and the strategy goal of 20%.[30]

3 Promote knowledge, talents and skills

With the achievement of the "Promote knowledge, talents and skills" objectives an essential key for Austria's formative capacity of future RTI developments and meeting the challenges resulting herefrom would be gained. Top quality education on all levels is one of the undisputed basic requirements for a society's success. Goals 3.1 to 3.5 apply to the priority of the STEM subjects, which are a key factor for future career paths – and not exclusively in the STEM area.

The "Increase the percentage of STEM graduates by 20%"[31] goal addresses the existing and further intensifying scarcity of specialists in the professional fields affected. Building on previous successes, it is nevertheless necessary to intensify the affinity with STEM. With the "STEM regions initiative", a further programme will support the successful development to increase the enthusiasm for computer science, data science, industrial engineering, robotics, molecular biosciences and further STEM areas with students and teachers. Raising the low percentage of women in technical studies and professions is a long-term, necessary and urgent goal here.[32]

Austria once again regresses in the overall standing of the IMD World Talent ranking.[33] Special strengths for Austria can be found in the dual training system (apprenticeships), in the healthcare system and quality of life. A declining company loyalty by specialists, the general scarcity of specialists, high cost of living and a high levies ratio have a negative impact on performance.

The goal of the RTI Strategy 2030 of putting two universities into the top 100 will on one hand increase the attractiveness of the higher education

- A.1 Regulation and taxes
- A.2 Education
- A.3 International ties
- B.1 Tertiary education
- B.2 Academic research
- C.1 Digitalisation
- C.4 Location attractiveness
- C.5 Gender equality

28 See RTI Monitor: 2.5.1 Strengthen participation in Horizon Europe, fti-monitor.rfte.at/Z/2.5.1.
29 See RTI Monitor: 2.5.2 Top three place with Horizon Europe success rate, fti-monitor.rfte.at/Z/2.5.2.
30 See RTI Monitor: 2.6 Corporate sector's success rate increase (Horizon Europe) from 18.2% to 20%, fti-monitor.rfte.at/Z/2.6.
31 See RTI Monitor: 3.1.1 Increase the percentage of STEM graduates by 20%, fti-monitor.rfte.at/Z/3.1.1.
32 See RTI Monitor: 3.1.2 Increase the percentage of women with graduates in technical subjects by 5%, fti-monitor.rfte.at/Z/3.1.2.
33 See RTI Monitor: 3.2 Top three placing in IMD World Talent Ranking, fti-monitor.rfte.at/Z/3.2.

institution location, and on the other hand contribute to the visibility of the importance of science and research at our universities. Even if the goal can presumably not be achieved, high esteem of the universities is important for democratic policy reasons to strengthen the general public's trust in science and research and therefore must at any rate be pursued.[34]

Increasing Austria's attractiveness for foreign researchers is defined in goal 3.4. With 53.1%, the goal of 45% is currently achieved for the appointment of professors. An extended database for further occupational groups at universities is unfortunately not available at the moment.

Goal 3.5 "100% more Austrian STEM students with semesters abroad" also contributes to the increase in internationalisation.[35] Following the interruption of studies-related stays abroad caused by the pandemic, an increase must be expected in the coming years.

34 See RTI Monitor: 3.3 Two Austrian universities among the top 100, fti-monitor.rfte.at/Z/3.3.

35 See FTI-Monitor: 3.5 100 % more Austrian STEM students MINT-Studierende mit Auslandssemester, fti-monitor.rfte.at/Z/3.5.

II

Degree to which the goals of the Circular Economy Strategy were achieved in 2023 performance period

AUSTRIAN CIRCULAR ECONOMY STRATEGY		Current value	Goal	Goal achievement
K.1.1	Material footprint (MF) reduced to 7 tonnes per capita and year by 2050	**21**	**7**	**33**
K.1.2	Domestic Material Consumption (DMC) reduced to 14 tonnes per capita and year by 2030	**19**	**14**	**73**
K.2	Increasing domestic resource productivity by 50% by 2030	**2,1**	**3,2**	**66**
K.3	Increasing the circularity rate to 18 % by 2030	**12**	**18**	**68**
K.4	Reduction of the material consumption in private households by 10% by 2030	**834**	**751**	**90**

Degree to which the goals of the Circular Economy Strategy were achieved in 2023 performance period

The Austrian Circular Economy Strategy (see BMK 2022a) was adopted in December last year and in addition to the principles and goals, also includes the instruments and specific measures with the corresponding rates required to achieve the respective goals. To effectively shape the transformation of the linear economy into a circular economy, there are also, among others, legal and regulatory framework conditions, as well as aspects of the financing and RTI funding policy. The created system-secure framework serves as a compass for redimensioning the energy and resource requirement in Austria. Clear here is the fact that a deep-seated political and cultural transformation is required to implement the ambitious goals and therefore so too is a national closing of the ranks between government, business and civil society (see CEFA 2022:11). The global circularity rate is below 10% and in Europe, it is just under 13%, whereby the latter is set to double by 2030. In view of the seriousness and urgency of the reorientation, a *circular mindset* is required with *circular companies* and *circular citizens* to create sustainable innovations (see CEFA2022:13).

→ B.3 Corporate RTI

The 2023 performance will be analysed and commented on in the following with regard to the strategic goals of the Circular Economy Strategy.

1 Reduction in resource consumption

Austria has high resource consumption in the EU comparison: The materials footprint in 2017 was 33 tons (t) per capita, while the materials consumption therein was 19 t per capita in 2018. The Austrian Government therefore pursues the goal in the Circular Economy Strategy of,

→ C.2 Climate and environment

- reducing the materials footprint (MF) to 7 t per capita and year by 2050 and

→ C.3 Circular economy

- reducing domestic materials consumption (DMC) to 14 t per capita and year by 2030.

In this year's report, as also in the web-based RTI monitor, the performance measurement with regard to these goals is performed similarly in the two DMC and MF dimensions and the raw material consumption (RMC), which is defined as DMC plus raw materials requirement for the imported semi-finished and finished goods minus the corresponding exports. According to the 2023 strengths-weaknesses analysis, Austria's resources consumption in the European comparison is very high – according to the last available data in 2020 the MF[36] was 21 t per capita (goal value: 7 t) and

→ D.1 Efficiency

36 See RTI Monitor: fti-monitor.rfte.at/Z/K.1.2 (MF per capita/year: Eurostat [env_ac_rme]).

in 2021 the DMC[37] was 19 t per capita (goal value: 14 t), however both have been trending slightly regressive since 2018.

2 Increase domestic resource productivity by 50% by 2030

Resource productivity measures the economic performance in EUR (GDP) per ton of DMC domestically and in recent years has risen with the decoupling of economic growth from resource consumption (see BMK 2022a:17). To be able to maintain this decoupling in the interest of further (sharply) declining resource consumption without economic and quality losses and without having to outsource resource-intensive production processes abroad, appropriate investments in energy and resource-friendly production processes are required, as they will be enabled with the Austrian Government's transformation offensive, for example (see Kienberger/Pomberger 2022:33ff, 62ff). The slight decoupling of the last 15 years at 1.4% of economic growth and the fall in resource consumption by 0.2% per annum are, however, not sufficient for the goal of increasing resource productivity by 50% compared with 2015. (See BMK 2022a:17). According to the strengths-weaknesses analysis, the corresponding "GDP per ton of material use (DMC)" indicator in 2021 was €2.1/kg (chain-linked volumes), that is, still clearly far from the goal value of €3.2/kg.

3 Increase circularity rate by 18% by 2030

An essential aspect of the circular economy is the usage rate of reusable materials (the aptly-named "Circular Material Use Rate" [CMU]). According to Eurostat[38], in 2020 the CMU, or circularity rate, was 10.8%, and in 2021 it was 12.3%. By 2030 it will be increased to 18% (see BMK 2022a:17) via circular-oriented return and reuse of materials. This would require a reduction in material use by approximately 20% and a simultaneous increase in recycling by some 10%.

4 Reduction in material consumption in private households by 10% by 2030

In 2018 Austria was the country EU-wide with the fifth highest rise in municipal waste (579 kg per capita). With the recycling rate of this waste, however, Austria achieves approximately 58% and is therefore clearly above the EU average of approximately 48%. Material consumption in private consumption in terms of the rise in municipal waste nevertheless continues to increase and in particular stronger than the population growth. The goal of the Circular Economy Strategy is therefore to reduce consumers' material consumption and therewith the per capita rise in municipal waste to the

37 See RTI Monitor: fti-monitor.rfte.at/Z/K.1.1 (DMC per capita/year: Eurostat [env_ac_mfa]).
38 See RTI Monitor: Increase in the circularity rate to 18% by 2030, fti-monitor.rfte.at/Z/K.3 (Eurostat [env_ac_cur]).

appropriate extent (see BMK 2022a:17). Compared to the reference year 2020 this should fall by 10% by 2030. According to the strengths-weaknesses analysis, in 2020[39] Austria produced 834 kg per capita (according to Eurostat time series positive trend development). The targeted goal value is 751 kg per resident.

39 See RTI Monitor: Reduction in material consumption in private households by 10% by 2030, fti-monitor.rfte.at/Z/K.4 (Eurostat [cei_pc031]).

III

Analysis of the strengths and weaknesses of the RTI system in international comparison

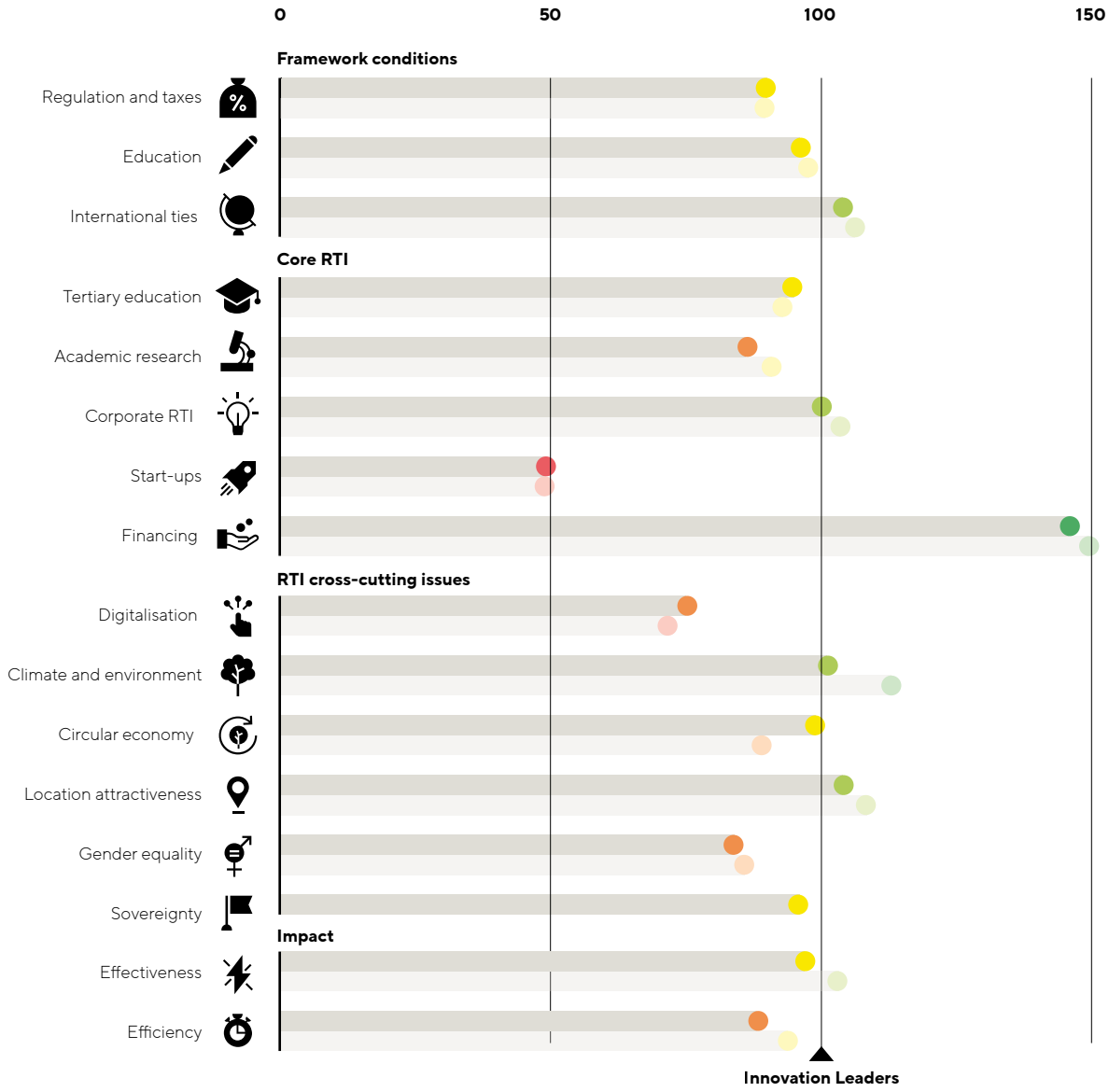


Figure 3: Austria's strengths and weaknesses compared with the innovation leaders: 2022 versus 2023

- Value ≥ 109.5
- 99.5 ≤ Value < 109.5
- 89.5 ≤ Value < 99.5
- 74.5 ≤ Value < 89.5
- Value < 74.5

Data at:
fti-monitor.rfte.at/

Overview of strengths and weaknesses

The strengths-weaknesses analysis shows a fall in performance in the previous year comparison for ten to fifteen sub-areas[40] of the RTI system – marginally, the change is seen less, for example, in international ties, but is more pronounced in environment & climate. The situation in the areas of circular economy (+10% compared to the innovation leaders), tertiary education and digitalisation (+2% and +3%) is shown to be slightly to clearly better than 2022. The positive development in the circular economy can be attributed, among other factors, to the inclusion of additional individual indicators from the "Innovative circular economy" area. The areas of regulation and taxes (90%) and, as before, start-ups (49%) are stagnating.

As the high volatility in the respective time series of some individual indicators has had a sharply negative or too positive effect on the value of the respective area indicator, a statistical smoothing of the empirical data material was performed, which has effects on the changes of the affected indicators. The following individual indicators were statistically smoothed using a moving average method (3-5 years):

- B.2 Academic research: ERC grants
- A.1 Regulation and taxes and B.4 Start-ups: VC funds financing structure and risk capital intensity
- C.2 Climate and environment: R&D energy and climate (all individual indicators)
- C.6 Technology sovereignty: Patent indicators

The area most negatively influenced in terms of value this year is environment and climate. While last year a significant increase was seen in public sector R&D funding for environment and energy, this year this trend has regressed sharply. The smoothing means the development is now running more stable, with the restriction that actual declines or improvements have a delayed impact.

Austria's relative position in the area of corporate RTI has also fallen, which is all the more serious, as although this indeed continues to be a strength of the domestic RTI system, the overall evaluation is however for the first time no longer clearly above the level of the innovation leaders, but rather on a par with it. Some sub-indicators are also developing negatively contrary to the international trend (see section B.3).

Despite a slight decline compared with the previous year, the level in the financing area continues to be high. This decrease is attributed to a deterioration with the "Corporate funding" composite indicator, caused by the

40 The recently added technical sovereignty (C.6) area this year has no findings, as there is no comparison possibility with the previous year.

decrease in the "Direct corporate funding" individual indicator (see section B.5).

On the whole, the strengths-weaknesses analysis for 2023 produces a similar result as in the previous year, during which Austria did indeed score well compared with the EU average, however did not manage, in accordance with the RTI Strategy goals, to join the innovation leaders and with an even greater distance to the top 3, especially in the areas of digitalisation (C.1) and innovative start-ups (B.4). The low penetration of digitalisation into the Austrian economy[41] (currently ranked 10 in the DESI) has an impact on the success of the green transformation, as digitalisation is a key factor in this respect (keyword: *twin transition*). Austria is also only ranked 15 in the area of urgently required STEM specialists. In the area of gender equality[42] (C.5) Austria has had a need to catch up compared with the innovation leaders for some years now and deteriorated further in this respect in 2022. The slight increase with "Researchers in companies" is opposed by a fall with the "Female ICT specialists" indicator and in the "Schools & universities – gender" composite indicator. Why Austria continues to show a regressive trend compared with the innovation countries and the top 3 in particular for some years now (see C.5), despite the numerous measures implemented in the area of gender equality, must be examined.

Although Austria scores relatively well in the area of location attractiveness compared with the innovation leaders (see C.4), due to the stipulated challenges (long-term high energy prices level, for example), it is important that the international developments be observed over time, to be able to react as quickly as possible to negative changes with appropriate measures. The tax system (see A.1 Regulation and taxes), for example, could then be used, whereby companies could write off their R&D investments in projects for the climate and digital transformation to reduce taxes even more extensively than before. Among others, this could contribute to steering companies' investment decisions in a proactive transformative direction, if the financial advantage is decisive for such a project. This requires a systemic approach and consistent orientation on a transformative innovation policy (see Schwaag Serger et al. 2022).

41 RTI Monitor, 1 "Join the international leaders and strengthen Austria as an RTI location", fti-monitor.rfte.at/Z/1.1.2

42 RTI Monitor, C.5 Gender equality – individual indicators, fti-monitor.rfte.at/B/C.5

RTI framework conditions

Regulation and taxes

Education

International ties

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.**

Figure 4: Austria's strengths and weaknesses in the A.1 area: Regulation and taxes compared with the innovation leaders

○ Input ● Output

Ziele der FTI-Strategie 2030:

1.2 5-10 neue FTI-Intensive Leitbetriebe
2.2 Venture Capital Investitionen auf 0,1 % des BIP heben
3.2 Top 3-Platzierung im IMD-World Talent Ranking

Data at:
fti-monitor.rfte.at/B/A.1

Regulation and taxes

Composite indicator

continuing trend

The development of the "Regulation and taxes" area has deteriorated marginally compared with the previous year. Two different dynamics can be seen within this area – on one hand we have the "Regulation" composite indicator, which continues to be above the goal achievement compared with the innovation leaders, and on the other hand there are the "Finance system" and "Tax system" composite indicators, which both show a regressive dynamic compared with the previous year, with a further high distance to the innovation leaders and the top 3. The greatest challenge continues to be the finance system.

With the individual indicators included under the finance system composite indicator, risk capital intensity, VC funds financing structure and size of the capital market (based on the Invest Europe[43] and World Bank[44] datasets), an upward trend cannot be seen in the long-term time series comparison. All three indicators continue to be below average behind the innovation leaders, the top 3 and the EU average as well. The risk capital intensity is measured based on the totals invested in Austria through domestic and foreign funds in relation to GDP, and for some years now with an average value of 0.14 (in % of GDP) it has been far below all other countries and the EU average. The "VC funds financing structure" indicator shows a slight upward trend from 2017, however with a marginal fall in 2021. Due to the data smoothing[45] the development is running more stable, however with the restriction that actual declines only have an impact after a certain delay. The "Size of the capital market" indicator is stagnating[46] in the long term (2000-2020) following a highest value in 2007 and the subsequent fall in 2008. This over time rather linear running development is faced with the challenge of the green and digital transformation, for whose implementation a functioning capital market and also more comprehensive financing capital with venture investments is a basic requirement (see Keuschnigg et al. 2017:102).

In the tax system area the "Tax and levies ratio[47] (in % of GDP)" indicator runs almost congruent with that of the innovation leaders in the long-term time comparison (2000 to 2021) and is therefore above the EU average and well above the top 3. The effective tax burden on companies ("Compa-

43 RTI Monitor, "Risk capital intensity" indicator (Invest Europe), fti-monitor.rfte.at/B/A.1.
44 RTI Monitor, "Size of the capital market" indicator (World Bank), fti-monitor.rfte.at/B/A.1.
45 As explained in greater detail in the summary, a data smoothing was performed due to the fluctuation margins.
46 RTI Monitor, A.1 Regulation and taxes, fti-monitor.rfte.at/B/A.1.
47 RTI Monitor, "Tax and levies ratio" indicator (OECD Revenue Statistics).

ny taxation" indicator[48]) also shows the highest percentage compared with all other countries – since the indicator's decline in 2005 due to the last major corporate tax reform (see C.4) no change has been observed here.

The still high tax and levies burden in Austria is crucial in that income and company taxation are part of the location factors that are responsible for setting up innovative RTI companies and the immigration of top executives, and therefore also for location attractiveness (see C.5). For an overall view of the situation, at this point we would refer to the research premium, which significantly promotes the funding of R&D activities and therefore the location. Since its increase in 2019 from 12% to 14%, research projects with a volume of over €1 billion were submitted in 2022 – some 80% of this by SMEs (see BMF 2023).

Generally speaking, Austria's tax system is characterised by an adverse structure – high levies on labour with simultaneous (still comparatively) low levies on polluting goods. This aspect is, however, thoroughly compensated in particular for the RTI sector by the comparatively high corporate funding in Austria (see Janger/Strauss-Kollin 2020). Specifically the effective average tax burden of companies[49] since 2013 has been consistently just above that of the innovation leaders at approximately 23%. According to the OECD the overall burden caused by wage costs (in % of gross earnings, "Wage and salary charges" indicator[50]) is also one of the highest compared with all countries.

The "Regulation" composite indicator has not changed compared with the previous year. The labour market regulation in the areas of individual terminations of normal employment contracts, limited employment contracts and with collective dismissals is at a constant level (according to OECD Employment Protection Database). With the strictness of labour market regulation over the period, Austria is continuously below the innovation leaders and the EU average and above the top 3 countries.[51]

With a value of 1.4 (based on the "Indicator for product market regulation" of the OECD [survey] from 2018, whereby higher values indicate stricter regulation), the product market regulation is in the upper ranking area. The overall value to some degree conceals the varying performance in the total of six categories. Austria scores poorly compared with the other countries in three categories – (i) Simplification and Evaluation of Regulations, (ii) Barriers, Service & Network Sectors and (iii) Investment and Barriers to Trade. In the first category (i) Austria achieves an extremely poor value compared with the reference countries for the "Interaction with Interest Groups" indicator included here. This is attributed to the absence of relevant requirements, which guarantee the transparency of lobbying activities.

48 RTI Monitor, "Company taxation" indicator (European Commission).
49 RTI Monitor, "Effective tax burden on companies" indicator (European Commission).
50 RTI Monitor, "Wage and salary charges" indicator (OECD Taxation).
51 RTI Monitor, Individual labour market indicators (OECD Employment Protection Database).

Surveys are also used with the "IPR regulation" indicator[52]. In the long-term comparison (2008-2022) Austria is practically on a par with the innovation leading countries – only the top 3 (CH, FI, LU) are ahead of it. Compared with the survey in 2020 (carried out every two years) the awareness of those asked with regard to the strictness of regulations to protect intellectual property fell somewhat compared with the previous year.[53]

52 RTI Monitor, "IPR regulation" indicator (World Economic Forum).

53 If we compare the values in the time series and the strengths-weaknesses analysis with the previous year, we see that these are provided in another form. This is because the raw values of the data are no longer normalised by the World Economic Forum.

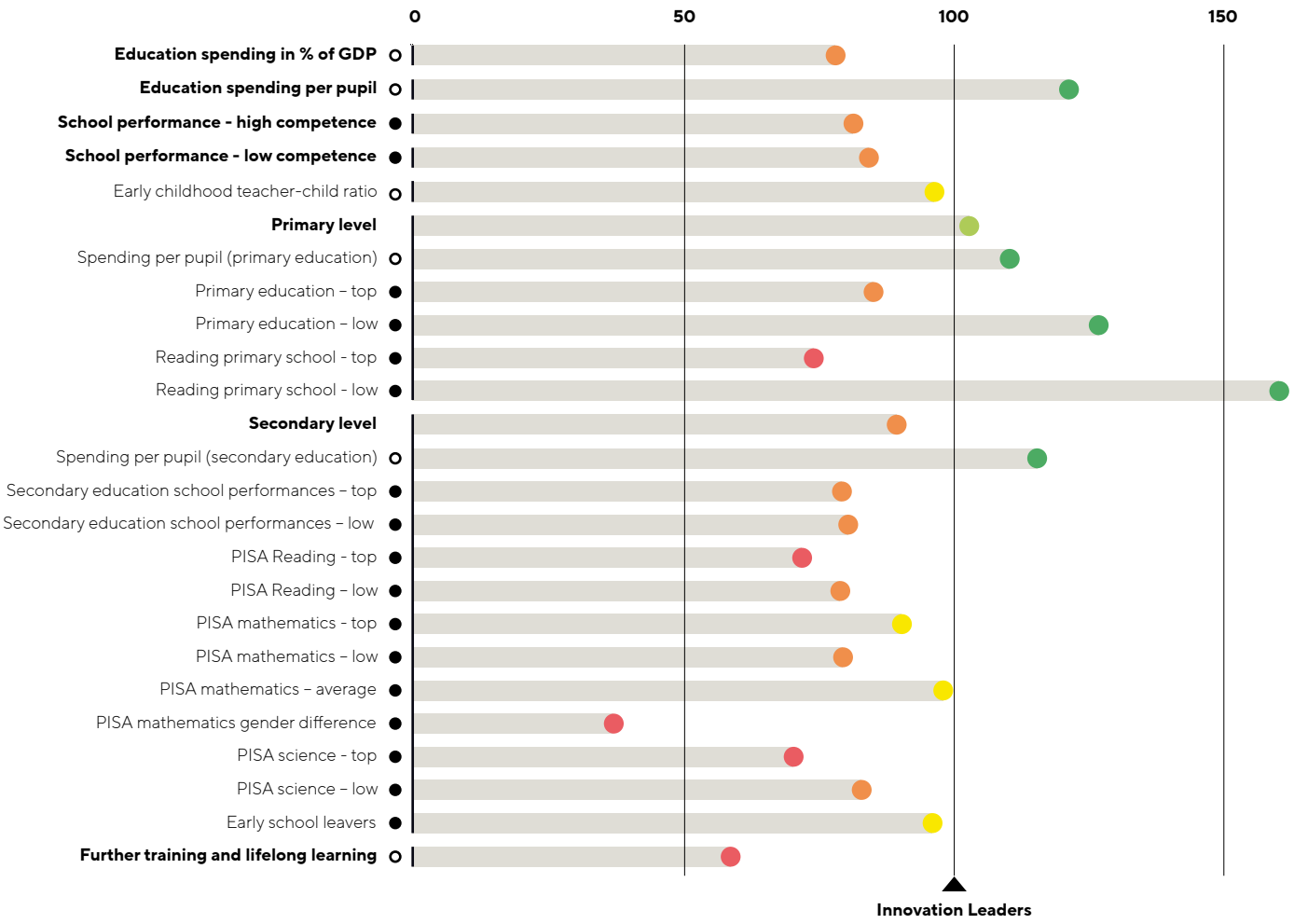


Figure 5: Austria's strengths and weaknesses in the A.2 area: Education compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

1.1.2 Rank improvement in international indices: Digital Economy and Society Index (DESI)
1.5 Drive forward digital transformation
3.2 Top three place in the IMD World Talent Ranking

Data at:
fti-monitor.rfte.at/B/A.2

Education

Composite indicator

downward trend

Education

Primary and secondary education is an important lever when it comes to the future human potential for RTI. On one hand, because each citizen is generally integrated into the school education system and is therefore reachable in this context, and on the other hand the essential foundations for knowledge are laid in the respective stage of life. This means that the course for the career choice is already set to some degree, especially after the lower secondary level. If we are to resolve the acute scarcity of specialists, measures can already be implemented in school-level education, to make specific occupational groups more attractive and to promote awareness of their existence.

While Austria scores above average relative to the EU in the area of education, on the basis of most individual indicators compared with both the innovation leaders and the top 3 countries we see a catch-up requirement, which is also very high in places. It must be noted however, as already mentioned in last year's report, that due to the pandemic, the majority of the indicators are still from 2019 and developments in the recent past are not mapped accordingly – this applies, for example, to the PISA surveys, which are only expected to be available at the end of 2023. Some indicators, the percentage of primary education pupils, for example, who can show very high or high competence with reading[54], are nevertheless concerning – Austria is far behind the EU average here, and that with basic competence, which is inherently important for the continued course of education. Even more disappointing is the situation when we look at the competencies of secondary education pupils – compared with the innovation leaders Austria has a relatively high number of pupils that have only low competencies (be it on the whole or in individual areas). The COVID-19 crisis means that these problems will intensify even further, as socially disadvantaged children in particular are adversely affected in their learning performance by school closures and distance learning (see Bock-Schappelwein/ Famira-Mühlberger 2021).

With education spending per student[55] Austria is in the group of the top 3 countries, although the corresponding spending in percentage of GDP[56] is far below average. The reason for this discrepancy lies in the significantly lower number of students in pre-tertiary education compared with the innovation leaders, whereby the lower identified GDP percentage is

54 RTI Monitor, "Primary education reading – top" indicator (PIRLS).
55 RTI Monitor, "Education spending per student" indicator (OECD Education at a Glance).
56 RTI Monitor, "Education spending in % of GDP" indicator (OECD Education at a Glance).

justifiable. Specifically only 15.5% of the Austrian population are registered in pre-tertiary education, while with the innovation leaders the figure (on average) is 20.4% of the population (see OECD 2022). Relative to this, however, the output must be seen as correspondingly weak, especially compared with the innovation leaders and the top 3, the school performances are far worse than the funding would suggest.

The development of the early childhood care ratio (measured as the ratio of children to supervisory staff) over recent years must be seen as positive on the whole[57] – from about 14 in 2011 to about 13 in 2020, this with a simultaneous increase in the relative percentage of children between four years old and the beginning of the mandatory school age of 1.5%P measured on the total population[58]. Important in this respect however, is the fact that the student-teacher ratio in the top 3 countries is significantly better (on average here there are 5.3 children to one teacher) and this has also improved slightly since 2011.

The number of early school leavers on the other hand has not been developing for the better in recent years – from 2014 to 2021, the value rose from 7% to 8%, while in the EU average it fell from 9.7% to 8.2%. The top 3 countries also improved very much in the same period – from 4.2% to 2.9%.[59] Against the background of the topics of further training and lifelong learning[60], which are only moderately anchored in Austria, in the future this might be an additional gain factor of the anyway already tangible scarcity of specialists, which is favoured due to the lack of suitable and interested trainees (see Dornmayr/Riepl 2022). With further training Austria is not only far behind the Nordic countries – Switzerland also has 50% higher further training participation than Austria, and Slovenia and Estonia rank far ahead of Austria as well.

Equipping students with digital terminal devices (laptops or tablets) must be positively highlighted here with the 5th class, against an own share of 25%, as part of the digitalisation offensive of the BMBWF (see BGBl. 2022). With this measure and the new curriculum regulation (see BGBl. 2023) some necessary agenda settings will be presented for modern and competence-oriented lessons.[61] Appropriate framework conditions and resources will however have to be provided to ensure the effective cooperation of teachers in overriding topics and to effectively support the interdisciplinary acquisition of competencies. Additional administrative and coordinating resources would possibly be one way to support teachers in this respect.

57 RTI Monitor, "Early childhood teacher-child ratio" indicator (OECD Education at a Glance).
58 RTI Monitor, "Early childhood care" indicator (Eurostat [educ_uoe_enra10]).
59 RTI Monitor, "Early school leavers" indicator (Eurostat [edat_lfse_14]).
60 RTI Monitor, "Further training & lifelong learning" indicator (Eurostat [trng_lfse_01]).
61 Even though it is not clear why the "basic digital education" subject cannot contribute to the acquisition of competencies for the overriding "IT education" topic.

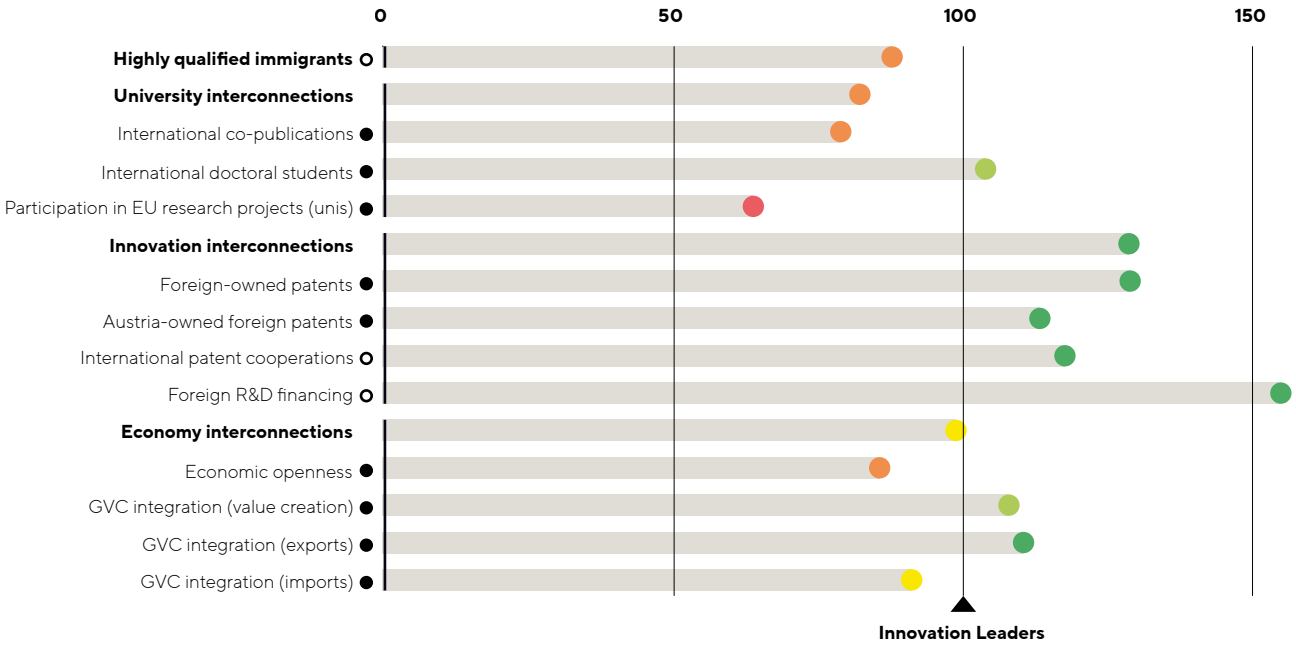


Figure 6: Austria's strengths and weaknesses in the A.3 area: International ties compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

1.4	Participating in at least 3 additional IPCEI
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
3.4	Universities: Foreign share in new recruit ments 45 %

Data at:
fti-monitor.rfte.at/B/A.3

International ties

Composite indicator

downward trend

International ties

Austria is an important location for international headquarters. Global ties are key for an open and highly export-oriented economy such as Austria's. The RTI system must have strong international ties to benefit from international knowledge flows – these are established on several levels, with international research collaborations, mobility of students and employees, corporate collaborations, or even as part of economic trade relations ("*disembodied and embodied knowledge*"). The international ties of the Austrian economy are reflected in numerous cooperations and projects with global partners. 390 international company headquarters have a positive influence on value creation (Schmitt et al. 2022) and are important employers and partners for science and research. In 2019, before the outbreak of COVID-19, the value creation effect was at €50.6 billion, which equals 12.4% of GDP, and the employment effect amounted to 675,746 jobs (Schnabl et al. 2022).

Economy as driver of strong international ties

The majority of company-associated indicators show similar ("Economy interconnections" sub-indicators) or even higher values ("Innovation interconnections") than the innovation leaders' group, also favoured by Austria's central location. A stable international networking of the economy is also confirmed in the multi-year comparison of the individual indicators. All values remain entirely in the trend of the innovation leaders or are above it.

This high level of international ties also translates positively in ETH Zürich's globalisation index, which measures the economic, social and political dimension of globalisation. In the KOF globalisation index 2022 Austria is once again ranked 7, whereby the political dimension in particular is rated (de facto) as very good. The evaluation for the economic globalisation sub-area on the other hand shows need for action with the areas of trade flows and finance flows.

The current data on ties in innovation activities (that is, patent analyses) shows hardly any changes over the previous year and continues to be significantly above the also very high general economic ties (integration into global value creation chains). The dependency of Austrian value creation on foreign demand (GVC Integration) in particular has once again increased here.

Austria's participations in the Important Projects of Common European Interest (IPCEI) are also important in this respect, but these of course serve the set-up and expansion of strategically important value creation

chains. IPCEI are front and centre in the current European industrial policy as a helpful legal instrument, while also linking it with other objectives (the green transformation, for example). Insofar as it is possible to set up such value creation chains with IPCEI, along with increased performance, Austria's international ties would also increase. Such an effect is however currently not foreseeable. Austria currently participates in four IPCEI (EuBatIn, Microelectronics I, Hy2Tech and Hy2Use – the latter was originally consolidated into a Hydrogen IPCEI). Approval for Austrian participation in the Microelectronics II IPCEI is also pending shortly and participation in a Photovoltaics IPCEI is targeted. The objective of taking part in a total of 5 IPCEI by 2030 has therefore almost been achieved, leaving the question as to where the necessary financial resources for further participations could come from still open.

University interconnections

The analysis of the international interconnections of the universities is performed using three indicators. The performance of these output figures is clearly above the European average, but for international doctoral students it only achieves the innovation leaders' average. Compared with the leading research countries the participation of Austrian universities in EU research projects is actually relatively low, but the success rate for it is relatively high (see B.2). The researchers at universities and non-university research institutions are once again very successful with the acquisition of ERC grants (see B.2 Academic research).

One of the goals of the RTI Strategy 2030 is to increase the participation rate in Horizon Europe. Important measures here require, among other elements, a strengthening of the international cooperation activities of universities and research-active companies. A significant increase in the cooperation and participation activities, however, requires additional resources, that is, both human resources and seed funding for participating in international collaborations. Access to international research infrastructures is especially important for successful research at the top of the field (see B.2). These are also an essential framework condition for achieving the goal of, "increasing the percentage of science and research staff applying from abroad, in particular to universities, to 45 percent" (for this see B.2 Academic research).

The further development of the European higher education area – European University Alliances – with the participation of Austrian universities and technical colleges also entails important steps to strengthen international competitiveness. Austrian universities take part in 13 of 44 alliances.

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 only ranks in the bottom half in this evaluation[62]. Austria's low attractiveness for well-trained migrants

62 RTI Monitor, "Immigration of (highly qualified) specialists" indicator (Eurostat) OECD Talent Attractiveness 2023 oecd.org/migration/talent-attractiveness/ [4 March 2023].

means it is also ranked 26 out of 38 industrial countries in the OECD "*Talent Attractiveness*" ranking (OECD 2023a). For better visibility it is therefore important to improve how the successes of Austrian science and research are presented internationally; it is also the framework conditions for researchers – immigration and residency regulations for citizens from non-EU states, excessive, partially intransparent application requirements, costly visa procedures, document checking processes, proof of German language skills – that are the decisive criteria for whether or not international students and researchers from non-EU countries want to come to Austria (for this see also B.1 Tertiary education and B.2 Academic research). Aside from scientific framework conditions, these processes and criteria should be arranged more transparently and more accommodating.[63]

63 Effects with new factors, with the *Rot-Weiß-Rot-Karte* (a kind of Austrian green card), for example, which came into effect on 1 October 2022, remain to be seen.

Recommendations for action

A.1 Regulation and taxes

⟶ With regard to the existing framework conditions (A.1-A.3) and the green and digital transformation, as essential cornerstones of the energy transformation and location policy, in view of the expected long-term high level of energy prices and the tax burden in Austria a systemic restructuring should follow. The tax system could then be used with regard to the transformation, for example, so that companies could write off their investments in the climate and digital transformation to reduce taxes even more extensively than was previously possible. This could, under the appropriate conditions, contribute to steering companies' investment decisions in a proactive transformative direction, if the financial advantage is decisive for a project. In this context there are already logically aligned instruments in the area of green finance, such as "Carbon Contracts for Difference" (see C.2 and C.3), for example, which could specifically support such a transformation in companies.

Along with the relief for workers (required for the transformation), the Austrian Council believes the incentives to reduce consumption via CO_2 taxation were set significantly too low-threshold. The postponement of the CO_2 pricing in itself is a step that does not consider the pending transformation sufficiently. The previous key points connected with the eco-social tax reform continue to be very rudimentary and only apply to specific parts of the economy. In the Scandinavian countries, Denmark and Sweden, for example, for some years now significantly more extensive eco-social tax reforms have been already completed (see Kettner 2020, Ökobüro 2020). Empirical analyses have also shown that the reduction in emissions based on a CO_2 pricing can result in higher growth (see Berger et al. 2021).

⟶ Neben der (für die Transformation notwendigen) Entlastung der Arbeitnehmer:innen waren die Anreize zum Minderverbrauch über die CO_2-Besteuerung aus Sicht des Rates deutlich zu niedrigschwellig gesetzt. Bereits die zeitliche Verschiebung der CO_2-Bepreisung stellt einen Schritt dar, der der anstehenden Transformation unzureichend Rechnung trägt. Weiterhin sind die bisherigen Eckpunkte im Zusammenhang mit der erfolgten ökosozialen Steuerreform noch sehr rudimentär und betreffen nur bestimmte Teile der Wirtschaft. So wurden beispielsweise in den skandinavischen Ländern Dänemark und Schweden schon seit vielen Jahren deutlich umfassendere Ökosozialsteuerreformen vollzogen (vgl. Kettner 2020, Ökobüro 2020) Zudem haben empirische Auswertungen gezeigt, dass die Senkung der Emissionen auf Basis einer CO_2-Bepreisung zu höherem Wachstum führen kann (vgl. Berger et al. 2021).

A.2 Education

⟶ The new curricula for, among others, the elementary schools and the grammar school lower grades along with the subject curricula also focus heavily on interdisciplinary competencies and on interdisciplinary teaching. Additional support for teachers, to be able to efficiently and effectively teach appropriate competencies must be urgently promoted. On one hand with regard to their training and further training, but on the other hand also with regard to additional resources of an administrative and coordinative nature.

⟶ It generally applies that the topic of further training and lifelong learning must be promoted. The importance of appropriate measures is underscored by the analysis by Bock-Schappelwein et al. (2017) – among other factors further training is necessary to, "meet new technology-related challenges". Along with the expansion of financial support instruments, however, the active promotion of social awareness of the value and importance of personal further training must also be intensified.

A.3 International ties



⟶ The participation of further Austrian universities in the European University Alliances[64] should be supported and intensified. International exchanges and the opening up of international prospects for students and researchers and general higher education staff should also be motivated within the scope of Erasmus+.

⟶ The framework conditions for the immigration of highly qualified foreign specialists should be further improved. The reform of the Rot-Weiß-Rot-Karte came into effect in October 2022. International specialists will subsequently be able to enter the Austrian labour market with fewer complications. Appropriate monitoring, which offers an evidence-based decision-making basis for possibly required changes, should be implemented to illustrate short and medium-term effects.

⟶ To further increase location attractiveness, measures which contribute to increasing the visibility of the science, research and innovation location, must also be introduced. A "marketing strategy", together with representatives from the world of politics, education and business, should be drafted for this to acquire highly qualified specialists in particular.

64 European Education Area, European Universities Initiative education.ec.europa.eu/education-levels/higher-education/european-universities-initiative [1 March 2023].

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.

Figure 7: Austria's strengths and weaknesses in the B.1 area: Tertiary education compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

1.1.2	Rank improvement in international indices: Digital Economy and Society Index (DESI)
1.5	Drive forward digital transformation
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	2 Austrian universities among the top 100 (THE World University Ranking)
3.5	Double students of STEM who completed a semester abroad

Data at:
fti-monitor.rfte.at/B/B.1

Tertiary education

Composite indicator

upward trend

The developments in the tertiary education sector assume a key position in achieving future successes in the RTI system. A close interconnection of the higher education indicators with the sections dealt with in this report, B.2 Academic research, D.2 Efficiency, C.4 Location attractiveness, A.3 International ties or C.5 Gender equality, is also evident. The quality of the tertiary education system is therefore an important factor in the RTI system and decisive for a society's innovativeness (see Hanushek/Woessmann 2020). The objectives of the RTI Strategy 2030 (BKA 2020a) and the areas of action prioritised by the Austrian Government in the RTI Package 2024-2026 (BKA 2022a) underscore this key importance of the education system, and especially the tertiary sector here, for a thriving social and technological further development.

Figure 7 provides an overview of the strengths and weaknesses in the B.1 tertiary education area compared with the innovation leaders. We see a recurring situation here in the international comparison. With the exception of the two indicators for third level graduates[65], the performance indicators applied thankfully remain in the area of the innovation leaders – and therefore in the most displayed comparison values also clearly above the EU average (see, RTI Strategy 2030 objectives: Goals 3.1-3.5).

With higher education spending growth[66] (ISCED 6-8) of 3.7% per student per annum, the per capita spending over the long-term period under consideration (2000-2020) remains in the area of the innovation leaders. The university budget for the current 2022 to 2024 performance agreement period continues this funding trend. With the sharply increased costs for energy and the high inflation of the past two years these entail, the funding requirements of the universities, however, also increase critically for both energy and for staffing. The presumed "room to manoeuvre" with the conclusion of the 2022-2024 performance agreement period for the further development of excellent conditions at the universities is significantly restricted by substantial cost increases. Even more to the point, negotiations

65 The discussion on the indicators for third level graduates must be held in the context of structural differences in the education systems and training paths of the comparison countries. A significant increase with STEM graduates (ISCED 5-8) must also be once again emphasised with average growth of 17.2% per annum since 2000. The basis for this is provided by a growing offering of training places in the STEM area at universities and technical colleges, as well as graduates of vocational higher-level schools. At the same time, the percentage of graduates of the ISCED 6-8 education level in the international comparison continues to be very low. Compared with 36 countries Austria is ranked only 31.

66 RTI Monitor, "University expenditure per student" indicator (OECD Education at a Glance)

on additional financing will be required to ensure "standard operation" (BMBWF 2022e).

Higher education policy measures must also incorporate impacts on the labour market policy – keyword "requirement for specialists" (see Austrian Council 2017). The new technical colleges development and funding plan 2023/2024 to 2025/2026 also takes into account the agreement of a three-stage expansion of 350 new first-year student study places each in the areas of both STEM/digitalisation and sustainability. The efficiency monitoring of the study places will also enable the restructuring of study places in urgently required STEM subjects.

Those responsible for running the technical colleges are also hit with an enormous costs increase. The funding plan does actually provide for an increase in the funding rates from 1 January 2023 by 10% and in the following year by a total of 15% compared with 2021, however it will very probably remain behind the rate of inflation (see Austrian Council 2023a). To cover added costs special funds of €14 million per year are now provided for cooperation and innovation.

The universities are making advances with their goal of improving supervisor-student ratios. The current higher education plan (BMBWF 2023a) also provides for an improvement from 1:39 to 1:35 by 2030. Recently the supervision ratio improved from 1:39 to 1:37, which is essentially due to the current falloff in examination-active studies. The abatement of the "pandemic effects", of the changed labour market and compensation measures, increased professional activity, for example, of the students contribute here to balancing out price increase effects ("socio-cultural effects"). Following the historical highest level of examination-active students at the end of the 2019-2021 performance agreement period, we subsequently see the forecast decline, also incorporated into the performance agreement goals, and the stabilising of examination-active students. The fact that, "less is currently being studied" than in the COVID-19 years is a systemic governance issue, which the BMBWF must influence via regulatory control in the area of study feasibility. At the same time from the development in 2018 and 2022 we can see that with the "360 new professors and equivalent positions at Austrian universities in the next three years" initiative, considered on the whole there has not been a sufficient compensation: The number (FTEs) of professors at universities indeed increased from 2,426 to 2,817, which would correspond with the required dynamic, however equivalent positions fell more or less to the same degree, from 2,769 to 2,450 FTEs (unidata 2023a). One of the main reasons for this decline is the current wave of university lecturer retirements. Even if advances were achieved recently, a significant increase in the funds for positions provided for this is required to improve the supervision ratios at universities – several hundred professors or equivalent positions are still needed. Additionally a reorganisation of the university employment legislation is also overdue, however a satisfactory solution to improve work conditions was not achieved in the University Act with the last legislative amendment.

A successful HR development at the universities is also a required component for further planned goals: Increase in completed studies of the STEM first graduations and the mobility share of graduates at all universities by 2030. With the “Develop and promote human resources” and “Support international prospects for students and researchers” areas of action for the “Promote knowledge, talents and skills” goal, the RTI Package also underscores the importance of the education system for society in general. It is necessary here to budget an adopted increase in the investments for all education sectors, so that the efficiency and quality of the teaching at education institutions can be improved and hidden potentials can be leveraged. Otherwise the necessary specialists in education, science and research will not be available on the labour market.

Tertiary education 

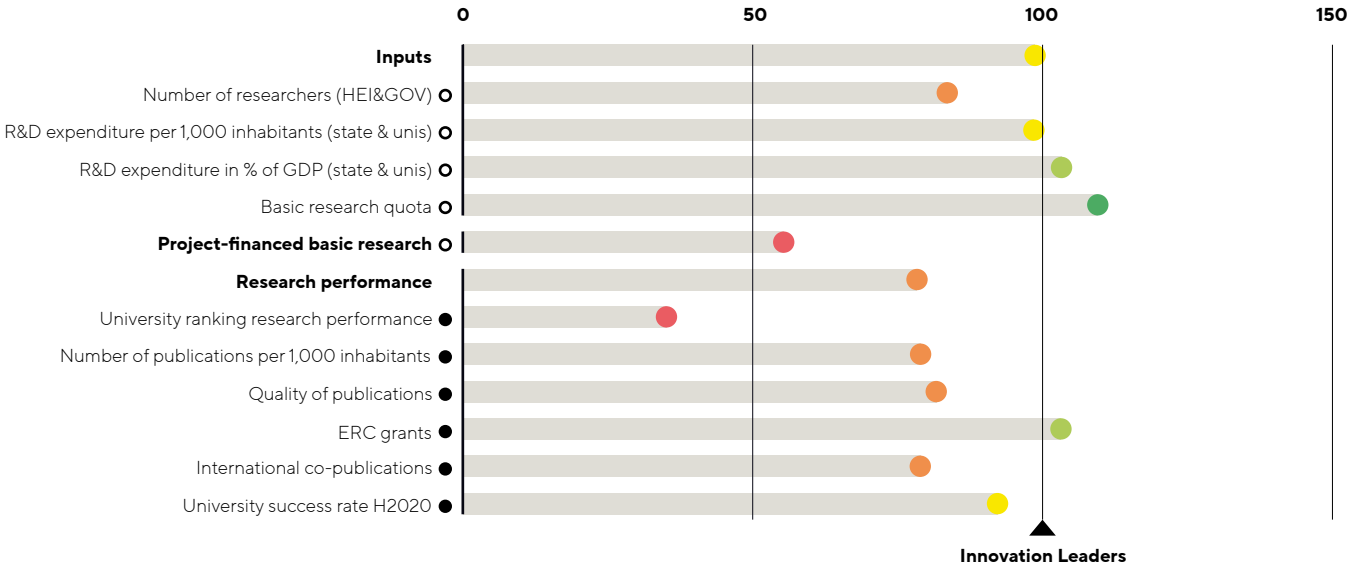


Figure 8: Austria's strengths and weaknesses in the B.2 area: Academic research compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

1.2	Recruit 5-10 new RTI-intensive lead companies and expand existing ones
2.3	100 % more economically successful academic spin-offs
2.4	Top 10 placing with European Research Council (ERC) grants
2.5.1	Strengthen participation in Horizon Europe
2.5.2	Top 3 ranking in Horizon Europe (or Horizon 2020) success rate
3.3	2 Austrian universities among the top 100 (THE World University Ranking)
3.4	Universities: Foreign share in new recruitments 45 %

Data at:
fti-monitor.rfte.at/B/B.2

Academic research

Composite indicator

downward trend

Essential parameters for innovativeness (see Trantow 2011:3) are provided by the KPIs for basic research at universities and non-university research institutions, measured here on the indicators for academic research (see figure 8). These KPIs are supplemented by the "Science and economy cooperation" analysis (see section B.3). The importance of cross-sector research is also emphasised with the objectives of the Austrian Government's RTI Strategy 2030 and now also in the second RTI Package 2024-2026. The areas of action, "Promote excellent basic research", "Support applied research and its impact on economy and society" and "RTI to achieve climate and energy goals", highlight the fundamental value of research to achieve the transformation goals. The rolling development of the RTI Package also enables agile policy responses with the integration of research interests from science and business.

The 2023 strengths-weaknesses analysis[67] for the B.2 Academic research area produces a heterogeneous, but also recurring situation. The input indicators, except for the indicator for project-financed basic research[68], are more or less on the level of the innovation leaders (see Basic research quota[69] and R&D expenditure, state sector and higher education[70], measured on per capita GDP). With basic research project financing, however, Austria lags continuously far behind the top 3 countries, the innovation leaders and also the EU average. Even calculating in the funds for applied research projects, which flow competitively via the FFG to the universities[71], only little would change with this finding.

On the whole there is still a significant distance to the innovation leaders in the evaluation of research performance (with a value of 78% this year). Quality and quantity of publications, international networking (international co-publications) or the success rate of the universities with Horizon Europe[72] bear witness to a successful but improvable development. The frequently discussed discrepancy between high R&D expenditure (state sector and higher education) and research performance in the measured

67 RTI Monitor, B.2 Academic research, strengths-weaknesses analysis 2023.
68 RTI Monitor, "Project-based financing of basic research with Austrian Science Fund-similar funds" indicator (funds' annual report).
69 RTI Monitor, "Basic research quota" indicator (OECD MSTI).
70 RTI Monitor, "R&D expenditure in the state sector and higher education" indicators (OECD MSTI)
71 Project funds of approximately €294 million were awarded from 2020 to 2022 to the higher education sector via the FFG.
72 Fluctuations in the success rate are due to the changed "associated status" of Switzerland and the UK in the EU framework programme.

publication indicators (number of publications[73] and quality of publications[74]) remains with the measures implemented to date.

This is partially explained by the historically grown, fragmented university landscape in Austria, which results in a poor evaluation in the university ranking[75] indicator. The long-term observation of this indicator (2009-2020) shows that Austria is even below the EU average. There is greater catch-up requirement with the innovation leaders and even more with the top 3 countries (CH, NL, AU). In individual disciplines, the universities do exhibit specific top performances, however these are not reflected in the overall ranking of the universities. In the World University Ranking (THE), three Austrian universities currently have a place between 100 and 200. Achieving RTI goal 3.3 therefore remains unlikely.

Academic research

Austria's researchers are still successful in acquiring ERC grants. The number and scope of acquired ERC grants attest to an excellent situation. On the whole, Austria is in the innovation leaders area in the three funding categories, Starting, Advanced and Consolidator Grants (see RTI goal 2.4) – with eight projects funded in 2022 the Institute of Science and Technology Austria (ISTA) is the national frontrunner.

With the *excellent=austria* programme, in 2021 a highly competitive excellence funding programme was set up at national level, with which top-quality research in Austria is funded via the FWF. With the *Clusters of Excellence*[76] (COE), five interdisciplinary research networks were selected in March 2023. The total funding amount of approximately €135 million for the first five years[77] consists of funding amounting to €81 million and an own funding share of 40%. A long-term anchoring of the selected research areas at international top level is therefore possible. Pioneer work in basic research will be funded with a second funding line, *Emerging Fields*[78]. €24 million will be provided for this in the coming year.

With approximately €140 million (€146 million in 2022), the Future Fund Austria (FFA) is a further important instrument for funding basic and applied research. The financing for the funds, which are administered by the Nationalstiftung-FTE (National Foundation RTD), was agreed for the period from 2022 to 2025.

On the whole, however, the amount and percentage of the competitive funding with the funding volume compared with the leading research nations is still clearly too low. Accordingly low too are the approval rates of

73 RTI Monitor, "Number of publications per 1,000 inhabitants" indicator (Scimago, World Bank).
74 RTI Monitor, "Quality of publications" indicator (EIS).
75 RTI Monitor, "University ranking research performance" indicator (CWTS Leiden Ranking).
76 FWF, Cluster of Excellence (COE), fwf.ac.at/de/forschungsfoerderung/fwf-programme/clusters-of-excellence-coe [3 March 2023].
77 An extension of a further five years is possible following a positive intermediate evaluation.
78 FWF, Emerging Fields, fwf.ac.at/de/forschungsfoerderung/fwf-programme/emerging-fields [3 March 2023].

the research projects funded via the FWF. If there is sustained high inflation in the coming years, significant write-downs with multi-year funding commitments can be expected. Due to rising costs for staffing and research resources it can also be expected that approval rates and research performance will fall further, if research funding budgets do not stay abreast of the cost increases. To further develop academic research in Austria, investments must therefore be continued in line with rising R&D costs. Not least of all research-intensive companies and industries require strong academic partners to be able to remain successful in international competition.

Highly qualified people in research and development are also an essential requirement. Austria can refer here to positive development, the number of researchers[79] (HEI&GOV) in the long-term time series comparison since 2016 is on a par with the EU average, however remains continuously behind the innovation leaders (see B.1 "Supervisor-student ratio at universities" indicator). Suitable measures to improve career options will be developed within the scope of the ERA-NAP (BMBWF 2022d) in a University Conference work group set up in May 2022 for the "Careers in research in the context of the European Research Area" topic.

A further essential requirement for research at the international top level is the operation of and access to modern national and international research infrastructures. The national research infrastructure action plan 2030 (BMBWF 2022b) emphasises this important goal of the RTI Strategy 2030. The strategic development of top quality infrastructures at universities, for example, is currently funded with a further Call for "Research infrastructures (digital)" amounting to €40 million.

With advancing technological development and increasing relevance of large-scale research infrastructures, the importance of international collaborations to set them up and operate them increases significantly. With the participation in European research infrastructures (ESFRI, for example), smaller countries also have the option of participating in complex and networked infrastructures. A major opportunity here, this framework condition is one of the most important factors for researchers when choosing a research location. The budget provided for participation in international large-scale research infrastructures, especially participation in ESFRI projects, must continue this development. The RTI Package 2024-2026 names the right measures for this, whose budgetary cover, however, must still be negotiated. Cost-intensive large-scale research infrastructures in particular, both existing and new ones to be set up, should be selected and examined here, especially with regard to their utilisation, cooperative usage possibility and more efficient operator models.

79 RTI Monitor, "Number of researchers" indicator (HEI&GOV) (OECD MSTI).

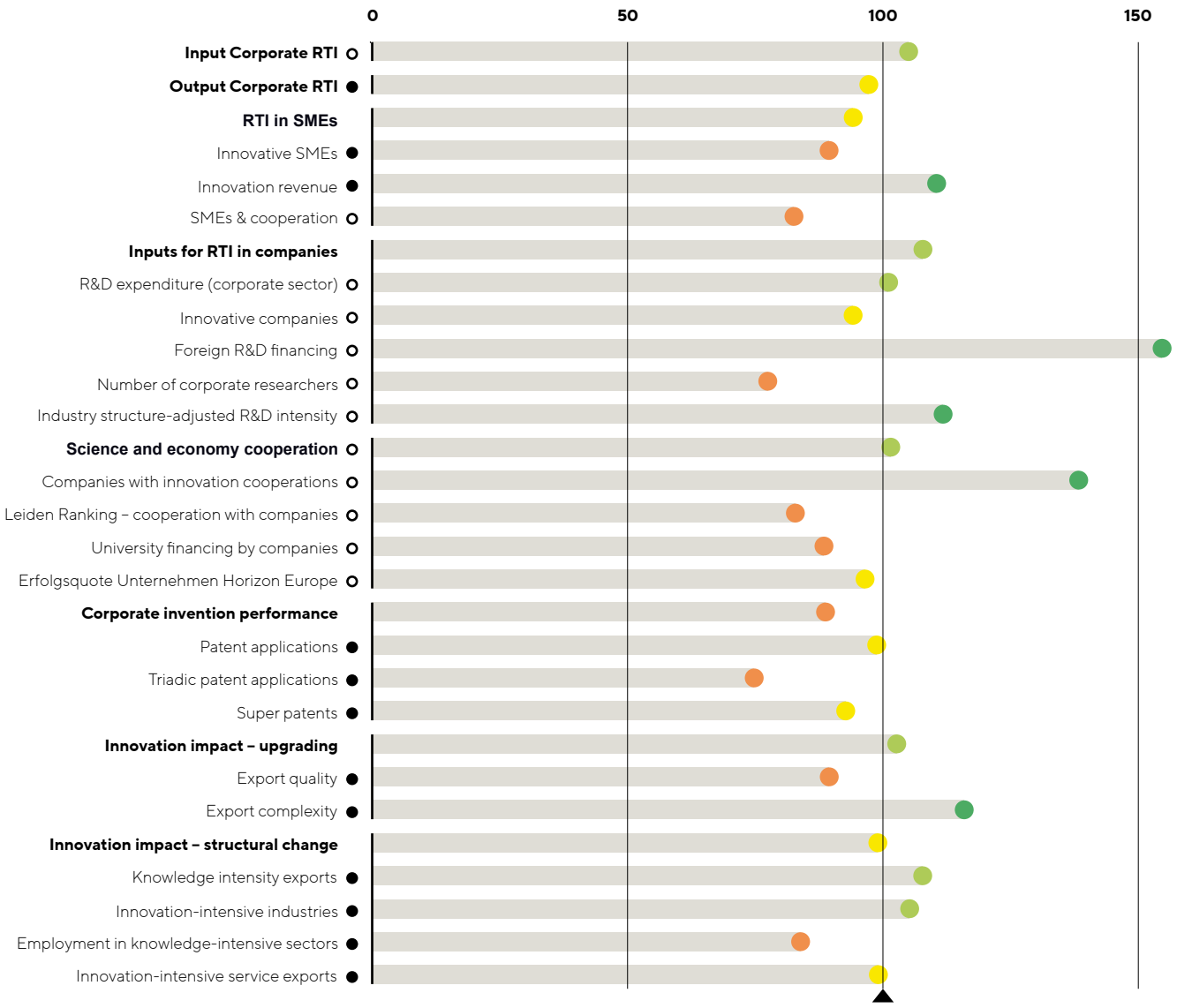


Figure 9: Austria's strengths and weaknesses in the B.3 area: Corporate RTI compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

1.2 Recruit 5-10 new RTI-intensive lead companies and expand existing ones
1.3 Increase number of R&Dactive companies by 20%
1.4 Participating in at least 3 additional IPCEI
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

Goals of the Circular Economy Strategy:

K.1.1 Material footprint (MF) reduced to 7 tonnes per capita and year by 2050
K.1.2 Domestic Material Consumption (DMC) reduced to 14 tonnes per capita and year by 2030
K.2 Increasing domestic resource productivity by 50% by 2030

Data at:
fti-monitor.rfte.at/B/B.3

Corporate RTI

Composite indicator

upward trend

The entire complex of entrepreneurial research and innovation activities continues to be one of the greatest strengths of the innovation system. Austria's to-date excellent position compared with the EU average and the European innovation leaders has only changed marginally since last year's report, however for the worse, that is, in the overall evaluation for the first time Austria is "only just still" on a par with the innovation leaders. Once again, Austria scores better with regard to the inputs in companies and their RTI activities than with the output. As before, companies' strong propensity to cooperate, revenue with innovations and R&D intensity are responsible for the continued good performance in the comparison. While Austria slightly loses its lead with regard to its strengths, it is still not balancing out its weaknesses positively.

Companies' innovation activities

According to the currently available data, the R&D expenditure of Austrian companies has fallen to the current level of the innovation leaders since 2019, which is problematic on two levels: i) The innovation leaders have demonstrated a continuous upward trend since 2014 (the global top 3 nations since 2012 even, and that with greater dynamic). ii) The negative development in Austria began before the economic crisis triggered by the COVID-19 pandemic (unlike the EU on average, for example, 2020 was the year the trend reversed). The hope that Austria could balance out the effects of the pandemic in 2021 for the moment therefore remains unconfirmed, whereby supply chain disturbances and other, uncertainty-increasing reorganisations of the international value creation chains or the scarcity of chips, for example, continued anyway and in places continue to exist. The number of researchers in companies compared to last year's observation period increased however, and this can be seen as a positive signal for future development.

The number of R&D-driving companies[80] developed positively in Austria up to 2019[81] with fluctuations (from 3,384 in 2011 up to 3,872). The development of this indicator in the validity period of the current RTI Strategy and therefore an initial estimate of the prospects of goal achievement, which relates to the 2021 report year, is, however, only possible at the earliest with the pending publication of the latest R&D survey in summer 2023. The fall in the percentage of innovative companies (including small and medium-sized enterprises – SMEs) at all companies is already evident,

80 R&D-driving entities as defined by Statistik Austria.
81 Statistik Austria's ongoing R&D survey refers to the 2021 report year and the results are expected to be published in July 2023.

being a trend which began in 2018 and which runs contrary to the goal of increasing R&D-active companies by 20%, if not directly[82], then at least in part. This development also had a negative impact on the RTI Strategy 2030's goal of joining the top 5 with the R&D rate (at least as long as decreasing corporate spending is not completely compensated for by state R&D expenditure and regardless of the fact that there will also have to be R&D-driving companies for public R&D expenditure).

This is countered by the objective of the Austrian Federal Government within the scope of the RTI Strategy (addressed in the RTI Package 2024-2026; see BKA 2022a), to acquire five to ten new RTI-intensive leading companies and to expand existing ones by 2030, as these play a key role for the location, the economy, the innovative transformation potential and the issue of technology sovereignty. Their importance lies in their market position, their position in the respective value creation chain, their RTI intensity, the immediate spillovers and the effects on their ecosystem (cluster formation at the site of a leading company, for example). In the interests of the RTI Strategy, only investments that either exceed €100 million or create 100 new jobs are relevant to perform these functions. In line with this definition, according to the BMAW's ABA media monitoring, there were five such investments in the automotive, pharma and microelectronics industries/sectors.

Corporate RTI

The continuing high revenue of SMEs with innovations compared with the innovation leaders fell slightly in recent years and therefore follows the general trend, however the three internationally leading countries are excluded from this, and with the current data (from 2020) Austria's lead in previous years compared with the innovation leaders has de facto shrunk to zero.

»
Die hohen Umsätze von KMU mit Innovationen nahmen in den letzten Jahren leicht ab, folgen aber dem allgemeinen Trend.

In the past with regard to its performance and the evaluation of its performance, Austria has always benefited from a comparatively very high propensity of its companies to cooperate in RTI activities. This finding is still true, however the amount of SMEs with innovation cooperations since 2017/2018 is below that of the innovation leaders and this distance has not changed since then, but compared with the top 3 it has fallen since 2018. At the same time, the percentage of companies that cooperate in innovation projects with universities or non-university research institutions has been falling since 2016 and is therefore developing negatively against the trend of all other comparison groups. This is increased even further by the fact that the volume of R&D performed in the higher education sector and financed by the corporate sector has essentially remained unchanged since 2010. Austria is at risk here of completely losing an excellent location factor and above all the important factor of innovation-related performance in just a few years.

The impact of research, technology and innovation and therefore the efficiency of the appropriate use of funds are illustrated by the attribut-

82 As innovations are not necessarily based on R&D.

able outputs. It can be seen here for Austria that the export quality (as a measure of the improvement of the product structure), the impact of innovation-intensive sectors on the overall value creation, the percentage of innovation-intensive sectors in service exports and the percentage of products of medium-high and high technology intensity exports in total exports have all declined. This falloff appears in places to be part of a prolonged and slightly fluctuating sideways movement. To some degree the beginning coincides at least time-wise with the effects of the COVID-19 pandemic, and in most cases Austria follows the same trend as the EU as a whole or its innovation leaders. Fact is, however, that hardly any indicators develop positively here either.

Invention performance, that is the patent applications of Austrian inventors, is an important output of the innovation system. All three indicators used for this show a decline compared with the last available dataset. Positive to mention here is the fact that the fall in the number of all patent applications at the European Patent Office (per 1,000 residents) is not as sharp as among the innovation leaders and the global top 3 countries, and that the number of "super patents" (that is, especially important technological patents) remains almost stable against the general downward trend. The latest data, however, still does not map possible effects of the COVID-19 pandemic. In 2022, the Austrian Patent Office83 reported a 2% fall compared with 2021, while countries such as France, Sweden or Denmark are already (again) reporting increasing application numbers.

The employment share of knowledge-intensive sectors also moves the figures closer to the innovation system outputs. The percentage in Austria has stagnated here for some years just above the EU average and in 2021 was below it for the first time, while the innovation leaders exhibit slight growth. Employment is, however, closely connected with the amount of R&D expenditure and the revenue generated with innovations, and both are currently developing rather unfavourably. Participation by Austrian companies in the European research framework programmes has been increasing continuously since 2020 and in 2022 was more or less on a par with the innovation leaders. A positive signal is sent by the successful participation in the EIC Accelerator, which supports small and medium-sized enterprises (SMEs), especially start-ups and spin-offs, in the development and distribution of breakthrough innovations.

Industrial policy implementation strategies

Austria's taking part in the Important Projects of Common European Interest (IPCEI) represents active participation in the European Union's industrial policy strategies and initiatives. Austria currently participates in four IPCEI – EuBatIn, Microelectronics I, Hy2Tech and Hy2Use (originally consolidated into a Hydrogen IPCEI)[84]. Approval for Austrian

83 ots.at/presseaussendung/OTS_20230314_OTS0058/oesterreichisches-patentamt-6-fakten-zum-erfindungsjahr-2022 [4 March 2023]

84 bmk.gv.at/themen/innovation/internationales/ipcei/aktive_teilnahmen.html [1 March 2023].

participation in the Microelectronics II IPCEI is also pending shortly, and efforts are underway to take part in a future Photovoltaics IPCEI. A further Life Sciences IPCEI is currently under discussion. The RTI Strategy's goal is therefore not only closer to being achieved, but also and in particular it ensures that the appropriate RTI and industrial policy effects can also be produced in Austria. The current discussions (Council of the European Union 2022) on the calls of some EU member states for a Joint European Forum for IPCEI, which will enable a structured search process, simplify the identification of relevant topics and accelerate the processes up until the formulation of an IPCEI, are relevant with regard to the IPCEI. If this to be implemented, it would be essential for Austrian companies and the entire national economy to participate with full commitment.

Applies similarly for the European Chips Act. The Austrian microchip industry is third in the EU in terms of its share in overall employment in the manufacturing sector and is number two measured on value creation (see Dachs 2023). The European Chips Act is a new policy instrument that will strengthen Europe's strategic autonomy in the microchips area. Along with R&D and innovation financing, the Chips Act also targets the mobilisation of investments in new chip production plants by national and regional governments, as well as by businesses. A third pillar targets setting up monitoring of the chip market, to prevent supply bottlenecks. The Chips Act provides for total financing volume of €43 billion, of which €11 billion are earmarked for R&D and innovation. The remaining volume for investments in new chip factories will be used up by the member states. Clarification of certain challenges is essential for a positive effect on Europe and therefore Austria (see Dachs 2023): Is the Chips Act "big enough" for its ambitious goals? How can companies and countries be prevented from going for "false" technologies? What effect will the heavily fragmented value creation chain have? How can we secure technological sovereignty beyond European production (with contracts with other regions, for example)? Regardless of such questions, Austria must prepare itself for implementation in this respect and must not wait until the final "ironing out" with a national implementation strategy.

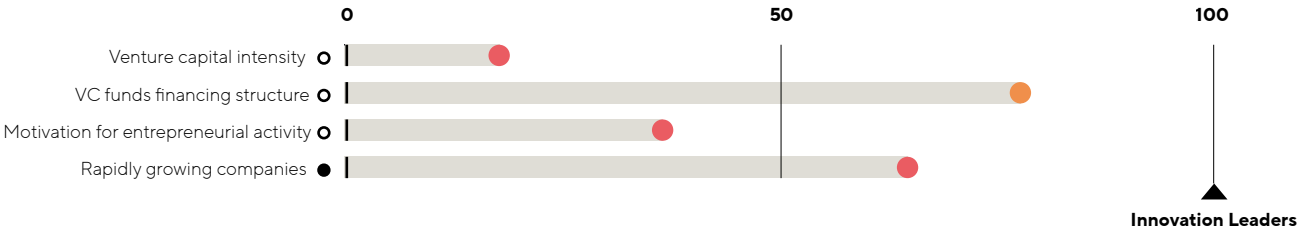


Figure 10: Austria's strengths and weaknesses in the B.4 area: Start-ups compared with the innovation leaders

○ Input ● Output

Start-ups

Goals of the RTI Strategy 2030:

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

2.3 100 % more economically successful academic spin-offs

Data at:
fti-monitor.rfte.at/B/B.4

Start-ups

Composite indicator

continuing trend

Start-ups, in particular research-intensive or innovation-based and scaling 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 area of spin-offs from innovative companies as a performance indicator of the innovation system is once again behind the innovation leaders. Austria will not do any better than the previous year's result either, as the higher risk capital intensity (which, however, is still below the 2007 result) and the comparatively better VC funds structure, entail poorer employment figures in rapidly growing companies and a worse motivation structure for entrepreneurial action (that is to say, start-ups). The distance to the EU average and the leading 3 countries globally was, however, reduced slightly.

Start-ups

Risk capital availability

Expressed as risk capital intensity, as one of the decisive variables for scaling possibilities (and therefore indirectly as motivation for a start-up in Austria), risk capital availability increased noticeably compared with the previous year and reached 0.14%[85]. The sustained sideways movement is therefore solidifying, that is, while the innovation leaders have exhibited uninterrupted growth in the availability of risk capital since 2009 and the EU on average since 2013 (from 0.35% in 2009 to 0.8% in 2021), Austria has essentially not improved here since 2007. Estimates that 2021 was a record year in the area of start-up financing will not change anything here either, especially as a large part of the additional risk capital went on the financing rounds of three companies (GoStudent, BitPanda and TTTech). It must also be assumed that the energy and economic crisis caused by Russia's war on Ukraine will seriously inhibit the development of the 2021 record year. The global volume of large-scale financing rounds decreased in 2022, as on one hand the starting situation for flotations of big start-ups as a particularly popular exit strategy deteriorated, and on the other hand, the willingness to invest fell entirely due to the increased uncertainty. How much this situation negatively affects the start-up activity in Austria cannot be conclusively evaluated at the moment, in particular because big financing rounds have to date been the exception in this country (see Burtscher 2022). Current reports assume a decrease in the invested amounts of about 18%. The RTI Strategy 2030 goal of increasing risk capital intensity to 0.1% of GDP has been continuously achieved since

85 This value was smoothed (see summary) to balance out the volatility of the corresponding data and unsmoothed is 0.22%. The values of previous years are also recorded before the smoothing, which is why there is a significant change in particular compared with the previous year's report (from 0.07% to 0.12%). The statements with regard to achieving the RTI Strategy's goal are therefore no longer correct.

2007[86], but is currently at 0.14% of GDP and has hardly changed compared, for example, with 2010 (0.13%) or 2018 (0.155%).

The ratio of state to private investors worsened again in 2021 following a multi-year catchup process, which suggests that risk capital supply in Austria in times of crisis in particular is supported above all by the state offering or banks, while such a correlation no longer exists among the innovation leaders and the EU as a whole since the global financial crisis or is not seen to this extent.

Another sustained trend is the lack of investments from Austria, that is, the greatest part of the invested amounts comes from abroad, whereby at least the numerical part of investments shifts in favour of domestic providers. No Austrian investors, however, were involved in financing exceeding €100 million. The risk of the migration abroad of know-how, IPR or even entire companies therefore still exists and continues to be a not to be underestimated threat for Austria. Hesitating on the long announced new corporate form for start-ups, which is supposed to make companies significantly more attractive for investors, also has a negative impact here. Currently no (new) details on the arrangement or even just the timetable are known.

Start-up dynamics

Start-ups

According to the Global Entrepreneurship Monitor (see GEM 2023) and the Austrian Federal Economic Chamber (see WKO 2023), on the whole start-ups have recovered from the effects of the COVID-19 pandemic and since 2022 at the latest have been at or slightly above the 2019 level. The Austrian Start-up Monitor (see ASM 2023), which by its definition, according to strong innovation-based and oriented start-ups, also assumes a stabilising of the start-up dynamics. There are, however, signs of a worsening of Austria's relative position, that is, other countries to date are recovering faster from the effects of the COVID-19 pandemic or were affected less by such – Austria improved entirely, for example, with regard to the rate of young entrepreneurs (so the percentage of these among the entire employable population), but at the same time fell in the European comparison from 12th place (from 16) to 16th place (from 20).

There was also a clear decline and therefore an at least temporary interruption of the sustained positive development since 2015 with employment in especially fast-growing companies (the aptly-named "gazelles"). This decrease, however, applies to the EU as a whole. The growth expectations as an approximation to the actual employment growth are developing positively in Austria and other European countries at least among young entrepreneurs, however the percentage of companies with especially high expectations in Austria is significantly lower than in France or Norway, for example, but almost on a par with the innovation leaders (see GEM 2023).

86 This finding, deviating from recent years, is due to the smoothing of the data, that is, all data was also adjusted retroactively to balance out the high volatility.

Attitudes and competencies

Social standards and attitudes are also always behind the sustained poor performance in the start-up area, with the willingness to take entrepreneurial risks, for example, or even to consider a start-up as a career option. According to the current Global Entrepreneurship Monitor (GEM 2023), Austria is indeed still in the lower mid-field in the European comparison, it has, however, significantly improved from the last position reported in 2020, when it comes to the issue of how desirable a career as an entrepreneur will be perceived, for example. As part of the same analysis, experts have however rated the dominant socio-cultural standards as continuing to be highly obstructive and negative. Regardless of the differing estimates, with the key issue of fear of failing, for example, the GEM (2023) identifies a decrease in the relevant information among the general public. It must at any rate be assumed that the socio-cultural transformation, which is required to make entrepreneurship and start-ups more attractive and consequently to improve the start-up dynamics, is, however, gradually moving in the "right" direction.

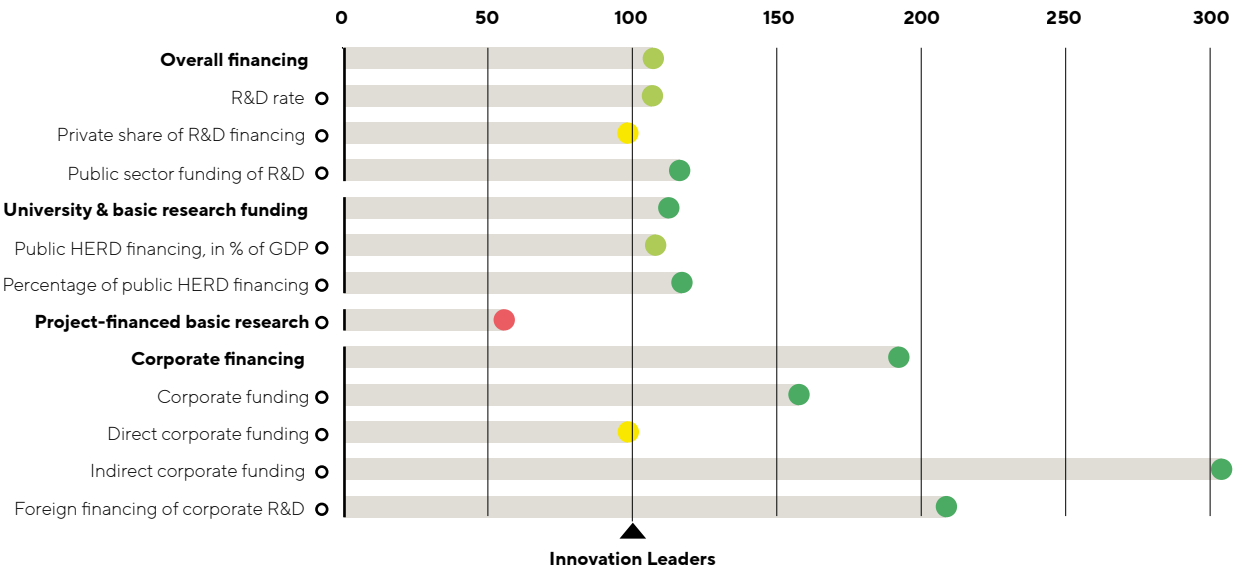


Figure 11: Austria's strengths and weaknesses in the B.5 area: Financing compared with the innovation leaders

○ Input ● Output

Financing

Goals of the RTI Strategy 2030:

1.4 Participating in at least 3 additional IPCEI
2.1 OECD top 5 in 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

Data at:
fti-monitor.rfte.at/B/B.5

Financing

Composite indicator

downward trend

On the whole corporate financing relative to the innovation leaders is still very high, as is the "Indirect corporate funding"[87] indicator (research premium allocations), which shows a sharp upward trend from 2019 to 2020. Austria ranks behind the UK and France among the top countries and has displaced Belgium in this ranking. In this context it must however be considered that the indicator shows relatively strong fluctuations, as large-scale companies apply, in places, for the research premium for several years. While the funding instrument for indirect R&D funding is above average high, the indirect corporate funding indicator[88] has been regressive since 2013 (predominantly FFG/AWS R&D-relevant allocations). This value began to even out continuously in 2017 at a consistent level above the EU average and just slightly above that of the innovation countries. The strong upward trend from 2009 to 2013 can since then no longer be achieved.

While the foreign financing[89] of corporate R&D was front and centre from 2002 to 2004 and still steadily approximating the top 3 countries, this positive trend began to continuously reverse in 2005 and since 2013 exhibits a constant value of approximately 21 (measured as a percentage of foreign corporate financing). With the BERD share Austria is nevertheless financed from abroad above the EU average and also above the innovation leaders.

Financing

The "Overall financing" composite indicator has only changed marginally compared with the previous year (2023: 107%; 2022: 104%). The subsumed R&D rate (R&D expenditure[90] in percentage of GDP) has increased since the first recording in 2001 in a continuous upward trend at the level of the innovation leaders. The latter was even just above these countries from 2014 to 2019. On average the Netherlands (not in the group in the previous year) even slightly pushes this value down and Belgium's performance is therefore responsible for the innovation leaders being on a par with Austria this year (comparison of the two time series[91], new vs old in the RTI monitor). In the long-term time comparison (2002-2020), seen as a whole Austria is below the level of the top 3 countries (2023: IL, KR, SE), which also show an upward trend since 2015. With a value of 98% in relation to the innovation leaders, the private sector funding in R&D expenditure[92] remains slightly below average (trend increasing), while the public funding with 116% is above average high, however since 2017 has been slightly

87 RTI Monitor, "Indirect corporate funding" indicator (OECD R&D Tax Incentive Indicators).
88 RTI Monitor, "Direct corporate funding" indicator (OECD R&D Tax Incentive Indicators).
89 RTI Monitor, "Foreign financing of corporate R&D" indicator (OECD MSTI).
90 RTI Monitor, "R&D rate" indicator (OECD MSTI).
91 RTI Monitor, "R&D rate, innovation leaders brown without NL and black with NL" indicator.
92 RTI Monitor, "Private share of R&D financing" indicator (OECD MSTI).

below the top 3 countries. The trend is moving in the direction of the top 3 countries (2023: NO, KR, DE).

While the financing of companies is still clearly above the innovation leaders' average, that of the universities is significantly closer to this benchmark and remains unchanged this year over last year (value: 112%). The development of the HERD public sector financing in the international comparison (measured in % of GDP) is 0.58% with a slight fall since 2015, and from 2011 to 2016 it was even above that of the top 3 countries. With the percentage of public HERD[93] financing, Austria is still above the level of the innovation leaders and the EU average, even if a slightly regressive trend can be seen since 2018[94]. With the most recent value of 84.5%, Austria is also just below the top 3 countries (last value: 88.9%) over the long-term comparison period (2002-2019).

With regard to project-financed basic research[95], the strengths-weaknesses analysis clearly shows that the percentage of core financing in the international comparison is indeed relatively high, however it is countered by a low share (measured as per capita annual allocations of funds for financing basic research) in the annual allocation of funds for financing basic research. The current value is 37.8 per capita compared with 35.7 last year. Austria has actually improved domestically, however since 2014 (first records) it is far below all comparison groups. The top 3 countries (2023: FI, US, CH) have a last value of 97.3.

Financing

93 RTI Monitor, "Percentage of public HERD financing" (Eurostat [rd_e_gerdfund]).
94 Possibly due to the 2014 debt crisis in the Euro area.
95 RTI Monitor, "Project-financed basic research" indicator (funds' annual report).

Recommendations for action

B.1 Tertiary education

⟶ Despite an increase in the budget for tertiary education institutions, there is no financial room to manoeuvre for universities and technical colleges. The price increase requires higher investments in education and research at universities, to increase the number of qualified teaching and research staff, to train more students at the universities with higher quality and to increase the number of graduates.

⟶ Problems in the employment legislation at the universities are also still prevalent (§ 109 of the University Act, fixed-term employment), for which a solution remains to be found. To meet the increasing demand for highly qualified graduates, especially in the STEM subjects, universities and technical colleges must be enabled to install the structural conditions for efficient expansion. One basic requirement in this respect are more professors and equivalent positions, as well as a consolidation of the employment relationships among the teaching staff, especially for talented young researchers, in order to increase the quality of student supervision at the universities in the subjects and disciplines in question. The funds required for this must therefore be provided for in the performance and financing agreements of the coming periods and must compensate for the price increase, as well as covering the requirements for creating the necessary positions.

⟶ To survive in the international competition with the best universities, the requirements for recruiting and developing excellent scientists must be optimised. The public universities must be both enabled here with the required budget resources, and also called upon to meet vocational and employment criteria, so there are no barriers for the best talents in international competition.

B.2 Academic research

⟶ The long-term growth rates of a national economy depend heavily on technological progress. Successful basic and applied research provide the basis for innovations. A significant increase in investments, especially in basic research funding awarded in competition at the level of the leading research nations, as well as a doubling of the funds for modern research infrastructures and participation in international infrastructures (ESFRI, for example), are urgently required measures to improve framework conditions. Due to the volatile inflation trend, the resources for multi-year funding commitments must also be adjusted according to the inflation rate.

⟶ Improvements with the output criteria and a general increase in research performance are directly linked with the available amount of successful researchers. The basis for this are sufficiently available and financed positions, as well as attractive career plans for scientific employees, especially for young researchers.

B.3 Corporate RTI

⟶ To not only increase companies' R&D expenditure in the medium-term, but moreover to also harmonize it with socio-political goals such as technology sovereignty, decarbonisation, etc., a significant and extensive financial policy commitment to Europe's industrial policy strategies and their implementation is key here. Participation in existing and additional IPCEI must therefore, and especially because of their partial financing by the European Recovery and Resilience Facility, be equipped with appropriate resources and implementation of the European Chips Act must be prepared now..

B.4 Start-ups

⟶ For the start-ups range of topics, but also corporate RTI (namely the number of research companies and via them private R&D expenditure), the strengthening of venture capital in the early phases by way of an umbrella fund (similar to the Danish Export and Investment Fund[96] role model) would be required to attract and activate investments from the institutional sector (pension funds, insurance companies or foundations, for example – see Keuschnigg 2019:9).

⟶ The implementation of the long-planned new corporate form for start-ups while considering a maximum of the required focus points on the participation of employees, facilitations in the start-up process and the attractiveness of Austrian start-ups for investors, will be decisive for the necessary impetus of business start-ups and the scaling options at the location. A full consideration of the requirements of the start-up and investor scene when it comes to the design and implementation of the planned new corporate form, FlexCo/FlexKapG, is required here. At any rate, implementing a simply slightly modified version of already existing corporate forms, such as the limited company, must be prevented.

B.5 Financing

⟶ The challenge in the area of R&D financing affects the overall amount of the available public and private funds less, and more so how such funds are awarded and the question as to what the public funding is provided for. This is also because, in addition to the funding system, the economic framework conditions also play a role in the success of innovation efforts, especially with regard to the geopolitical challenges – IRA, for example (for this see Introduction). Further improvements of the framework conditions for innovation (also via restructurings), the funding of human resources or a restructuring of the capital market, for example, could increase Austria's innovation efficiency, a conclusion which was already drawn in 2009 in the system evaluation (see Aiginger et al. 2009:49).

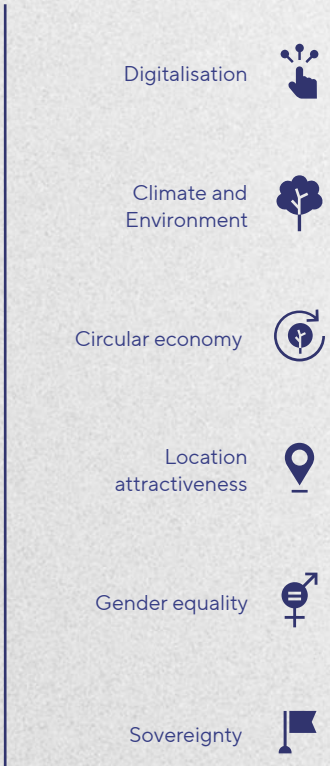
⟶ Detailed data-based analyses are recommended to further develop the R&D financing structure, as well as the corresponding conditions recently created by setting up the Austrian Microdata Center. The effect of the R&D funding could then be evaluated more evidence-based. The systemic interaction (also with regard to the grand challenges) must in particular be examined, in the universities area that of core financing and project-based funding, for example, and in the corporate area that between direct and indirect funding.

96 eifo.dk/en/ [2 March 2023].

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.



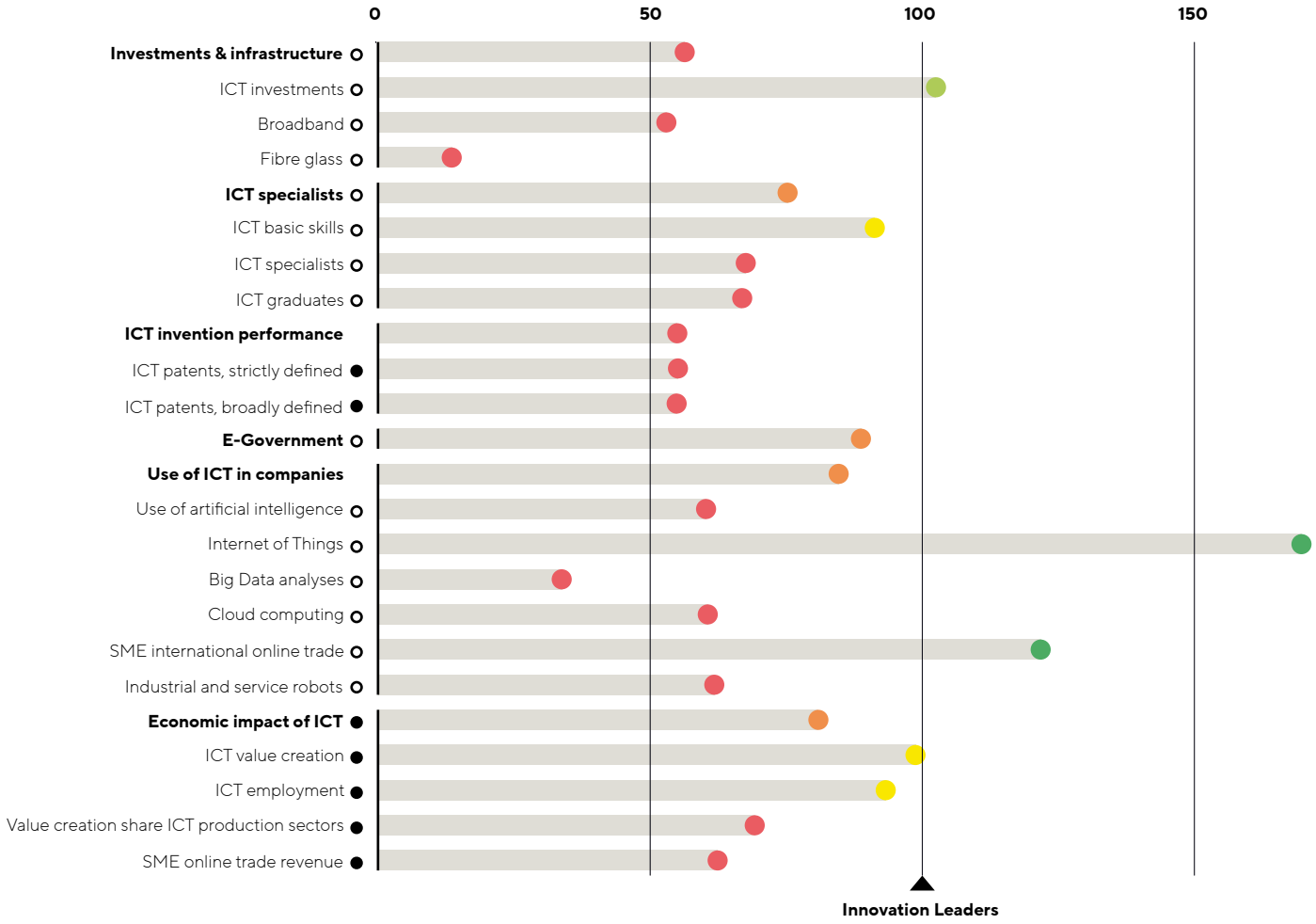


Figure 11: Austria's strengths and weaknesses in the C.1 area: Digitalisation compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

1.1.2 Rank improvement in international indices: Digital Economy and Society Index (DESI)
1.5 Drive forward digital transformation
3.1.1 Increase STEM graduates by 20 %

Data at:
fti-monitor.rfte.at/B/C.1

Digitalisation

Composite indicator

upward trend

Digital products and services grow further in importance for economic and scientific development, while correspondingly the cross-cutting issue of digitalisation is the benchmark for the sustainability of the Austrian RTI system, among other factors. The findings for the state of digitalisation in Austria once again are not positive, even though the area indicator with regard to the innovation leaders is above 75% for the first time. But indeed not all indicators by far point to a positive trend. While, for example, the indicator for commercially used broadband penetration is slightly regressive for Austria (but only with three available data points), all comparison groups increased their share, which increases the distance. The share of fibre optic connections in the EU average and with the innovation leaders is also growing significantly stronger than in Austria. All three comparison groups also tend to develop stronger than Austria with the ICT specialist indicators. On the whole, Austria continues to lag far behind the innovation leaders in the digitalisation area and is even something of a "straggler" compared with the EU average.

Austrian companies are however strong in the use of the Internet of Things (IoT) in the entrepreneurial environment[97], whereby, in addition to building security and controlling energy consumption, condition-dependent maintenance with the use of IoT systems is considered a strength.

Digitalisation

New in the RTI monitor was an indicator for e-Government[98], so the use and provision of digital services in public administration. The basis for this is provided by the five sub-indicators of the index for the digital economy and society (DESI, see European Commission 2022a): (I) "e-Government users" provides the relative number of those Internet users that interacted with authorities via the Internet in the past twelve months, (ii) "pre-filled-out forms" rates the extent to which electronic forms are already pre-filled-out with public knowledge data, (iii) "digital public services for citizens" measures the number of online-available services for citizens, and (iv) "digital public services for companies" indicates the degree to which public sector services are interoperable for companies and function cross-border. Austria can position itself above the EU average here, compared with the innovation leaders and the top 3 countries (EE, FI, NL), however, there is still clear catch-up requirement. Austria also performs above average compared with the EU member states, with the digital public services for companies, for example.

97 FTI Monitor, "Internet of Things" indicator (Eurostat).
98 RTI Monitor, "e-Government" indicator (DESI).

As Austria's ranking improvement in the DESI is explicitly mentioned in the RTI Strategy, focus is directed at this point on the critical areas. One of the four main dimensions of the DESI is the connectivity produced by ten individual indicators. Austria is ranked 14 in this dimension and is below the EU average. If we consider the respective last three data points, the individual indicators, apart from the broadband price index, consistently point to a positive trend (even strong in places), whereby most other countries also grow rapidly in the corresponding individual indicators. With the use of lines in homes that have a speed of at least 100 Mbit/s, for example, Austria is only better than Greece and Croatia and has significant catch-up requirement here. With the coverage of homes with a fixed network with very high capacities, Austria can also only perform better than just four EU countries – in rural areas, it is then only three countries that are weaker than Austria. Austria also lags behind EU-wide, ranked fifth-last with the supply of fibre optics up to buildings (fibre to the premises, FTTP).

The broadband penetration in companies[99] must also be rated as especially negative in this context – compared with the trends of the innovation leaders, the top 3 countries and the EU average, Austria's value (measured as a percentage of the companies that have an Internet connection with a speed of at least 100 Mbit/s) over recent years has now fallen to 39.3%. Furthermore the percentage of fibre optic connections[100] in Austria is growing slower than in the comparison groups, despite Austria's low current level, and therefore the planned investments in the infrastructure expansion (broadband billion) are attributed special importance.

The economic impact of ICT develops in various ways in Austria – Austria's value creation share of the ICT production sectors[101] only grew slightly, while the three comparison groups saw strong growth over the past year in particular. The EU average and the innovation leaders have an approximately 50% higher share than Austria, while with the top 3 countries the share is more than double Austria's. The importance of online trade revenue for SMEs[102] did actually fall over recent years with all comparison groups, however Austria in particular exhibits a negative trend compared with the EU average.

Digitalisation

In addition to the digitalisation of various administration processes for private users and companies, there is however also considerable potential in the use of register data (see ZSI 2022). First of all, in this respect the legislative requirements with regard to department-related regulations must be met. But Austria is also faced with structural and technical challenges, in implementing the specifications of the European Data Governance Legal Act by autumn 2023, for example (see European Parliament 2022).

99 RTI Monitor, "Broadband" indicator (Eurostat [isoc_ci_it_en2], OECD ICT Access and Usage by Businesses).
100 RTI Monitor, "Fibre optics" indicator (OECD Telecommunication Statistic).
101 RTI Monitor, "Value creation share, ICT production sectors" indicator (Eurostat SBS).
102 RTI Monitor, "SME online trade revenue" indicator (Eurostat – Community survey on ICT usage and eCommerce in Enterprises [E_ETURN]).

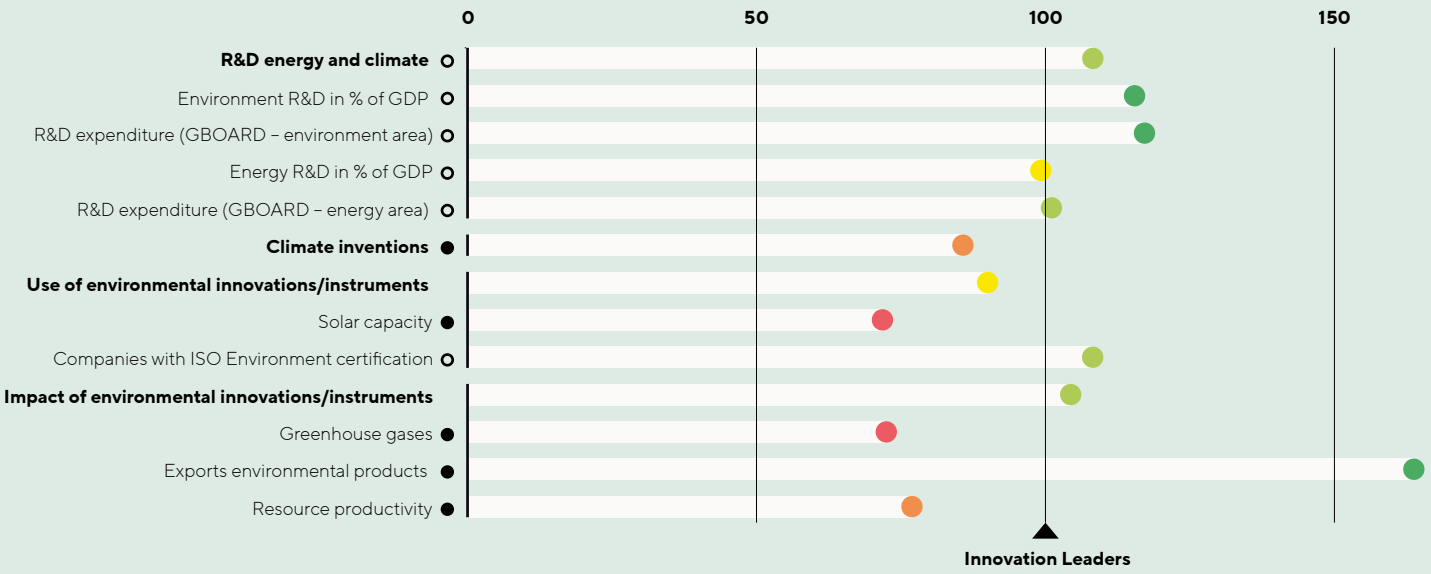


Figure 12: Austria's strengths and weaknesses in the C.2 area: Environment and climate compared with the innovation leaders

○ Input ● Output

Goals of the Circular Economy Strategy:

K.1.1 Material footprint (MF) reduced to 7 tonnes per capita and year by 2050

K.1.2 Domestic Material Consumption (DMC) reduced to 14 tonnes per capita and year by 2030

K.2 Increasing domestic resource productivity by 50% by 2030

K.4 Reduction of the material consumption in private households by 10% by 2030

Data at:
fti-monitor.rfte.at/B/C.2

Climate and environment

Composite indicator

downward trend

In the environment and climate area, the fall in most of the individual indicators compared with the previous year is the most surprising. While Austria improved in the "Climate inventions" indicator and in the "Use of environmental innovations/instruments" composite indicator (caused, among other things, by the increase in ISO environment certifications), the "Solar capacity" indicator[103] compared with the previous year fell from 90% to 72% – although in the long-term time series comparison (2000-2021) the percentage of solar capacity in the share of overall electricity generation is at 10.2%. Once again joining the group of the innovation leaders this year, the Netherlands (also at number 1 in the top 3 ranking) have a high influence on this indicator and therefore raise the level sharply; in this year's comparison Austria is therefore below the level of the innovation leaders and that in the EU average. With regard to the share of solar capacity in overall electricity generation, Hungary has pushed Germany from the number 3 spot (in the previous year).

There was a slight fall in the "Impact of environmental innovations/instruments" composite indicator, which is mainly attributed to a negative trend with the indicators for greenhouse gases and resource productivity (consistent with the results of the European Innovation Scoreboard[104]). Greenhouse gases are weighted on the basis of their respective greenhouse potential, aggregated into one unit and expressed as units in CO_2 equivalents. The indicator does not give any information whatsoever on emissions and their reduction in connection with land use and forestry. The emissions of international aviation traffic are however included. The fall in resource productivity [105]despite annual growth of 1.0%P is also attributed to the Netherlands, which are once again at number 2 in the top 3 countries' ranking.

Climate and Environment

The exports of environmental products[106] by contrast increased further from 153% in the previous year to 164%. As already in the previous year, Austria is in the top 3 countries here (behind Finland and Denmark) and therefore also continues to be far above the level of the EU average and that of the innovation leaders. The continuous increase since 2016 did however even out from 2018 to 2020. As already shown in the previous year's report, this positive trend of the indicator is mainly attributed to Austria's forest wealth. The raw materials from forests are the basis for all

103 RTI Monitor, "Solar capacity" indicator (Eurostat [nrg_inf_epc]).
104 See European Innovation Scoreboard 2022, European Commission.
105 RTI Monitor, "Resource productivity" indicator (Eurostat [sdg_12_20]).
106 RTI Monitor, "Exports of environmental products" indicator (Eurostat [env_ac_egss2]).

products that are traded on international markets as export goods (raw wood types, energy resources and various ancillary uses). It must be critically noted that this positive development is a result of natural resources and not of intentional innovation activities.

Decisive for the regressive trend of the environment and climate area (overall) is in particular the worsening of the aggregated "R&D energy and climate" composite indicator and the subsumed individual indicators that fall under it. As already in the previous year, on one hand expenditure for R&D in percentage of GDP (cyclical components) is calculated, and on the other the expenditure for R&D in percentage of the federal budget is also calculated. The priority of the expenditure for environment and energy can be derived from the latter. A statistical smoothing of the individual indicators was also performed here to cushion the strong fluctuation margins and to provide a realistic view of the situation. Accordingly, the R&D expenditure in the energy[107] area is above the EU average level and close to that of the innovation leaders. It must be noted that the top 3 countries with this indicator exhibit a regressive trend. In the area of R&D expenditure for the environment[108], the top 3 saw a slight upward trend, while the time series in the EU average also continues to run at a constant. Austria has caught up rapidly here since 2018 and is now at the level of the innovation leaders.

According to a study performed by the University of Leoben as commissioned by the Austrian Council to examine the systemic correlation of decarbonisation and the circular economy, the Austrian industrial sector (13 sectors according to IEA) is responsible for approximately 37% of the overall energy consumption and more than 34% of all national CO_2 emissions (see Kienberger/Pomberger 2022:13ff). The energy-intensive sub-sectors produce basic materials such as crude steel, cement, paper, glass and plastics. More than 70% of the industrial energy requirements and CO_2 emissions are attributable to these sectors. By contrast, the remaining, non-energy-intensive sub-sectors (pharma, for example), which process the basic materials into products over the value creation cycle, are responsible for less than 30% of emissions.

The greatest part of the emissions of energy-intensive industries is attributed to the production of basic materials from primary raw materials (crude steel from iron ore or raw cement from limestone, for example). Emissions can be reduced considerably here, if the primary production can be reduced by the use of secondary raw materials (steel scrap, recycled concrete, for example – see Kienberger/Pomberger 2022:13 and C.3). With the appropriate process design, basic materials can then be produced with almost identical properties as those of the primary route. Production routes would have to be adjusted technologically for this (electric arc furnaces, for example), and the availability of the respective secondary (or recycling) raw materials would also have to be guaranteed here.

107 RTI Monitor, "R&D expenditure in the energy area" indicator (Eurostat [gba_nabsfin07])
108 RTI Monitor, "R&D expenditure in the environment area" indicator (Eurostat [gba_nabsfin07])

The results of the study show that for iron and steel the energy saving is at 57% and the CO_2 saving is 95% – the latter however only with a fundamental change in the production technology. In the cement industry, the possible saving after examining the technology routes is at approximately 19% in the use of energy and at approximately 26% for CO_2, with the use of recycled building materials, for example, or a reduction in the clinker constituent in cement production (see 2022:70 table). The chemical and petrochemical industry offers a saving potential of approximately 21% with specific energy consumption and approximately 54% CO_2 combined with fuel switching (see Kienberger/Pomberger 2022:73 table).

Transformation opportunities for Austria in the Tech4Green area

The transition to a green economy also results in a change of the goods and services produced in Austria. In addition to the evidence-based findings of last year's and this year's performance report and the analyses in the RTI monitor, as commissioned by the Austrian Council, the Complexity Science Hub (CSH) Vienna created a knowledge-based product chamber model based on the data of various sources (OECD, APEC, WTO – see Reisch et al. 2022:3).

The economic complexity theory assumes that every country has the capabilities to produce and export products with differing complexity (see Hidalgo/Hausmann 2009). The amount of a country's capabilities is determined by the geographical conditions, its workforce, the available technology, infrastructures and framework conditions (for this see C.4, C.6, D.1, D.2). A country with numerous capabilities can generally produce more complex products, which brings higher revenue. Every country can be assigned a product space in which each product (more precisely, each product class according to harmonised system codes, see WCO 2023) is presented as an intersection in a two-dimensional graph. The distance between two products represents the similarity of the capabilities of the country required for production (see Hidalgo et al. 2007) – the lower the distance, the more similar they are.

The product space model created for the Austrian Council determines the potential of green products and product groups for which Austria already has the necessary capabilities for production, and which therefore offer specific opportunities for an accelerated green transformation. This model is provided web-based via the ECTO Dashboard[109] (*Economic Complexity and Green Transformation Opportunities*). The global market size for these products was also analysed in the model (evaluation of the development potential according to demand) and the dependence of critical primary raw materials was scrutinised. The results are assigned in the ECTO Dashboard to the nine federal states and therefore indirectly to the companies and industries based there. In the accompanying study (see Reisch et al. 2022),

109 Dashboard for Economic Complexity and Green Transformation Opportunities in Austria, https://ecto.rfte.at/ (RTI Monitor 2.0 – green transformation area).

Austria's green development possibilities are also compared with those of Germany and Switzerland.

The model shows that Austria already competitively exports 41 of some 75 green products (machinery, electrical equipment, for example). These include several with higher export complexity and high global trade volume (see D.2 Efficiency: Innovation, "Export complexity and quality" indicator). Added to this are five product categories with higher product complexity, low (still) expected competition and a big global market, where it involves the following categories with their global export volumes estimated with the model: (i) Automatic control instruments $29.7 billion, (ii) pumps for fluids $60.2 billion, (iii) compressors and fans $68.9 billion, (iv) devices for thermostatic controlled valves $83.7 billion, (v) instruments for measuring the properties of fluids $21 billion (see Reisch et al. 2022:19).

Before this year is out the ECTO Dashboard will be extended by the forecast revenue increase per sector dependent on additional production of the identified green products and product groups and consequently the expected sectoral labour requirements – clustered according to vocational classes and training.

In addition to the promotion of economic growth (1st dimension), the strengthening of the innovation system and the linking and optimisation of the interaction between the various stakeholders (2nd dimension), the 3rd dimension of the innovation policy targets the delivery of goal-oriented innovations (see Diercks et al. 2019:880). The ECTO Dashboard offers the appropriate evidence-based scientific model for this 3rd dimension.

An accelerated implementation and effective use of the Austrian transformation opportunities in the Tech4Green area, however, require the mobilisation of private capital, among other elements. The European Commission has already several times and correctly emphasised the fact that green finance (especially green bonds here) can play a key role in financing climate reversal (see European Commission 2016).

Green Finance

The RTI Strategy 2030 cites the priority use of R&D as an important pillar to achieve climate goals. Green finance can be utilised here as an essential instrument to achieve the green transformation and the corresponding climate goals with greater focus and faster. Under "RTI to achieve climate goals", the RTI Strategy 2030 already includes those factors that are relevant in the green finance context:

- "Strengthening open content and technology-neutral research in the areas of influence factors, effects and slowdown of the climate crisis as well as in the areas of climate change adaptation and resource efficiency (among other activities by stimulating private funding and participation in EU programmes);
- development of key technologies to improve climate protection, accelerate cross-sector cooperation and implementation of holistic solutions (for example, construction and energy sector, mobility, etc.) while maintaining technology neutrality;
- development of model regions and big-format experimental spaces;
- expansion of relevant data collection and use of digitalisation, as well as stakeholder networking." (BKA 2020a: 10)

Green finance must assume a prominent role with all these items. The transformation of a linear economy into a circular one, via available data for example, can then be monitored (the annual Green Bond Report, for instance, is compulsory in Austria). Cross-sector cooperation and the implementation of holistic solutions is possible on the basis of green-financed projects.

As part of the European Green Deal, considerable funds were released to finance green projects, which, however, the market can only absorb via specific routes. In addition to green bonds and the in recent years constantly growing (voluntary) compensation market, in the environment area these are "Public Private Partnerships (PPPs)".

Green Bonds

As a consequence of the Green Deal, green bonds have increased sharply since the European Investment Bank's initial initiatives in 2007 (Climate Awareness Bond) as a financing source of green projects, both absolute and relative to conventional investments. They can therefore be interpreted as an indicator of a continuously growing "green transformation" (that is, an increasing volume of green bonds would imply a higher level of green transformation). The green bonds instrument provides financial resources for solutions to stop climate change, which can be issued by governments, banks, local councils (so-called *Local Green Bonds*) or by companies (see OECD 2017).

The label for green bonds can be applied on every debt instrument format, including private placement, securitisation or covered bonds. Green bonds with the seal of approval are an option, if they comply with the *ICMA (International Capital Market Association) Green Bond Principles* or the *LMA (Loan Market Association) Green Loan Principles* (see CBI 2019). Decisive here is that the returns only flow into "green" assets.

The term "green" is defined differently around the world. The Climate Bonds Initiative (CBI) uses the *Climate Bonds Taxonomy*[110], which incorporates eight categories: Energy, buildings, transport, water, waste/pollution control, land use, industry and ICT. Within the scope of the *Climate Bonds Standard* the CBI has published ten sectoral criteria (see CBI 2019), according to which issuers can have their bonds or loans certified. A strict procedure ensures that the use of returns pursues the goal of limiting global warming to 2 °C. The further increasing issuance of green bonds and green finance reflects the strong market dynamics in recent years for this form of bond issues.

To offer investors the highest level of transparency and provide an overview of the achieved advances and positive ecological effects, the Republic of Austria has committed, from the calendar year following the first issuance, to publishing an annually updated report on the use of the returns of green bonds (*Allocation Report* – see OeBFA 2022). The first green bond issued here in this country shows that a large part of the funds flows into clean and sustainable transport, into the expansion of the rail network, for example. Furthermore, projects in the energy efficiency area are financed with the issuance of the green bond, including, for example, smart networks and energy storage, wastewater management, the expansion of renewable energies, sustainable land use and biodiversity.

Compensation areas

The size of the (voluntary) compensation market has in particular grown continuously with regard to the use of moorland, as seen in Germany, for example (see Oekom 2022).[111] Already there are established commercial providers (for example, RSS – Remote Sensing Solutions GmbH[112] with the forest climate certificate or the *Reducing Emissions from Deforestation and Forest Degradation* [REDD] projects[113]), who also offer monitoring of forest areas, for instance, with the corresponding set of indicators. With the aid of transparent and standardised earth observation methods, the CO_2 reduction potential of reforestations, forest restructuring and existing forests can then be estimated.

110 Climate Bonds Taxonomy, climatebonds.net/standard/taxonomy [4 March 2023].
111 In Germany there is therefore already an advanced ecopoints system for monetising ecological services.
112 RSS – Remote Sensing Solutions GmbH, remote-sensing-solutions.com/waldmonitoring [4 March 2023].
113 UN-REDD Programme, .un-redd.org/ [5 March 2023].

The Green Transition Information Factory[114] (GTIF) demonstrator could be used for Austria in this respect. The cloud-based environment is used to apply earth observation data for the energy, mobility, sustainable cities, carbon accounting and EO adaptation services areas. The latest technologies of the ESA help here to guarantee a carbon-neutral society by 2050. Austria serves as a role model for the demonstrator, which will be available for the whole of Europe in the future.

Public Private Partnerships (PPP)

Public Private Partnerships are also a key instrument for the green transformation. The World Bank itself has indicated that achieving the goals of the Green Deal critically depends on the integration of PPPs, whereby private investments play a key role.[115]

Carbon Contracts for Difference (CCD), an instrument that can promote the market launch of innovative and climate-friendly process technologies and which complements R&D funding, must be mentioned in this context. Imbalances on the market for environmental technologies, which can emerge for certain companies or industrial sectors, will therefore only be compensated to a limited degree when they can optimise their production processes with regard to their emissions level. CCD offer an option to favour the market launch of such processes via the cushioning of cost differences and risks. The presentation of CCD can also be seen as an indicator for a progressing and focussed green transformation – if the share of CCD increases across the board, this would indicate a higher number of companies specifically using environmental technologies in their production processes.

As cursorily shown here, there is now a series of focused instruments, which specifically connect the green transformation with green financing methods, and which clearly illustrate the essential importance of the capital market (especially private investors) for the implementation of the green transformation.

114 Together with the European Space Agency (ESA), Austria is developing a demonstrator with tools for the green transformation based on earth observation data. Link to the beta version: austria-in-space.at/de/news/2023/20230220-erdbeobachtung-fuer-den-gruenen-und-digitalen-wandel.php [14 March 2023].

115 World Bank Blogs: Europe's Green Deal needs PPP thinking, blogs.worldbank.org/ppps/europes-green-deal-needs-ppp-thinking [5 March 2023].

Figure 13: Austria's strengths and weaknesses in the C.3 area: Circular economy compared with the innovation leaders

○ Input ● Output

Goals of the Circular Economy Strategy:

K.1.1 Material footprint (MF) reduced to 7 tonnes per capita and year by 2050

K.1.2 Domestic Material Consumption (DMC) reduced to 14 tonnes per capita and year by 2030

K.2 Increasing domestic resource productivity by 50% by 2030

K.3 Increasing the circularity rate to 18 % by 2030

K.4 Reduction of the material consumption in private households by 10% by 2030

Data at:
fti-monitor.rfte.at/B/C.3

Circular economy

Composite indicator

upward trend

The circular economy area was added for the first time last year to the performance report and the web-based RTI monitor. This year this area also references the goals of the Circular Economy Strategy (see section II, Analysis of the achievement of the circular economy goals). Additional individual indicators have been added this year, which result in the "Circular economy innovation" composite indicator. Compared with the previous year the area indicator consequently rose from 89% to 99%. Patents, among other elements, were already analysed in the previous year as an output indicator. Used this year were specialised individual indicators, which provided information on relative specialisation patterns of Austrian inventions in the circular economy area and are calculated via a relative specialisation index, the aptly-named *revealed technological advantage* (RTA) (see Unterlass et al. 2013: 10): RTA circular economy-relevant patent applications and RTA patent applications for supportive enabling technologies. The RTA is the standard indicator used for characterising the technological specialisation profile of an innovation system (see Unterlass et al. 2013: 29ff). Instead of Austria's patent activity relative to the innovation leaders, their technological and commercial importance in the circular economy is measured here. The RTA also provides information with regard to the degree of specialisation. In the long-term comparison, the two indicators in figure 14 show[116] a constant (stable) trend in the EU average and relative to the innovation leaders. The top 3 countries are above this level with higher volatility and a regressive trend; with the RTA circular economy-relevant patents since 2016 and the RTA-supporting patents since 2018.

The relevance of circular economy technologies and patents this year is additionally evaluated with the two PageRank indicators, "PageRank circular economy" and "PageRank supportive enabling technologies", which enables a ranking in the international comparison based on the importance of registered inventions. To consider the size of the country in the international comparison and therefore also the number of active inventors, the calculated PageRank values are weighted on the basis of the total population (citation weighting, see Reinstaller et al. 2022:28, 31). This results in a small economy such as Austria's, which registers few but important patents, appearing in the upper ranks of the ranking (see Reinstaller et al. 2022:29, fig. 10, 11). The adverse effect of this method (see Reinstaller et al., 2022:28) was attenuated in this report, as payment is made based on the inventor's place of residence and not where the application is made.

Circular economy

116 RTI Monitor, C.3 Circular economy, see time series visualisations of the individual indicators.

The percentage of recycled raw materials and their return into the cycle of materials ("Usage rate of reusable materials" indicator[117]) this year shows an upward trend in the long-term time comparison (2010-2021). The time series also shows that in this area the Netherlands heavily influences the indicator (positively). If the Netherlands were not in the group of innovation leaders this year, Austria would be above this level. Austria's annual growth rate[118] is at 5.7%. As already in the previous year, the economic impact of the circular economy is above the average. A slight fall is seen with the "Gross investment in % of GDP" indicator[119], for which circular economy-relevant tangible assets in % of GDP were analysed. Observed in the time series in the long-term comparison (2009-2019) Austria is constantly below the level of the innovation leaders and that of the EU average. The top 3 countries in this area since 2017 exhibit a continuous downward trend.

The current percentage of reused raw materials of energy-intensive industries according to a University of Leoben study commissioned by the Austrian Council (Kienberger/Pomberger 2022:33ff, 62ff) in iron and steel processing is 10%, in the paper industry approximately 50%, for cement 15-30% and with the plastics industry it is a quarter of the material use. In addition to RTI-based recommendations for action (see subsystem C: Recommendations for action) this also requires new additions to and adaptations of legal framework conditions. The Waste Management Act (WMA) has grown historically and was continuously adapted to the conditions and necessities of the respective period. With regard to the circular economy, there are, however, divergences, that need to be removed (see Kienberger/Pomberger 2022:78ff). It is important here that the WMA be adapted to the present conditions and the challenges of the future (recycling lithium ion batteries, for example), to promote innovations and creative solutions in handling residual materials rather than to restrict these (removal of obstacles to using secondary raw materials, for instance, such as eliminating limit values that are not practice-relevant). It must be possible to evaluate secondary raw materials in the same way as primary raw materials are according to the same (logical) quality criteria (see Kienberger/Pomberger 2022:79). The standardisation system continues, however, to be decoupled from the direct knowledge from R&D and is therefore contrary to the use of secondary materials. In the interests of the transformation towards the circular economy, it must be ensured that the know-how from R&D is immediately considered in the standardisation (see Kienberger/Pomberger 2022:79). A further measure, which is both regulated in legal norms and organisationally implemented, is the expansion of separate collection of recyclables in local councils and in commercial and industrial areas, with the focussed collection of all plastic waste, for example (see Kienberger/Pomberger 2022:80).

Circular economy

117 RTI Monitor, "Usage rate of reusable materials" indicator (Eurostat [env_ac_cur]).
118 RTI Monitor, C.3 Circular economy, see strengths-weaknesses analysis 2023.
119 RTI Monitor, "Gross investment in % of GDP" indicator (Eurostat [cei_cie010]).

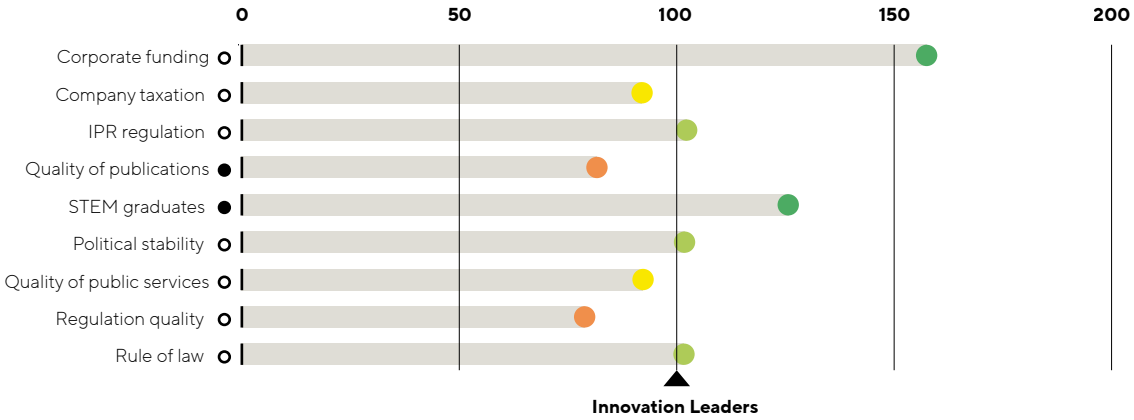


Figure 15: Austria's strengths and weaknesses in the C.4 area: Location attractiveness compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

1.2 Recruit 5-10 new RTI-intensive lead companies and expand existing ones

1.3 Increase number of R&Dactive companies by 20%

3.1.1 Increase STEM graduates by 20 %

Data at:
fti-monitor.rfte.at/B/C.4

Location attractiveness

Composite indicator

downward trend

Location attractiveness in particular plays a major role for small, open national economies such as Austria's, and not just because of international developments (see Janger/Strauss-Kollin 2020:44). Along with the general framework conditions, corporate funding and taxation, the quality of publications (as an indicator for high-performance research institutions) and human resources for innovation (STEM graduates) as key location determinants for RTI-intensive companies are analysed in the following.[120]

According to the strengths-weaknesses analysis (initial value 2002: 0.18; last value 2019: 0.27), corporate funding[121] exhibits an increasing trend, however the indicator saw a decrease compared with the previous year (2022: 196%; 2023: 157%). Direct corporate funding is regressive in this area (for this see B.5). Austria nevertheless also continues to perform above average with regard to location attractiveness, and measured on GDP is above the innovation leaders' average.

Still negative is the development of effective corporate taxation[122] in Austria (positioned in the bottom third of all countries). This development must in particular be observed with regard to location attractiveness, despite the high research funding. The trend has therefore stagnated since the corporate tax reform in 2005 (for this see A.1), and Austria's relative position within the EU has consequently also deteriorated. In this context, for example, the deductibility of equity capital interest could boost the incentives for investment and innovation, increase competitiveness and location attractiveness and improve crisis durability by removing the debt burden (see Keuschnigg 2016). Even greater restructuring of the taxation system with regard to the green and digital transformation is recommended. With regard to the strictness of the regulation[123] of intellectual property rights, in the long-term time series comparison (2008-2022) Austria is about on a par with the innovation leaders in this period (slightly above it since 2021) and below the level of the global top 3 (for this see section A.1 Regulation and taxes).

Location attractiveness

The "Quality of publications"[124] indicator stagnates with a slight downward trend compared with the previous year (2023: 103%; 2022: 102%). Austria is therefore further behind the top 3 and the innovation leaders. The perfor-

120 For this in the RTI Monitor see, Goals of the RTI Strategy 2030, Goal 1.2 "Acquire 5-10 new RTI-intensive leading companies and expand existing ones".
121 RTI Monitor, "Corporate funding" indicator (OECD R&D Tax Incentive Indicators).
122 RTI Monitor, "Company taxation" indicator (European Commission).
123 RTI Monitor, "IPR regulation" indicator (World Economic Forum).
124 RTI Monitor, "Quality of publications" indicator (EIS).

mance of the Austrian research system measured on *highly cited publications* is actually above the EU average since 2012, nevertheless for some years now Austria has not managed to join the group of innovation leaders (the growth rate in % per annum is -0.3). The development in the STEM graduates area is more positive[125]. The indicator here improved compared with the previous year (2023: 126%; 2022: 119%). Following a (sharp) increase from 2012 to 2013, the values nevertheless evened out at a value of approximately 23 (measured as tertiary graduates in scientific and technological subjects per 1,000 inhabitants aged 20 to 29). Austria is still below the level of the global top 3 (with an increasing level distance), however shows good performance with tertiary graduates in scientific and technological subjects (see B.1). The "Political stability" indicator[126] runs relatively volatile in the long-term time comparison, with a downward trend since 2013. In 2021 Austria was practically on the same level as the innovation leaders and far below the level of the top 3 countries (NZ, IS, LU).

According to the World Bank the indicator for measuring the quality of public sector services[127] is an essential component of *governance effectiveness* and fell slightly for Austria compared with the previous year (by around 7%P). In this area, Austria is however still above the level of the EU average, and this year is just below that of the innovation leaders. The rule of law indicator, which along with rule of law principles also analyses the quality of administrative authorities, did not change compared with the previous year and is only just above the level of the innovation leaders, but below the top 3 (FI, NO, DK). The indicator's trend has however been falling since 2019. With regard to regulatory quality,[128] Austria exhibits a downward trend (absolute from 1.5 to 1.3) towards the EU average, while the innovation leaders enjoy an upward trend to join the top 3.

Even if on the whole, Austria achieves positive performance with location attractiveness, especially due to the high corporate funding, securing location attractiveness is unbalanced because of the values of the individual indicators. RTI-specific the indicator for measuring the quality of public services and in particular the quality of publications and regulatory quality indicators must be mentioned here.

Location attractiveness

125 RTI Monitor, "STEM graduates" indicator (Eurostat [educ_uoe_grad04]).
126 RTI Monitor, "Political stability" indicator (World Governance Indicators).
127 RTI Monitor, "Quality of public services" indicator (World Governance Indicators).
128 RTI Monitor, "Regulatory quality" indicator (World Governance Indicators).

Figure 16: Austria's strengths and weaknesses in the C.5 area: Gender equality compared with the innovation leaders

○ Input ● Output

Goals of the RTI Strategy 2030:

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

Data at:
fti-monitor.rfte.at/B/C.5

Gender equality

Composite indicator

downward trend

Gender equality continues to be one of the challenges of Austrian RTI policy, especially in view of the increasing demand for human capital. In this area, both on the whole and in the two "Occupational differences" and "Schools & universities" sub-areas, compared with the previous year Austria fell further (slightly) or is stagnating compared with all comparison groups. The greatest weaknesses here are the percentage of women in overall R&D staff, the number of female ICT graduates and the performance difference between girls and boys with the international PISA test in the maths area.

Statistik Austria's last R&D survey also confirms this (see Statistik Austria 2019): In full-time equivalents, the percentage of women in R&D in Austria is only 24.4%, whereby with 44.5% the higher education sector and with 50.2% the private non-profit sector exhibit the best values Austria-wide. The greatest imbalance is seen, of all places, in the sector that includes 70% of all R&D employees – the corporate sector. Only 15.7% of the FTEs here are women. A look at the industry sectors reveals that women are seriously under-represented, especially in the relatively important areas (in total 32.7% of the overall R&D full-time equivalents) of engineering, electrical equipment and information technology services, with an average of 10.2%. Along with the quantitatively less significant R&D sector of hospitality and gastronomy, with 53.6% women only form the majority of R&D employees with pharmaceutical products (in total 2% of R&D full-time equivalents).

The Women in Digital Scoreboard also shows catch-up requirement for Austria (see European Commission 2022c) – with Internet use by women, within the EU Austria ranks only 13th; with women's digital skills and employment figures it is even only at number 17. On the whole, Austria ranks far behind Malta and just ahead of Belgium at number 11.

In view of the persisting challenges, within the scope of the FFG impact monitoring, *KMU Forschung Austria* (Heckl/Kofler 2022) performed a separate analysis of the R&D projects funded by the FFG, and concluded that with the measures to promote equality in R&D implemented to date in and by the FFG, despite comprehensively addressing all three relevant levels of action (individuals, institutions, gender as research content), stimuli to change can be neither seen nor quantified. The percentage of female R&D staff with the companies involved in such funded projects does not differ from Statistik Austria's aggregated figures for research-active companies. KMU Forschung Austria's analysis concludes that, because of to-date poorly applied leverage (an obligatory consideration of female project managers in all projects in all programmes, for example), a real

gender mainstreaming of the topic in the training and research system is also required across the board. The effectiveness of the FFG's individual measures was largely confirmed with evaluations, however due to the programmes' low funding, for the most part it is only limited. Additionally, many programmes target system changes, which cannot be achieved with intermittent interventions.

With regard to the indicators, the number of female ICT graduates[129] is still a significant weak point in the Austrian RTI system. Not only is the number of female graduates already extremely below average compared with all comparison groups, the trend relative to the comparison groups is also negative – in absolute figures the amount of female ICT graduates stagnated between 2019 and 2020 or was even slightly regressive. These numbers do not favour a relatively positive future development in another indicator – the percentage of women among ICT specialists[130]. The comparably positive development in the period from 2014 to 2019, during which Austria was able to catch up compared with all comparison groups and even leave the innovation leaders in its wake, was halted in 2020 and 2021. In the meantime Austria is once again below the EU average, whereby contrary to the trends of the EU countries and the innovation leaders, in which the percentage of female ICT specialists is increasing (if only slightly), the percentage in Austria is even falling and is currently at 19%.

In unison with the female ICT graduates, the number of female STEM graduates per 1,000 inhabitants[131] is also essentially stagnating, while slight growth can be seen in the comparison groups. The goal anchored in the RTI Strategy of increasing STEM graduates by 20% is therefore currently achieved for the most part with male students, whereby the male dominance in this area is rather more sealed in than broken open. Together with the low number of female ICT specialists we see that in these areas in particular additional measures will have to be developed and implemented. On one hand to raise the percentage of women in the ICT and STEM area, and on the other hand to make it easier to achieve the goal of increasing the number STEM graduates. The poor numbers with female ICT graduates and specialists are therefore not only problematic in terms of gender equality – they are in particular systemically highly disruptive, also in view of the persisting scarcity of specialists.

Gender equality

129 RTI Monitor, "Female ICT graduates" indicator (Eurostat [educ_uoe_grad02]).
130 RTI Monitor, "Female ICT specialists" indicator (Eurostat [isoc_sks_itsps]).
131 RTI Monitor, "Female STEM graduates" indicator (Eurostat [educ_uoe_grad04]).

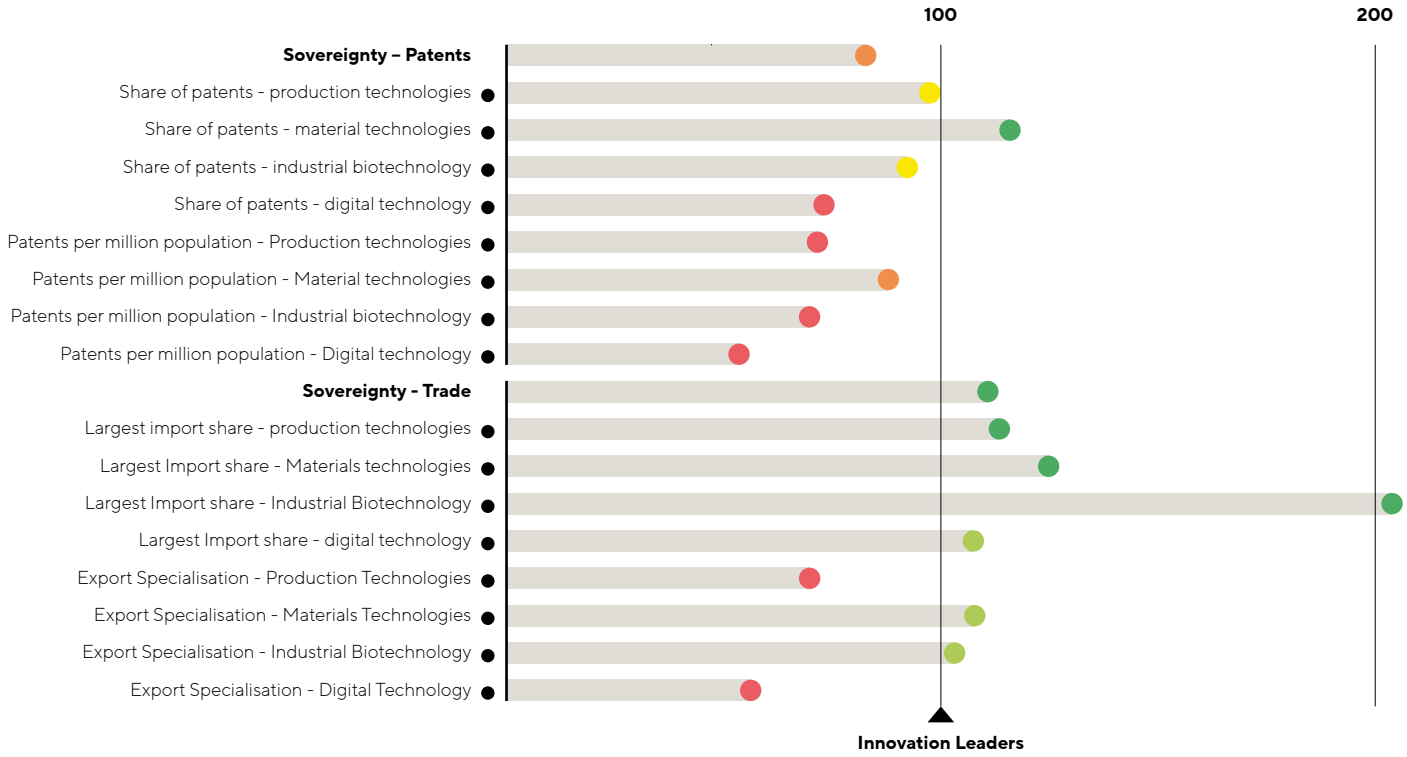


Figure 17: EU-27 strengths and weaknesses in the C.6 area:
Technology sovereignty, compared with the USA
(see RTI monitor for the China, South Korea and Japan comparison charts)

○ Input ● Output

Goals of the RTI Strategy 2030:

1.4 Participating in at least 3 additional IPCEI
1.5 Drive forward digital transformation
2.2 Expansion of the venture capital pool to 0.1 % compared to GDP

Data at:
fti-monitor.rfte.at/B/C.6

Technology sovereignty

Composite indicator

Technology sovereignty in terms of the reduction of unilateral dependencies has already been discussed in Europe for some time now, and, with Russia's war on Ukraine and the energy crisis it brings with it, as well as the interruption (again) of international supply and value creation chains, has conclusively pushed to the fore of current strategy development and political action. The term sovereignty is key here, but unlike autonomy (or even self-sufficiency), it defines the ability to act with self-determination and above all not influenced by others. Technology sovereignty is therefore defined as, "[...] the ability of a state or confederation of states to maintain and further develop the technologies it defines for itself as critical for welfare, competitiveness and state capacity to act, or to be able to obtain them without unilateral structural dependence on other economic areas" (Edler et al. 2020). The possible avoidance of unilateral dependencies is based here on two pillars – the capabilities to control and apply technologies and/or access to diversified suppliers/cooperation partners.

A key issue is how technology sovereignty can be recorded and measured, that is, how unilateral dependencies can be identified, so they can be prevented or removed (see Hofmann et al. 2023). This requires, (i) a continuously updated identification of the key technologies, (ii) definition of the corresponding performance on the basis of publication, patent and trade data, as well as (iii) supplementing with qualitative analyses in case studies, etc. Measurement is currently planned and considered in various ways by different initiatives and in the scientific literature (the European Sovereignty Index of the European Council on Foreign Relations [2022], for example, or for the partial aspect of raw material dependency, the Raw Materials Scoreboard of the European Commission [2021]). A consideration of technology sovereignty at individual country level would not always be beneficial (particularly in the EU), as it has less to do with individual country performance than it has to do with joint performance.

Patent and trade data was analysed for this report in a recent study by Hofmann et al. (2023). The EU-27 are primarily presented here as a whole (that is, the values of the member countries are added up, instead of forming an average), to compare them with technology-intensive countries such as the USA, Japan, South Korea and China, whereby the USA serve as the central benchmark. On the whole, European technology sovereignty looks relatively good, that is, it is practically on a par with the USA, is clearly above South Korea and China, but behind Japan. European sovereignty (apart from export specialisation in the area of production and digital technologies) in the trade area is significantly stronger than in the patent

Sovereignty

area (with the exception of material technologies). The entire area of digital technologies, not so surprising in view of the dominance of US American IT companies or Asian production capacities, presents a European weakness, which will be addressed accordingly by legislation and initiatives such as the Digital Markets Act or the European Chips Act.

At technology field level the EU shows its greatest strengths with photonics (2nd), advanced materials (2nd), nanotechnology (2nd), biotechnology (2nd), IT for mobility (1st), Internet of Things (1st) and cybersecurity (2nd). The EU has the lowest shares with artificial intelligence, big data and micro-/nanoelectronics. The same indicator calculated with triadic patents (in terms of potentially commercial, especially important inventions) shows Japan's and the USA's significant dominance, where they are by far first and second in every field (whereby the dominance of multinational companies in these countries has a clear effect on the results). China for the most part scored poorer with these prospects than the EU, apart from the cybersecurity area. If the same indicator is value-scaled with the aid of the population value, it naturally produces a different result, in which small countries such as Austria also achieve comparable values – the position of Japan, Switzerland and South Korea is even stronger; the innovation leaders, Germany, but also Austria and the USA, are generally ahead of the EU-27.

The foreign trade indicators show economically realised flows of goods and services and can provide an answer to the question of how dependent a region is on corresponding imports. The share of non-EU countries of the imports in the EU fluctuates depending on the technology between 40% (material technologies) and 60% (IT for mobility), mostly in harmony with the identified strength and weakness areas of the EU. In 8 out of 12 key technologies China is the EU-27's biggest supplier. The analysis of the export focus points based on the share of the key technology exports in the total trade shows the already familiar situation of specialisation and high sovereignty of the EU in the area of advanced production and material technologies, as well as biotechnology, while in the area of digitalisation there are significant deficits, that is, there are dependencies. China, however, is almost the most specialised country in these technologies, while Japan and South Korea are heavily specialised in the production and material technologies. Austria is very strong with advanced materials and is 2nd after Japan.

On the whole, the EU is a bigger, technologically more advanced economic area, which with many key technologies achieves high sovereignty with significant shares in knowledge production. However it also shows clear deficits and high catchup potential compared with countries such as Japan, South Korea or Switzerland. The EU is also clearly behind in some key technologies, such as digital technologies for example (artificial intelligence, big data, micro-/nanoelectronics). The strengths are in advanced production and material technologies, but also partially in biotechnology. China shows the strongest growth trends in invention performance, for example, and is already more specialised than the EU in many key technologies. Relative to the population size, China is still at the bottom end of the

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international comparison regions, however the catchup trends could move clearly forward and China could soon exhibit far greater dominance than it currently does. China is also extremely successful in exporting numerous key technologies. This is based not only on knowledge advantages, but rather also on cost and production advantages – China is currently focussed on sharply increasing its knowledge components. Austria shows own specialisation patterns, which have a positive impact in terms of technology sovereignty, however does not exhibit an overall situation that deviates in any notable way from the EU, that is, the strategy and activities at European level in almost every case are directly relevant for Austria.

The development and implementation of extensive initiatives, in which, for example, the set-up or relocation of production systems is just one element, will be key for Austria and Europe. Trade law issues, bilateral agreements and investments in non-EU states must be planned and swiftly implemented.

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Recommendations for action

C.1 Digitalisation

⟶ The expansion of the digital infrastructure is an essential area for future-oriented investments. This on one hand affects communication networks (fibre optic expansion) and their capacities, but on the other hand also applies to the data they transport. The public sector should swiftly unleash the role model effect here and with regard to register data should accelerate facilitation in the Austrian Micro Data Center.

⟶ Investments in human resources are another essential area. Austria on one hand requires more ICT specialists, whereby much can already be gained here if the percentage of women approximates the male figures, both with students and with graduates. On the other hand the ICT basic skills must also be increased. This is to some degree stipulated with the new curricula, as mentioned in chapter A.2, for students now entering school, however firstly teachers must be motivated to train further and secondly this still does not reach the adult population. Similar to the recommendations for action for subsystem A, further training and lifelong learning must be specifically promoted, especially in the rapidly developing digitalisation topics.

C.2 Climate and environment

⟶ The economic efficiency of decarbonisation measures depends on the costs for energy and framework conditions (regulation and taxes, CO_2 pricing, for example). The lower the costs for CO_2-free electricity, biogas and CO_2-free hydrogen, the better the economic efficiency of the measures (see Diendorfer 2021:50). The OECD (OECD et al. 2015) identifies four policy pillars for a greenhouse gas-neutral future, whereby the combination of various instruments from all pillars in particular exhibits the greatest effectiveness: (i) Price signals for CO_2, such as EU-ETS and other trading systems, for example, CO_2 taxes (direct & indirect), Carbon Border Adjustments or Carbon Contracts for Future (see C. Green finance). A critical variable of these instruments is their influence on competitiveness. (ii) Regulatory measures, such as obligations to register, technology standards or bans, for example. Along with acceptance, this also requires the corresponding commitments to be able to also guarantee long-term planning. (iii) RTI policies for new (green) technologies, such as innovation-oriented public procurement, green certificates, subsidies (feed-in tariffs, for instance) or regulatory experimental spaces, for example. (iv) Creating awareness, with appropriate (interdisciplinary) training and further training programmes, labelling within the scope of lifecycle analyses, for example, among other activities. The latter also requires suitable monitoring and parameters, which enable measurement of the effectiveness of the measures implemented.

⟶ A stronger circular economy is ensured with multiple levers to reduce energy consumption and lower CO_2 emissions (see C.3 Circular economy). Recycling – especially the recycling of critical raw materials and metals, which play an essential role in the energy transformation – is often extolled as a panacea to cover raw material requirements. The amount of secondary raw materials from the recycling of, for example, future waste, will however not play an essential role in covering raw material requirements for some time to come. Products such as PV modules or lithium ion batteries have long since been lingering in anthropogenic existence and can therefore

only be used with a corresponding delay, so this must also be considered.

C.3 Circular economy

Based on the findings of the University of Leoben study commissioned by the Austrian Council (Kienberger/Pomberger 2022:77ff) and the round of discussions of the workshop organised by the Austrian Council on 4 November 2022 on the topic of "Releasing transformative potential", the following priorities and specific measures for the Austrian RTI Strategy are recommended:

⟶ Requirements that hinder the use of secondary raw materials or give them a "secondary", lesser status, should be removed, by, for example, eliminating limit values that are not practice-relevant (total contents of heavy metals in mineral products, which are firmly integrated into a mineral phase, for instance). It must be possible to evaluate secondary raw materials according to the same (logical) quality criteria as primary raw materials.

⟶ The Waste Management Act firstly targets the exclusion of pollutants and secondly the best possible use of resources. These two goals contradict one another, as with a best possible depollution, resources are also wasted. A good balance between these goals must be found. High grade raw materials from waste should in particular be appropriately allocated as such (secondary raw material or R-raw material) and favoured in waste legislation (as product instead of waste, for example). This promotes the formation of industry-related recycling loops directly between individual sectors outside of waste management.

⟶ Specifications to use a minimum amount of secondary raw materials in products and to ensure the (real) recycling capability of products at the end of their service life form a commitment to circular economy thinking. The availability of secondary raw materials must however be considered with the stipulation of such rates.

⟶ The Austrian standards landscape should be carefully examined for its conformity and the differences with the standards for the circular economy and requirements for changes must be illustrated. The building materials area is an example for the need to adapt corresponding technical standards. Maximum amounts of clinker-substitute key components are specified here for different types of cement, for example. A more specific standardisation method would be a restriction on the required material properties, such as strength, flowability, hardening time, etc., to promote the best possible clinker substitution.

⟶ Further recommendations include increasing the disused hazardous site levy as a device to deter landfilling and encourage material recycling, or training and further training in the circular economy field of topics as an essential factor for the future, with interdisciplinary anchoring of the topic in the primary education area already, for example. Sufficient financial resources must be provided to finance pilot plants and the transfer of technologies on an industrial scale An essential requirement for such projects to succeed is the interaction of industry and scientific partners, such as research institutions and universities. Along with research funding, private risk capital should also be acquired more intensively via the financial markets to implement projects on an industrial scale (see C. Green finance).

C.4 Location attractiveness

⟶ Location attractiveness will become more important in the future – also with regard to the effects of the US American IRA. Generally speaking, in small countries, such as Austria, the risk of companies emigrating is greater, companies are more mobile and direct investments respond more flexibly to the tax and levies burden and other costs (see Keuschnigg 2016). Small countries must therefore compensate for the disadvantage of the restricted market size with other location factors. Austria's successful efforts over the past 20 years with regard to its location attractiveness for RTI-intensive companies must nevertheless be emphasised at this point. This was in particular possible with the massive increase in research funding. These location factors must now be further expanded with specific prioritisation, with regard to RTI-intensive companies, for example.

⟶ In transformative technologies in particular, companies and industries will focus more on the countries in which the best conditions are offered, because the transformation will not be possible at the required speed without private investors. Location attractiveness in the future therefore also means the provision of an innovative environment with the corresponding framework conditions. These include, among others, the funding of transformative (key) technologies, investments in education, human resources and the specific alignment of the RTI funding and taxation system.

C.5 Gender equality

⟶ Binding measures and a comprehensive implementation in terms of a national closing of the ranks of all relevant social stakeholders are required so that equal opportunity is no longer merely seen as a cross-cutting issue, and is actually implemented instead. The combination of private sector commitments with a cross-policy area binding implementation strategy of state stakeholders and education and research organisations will have to be implemented with such an initiative.

⟶ Austria requires real gender mainstreaming, including a rollout of appropriate funding criteria for all research and innovation funding. Based on the successful methods of the Swedish innovation agency, Vinnova, an obligation to meet a quota for women in the project management of funded projects could be expedient here (see Ivarsson 2021).

C.6 Technology sovereignty

⟶ Technological sovereignty is explicitly addressed in the RTI Package 2024-2026 (BKA 2022) – the development of an own strategy, which bundles all methods, could further contribute to coordinating the activities in this respect, both in Austria and Europe-wide.

⟶ To reduce or prevent unilateral dependencies of politically "sensitive" countries, the EU must significantly improve the framework conditions for the commercialisation of scientific progress, in particular the low risk capital intensity, by creating a common single European capital market, for example. For Austria the appropriate and long-since known measures must at last be implemented, that is, in particular the setting up of an umbrella fund (similar to the Danish Export and Investment Fund), to attract and activate investments from the institutional sector (pension funds or foundations, for example) and the long-since planned new corporate form for start-ups. Both are directly relevant for Austria's sovereignty and the Austrian contribution to European technology sovereignty.

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.

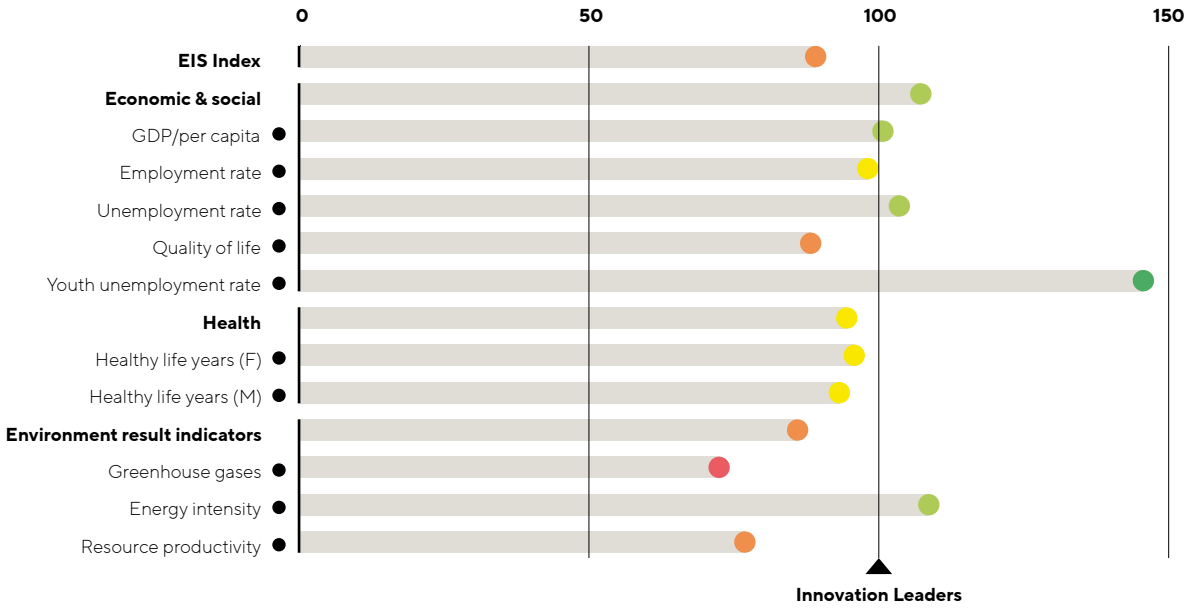

Figure 18: Austria's strengths and weaknesses in the D.1 area: Effectiveness compared with the innovation leaders
○ Input ● Output

Goals of the RTI Strategy 2030:

1.1.1 European Innovation Scoreboard Index (EIS)
1.1.3 Global Innovation Index (GII)

Goals of the Circular Economy Strategy:

K.2 Increasing domestic resource productivity by 50% by 2030

Data at:
fti-monitor.rfte.at/B/D.1

Effectiveness

Composite indicator

downward trend

In the effectiveness area, in which the performances of key impact indicators are measured and compared in the three dimensions, economic & social, health and environment, the "Economic & social" composite indicator performed slightly poorer compared with the previous year, however compared with the innovation leaders remains higher and is therefore one of Austria's major strengths. The development with the health, and environment in particular, area indicators is more negative.

The per capita gross domestic product[132] (GDP – measured in uniform purchasing power standards) in the long-term time series comparison (2000-2019) is just above that of the innovation leaders and since 2020 has been almost on a par (in absolute values for 2021: AT 54,121, IL 53,017). Austria therefore ranks in the top third of the comparison countries – this position is relatively stable over the period (see Peneder et al. 2022: 812). The top 3 countries showed strong growth from 2014 and this year (top 3: IL, CH, NO) have an absolute value of 79,730). The employment rate[133] is on a par and with 72.4% (amount of employable people in the population in %) is just above the EU average value (69.9%). Compared with the other indicators for economic & social the employment rate[134] is less consistent. The value in Austria has been increasing since 2019 and is at 6.2% (20019: 4.5%) and therefore still only just below the EU average and that of the innovation leaders (see Peneder et al. 2022:814). The broadly defined "quality of life"[135] was measured once in 2020 and is composed of several indicators. With this single measurement, Austria is above the EU average, however below the innovation leaders and the top 3 (NO, NL, DK, whereby NL and DK have also been among the innovation leaders for some years now). The last indicator in the economic & social area is the (inverted) youth unemployment rate[136]. With 29.6%, Spain has the highest youth unemployment rate in the European Union (EU-27). On average, approximately 14.4% young people willing to work were unemployed in the European Union (as of January 2023). Germany has the lowest youth unemployment rate in the EU with approximately 5.7%, while the Czech Republic is at 7.1% (see Statista 2023). In the international comparison, the youth unemployment rate in Austria is lower than that of the innovation leaders and the EU average, however higher than the top 3. The rate fell from 2016 to 2019, but has since increased slightly again – the current value is 11 (measured

132 RTI Monitor, "GDP/per capita" indicator (World Bank).
133 RTI Monitor, "Employment rate" indicator (Eurostat [ifsi_emp_a]).
134 RTI Monitor, "Unemployment rate" indicator (Eurostat [ifsa_urgan]).
135 RTI Monitor, "Quality of life" indicator (OECD Better Life Index).
136 RTI Monitor, "Youth unemployment rate" (Eurostat [une_rt_a]).

as the amount of unemployed people among the employable population between 15 and 24 years old). The Netherlands improve the ranking of the innovation leaders in this area, as also shown in the comparison of the two time series.

The "Health"[137] composite indicator compared with the previous year is more or less at the same level, however is significantly below the innovation leaders. The "Healthy life years (F)" indicator has been running, as also with the innovation leaders, the top 3 and the EU average, relatively consistent since the first measurement in 2005. With a value of 71 (measured in % of the life years), Austria is just below the level of the innovation leaders, the EU average and the top 3, and therefore indicates high need for action for the RTI policy (see EU Mission Cancer). The trend has been falling since 2012 (value: 73.7), with a slight increase in 2020. The "Healthy life years (M)" indicator shows a similar picture.

The European Innovation Scoreboard (EIS) offers a comparison analysis of the innovation performance in the EU countries, in other European countries and in specific regions. The EIS indicator used here is composed of a total of 27 unweighted individual indicators, which affect several innovation-relevant areas (human resources, research spending, patents, structural change, for example) and identify the relative strengths and weaknesses of the national innovation system. The level in this area at 89 percent is the same as the previous year.

The "Environment" composite indicator scores poorer than in the previous year (for this see C.2 Climate and environment). Resource productivity[138] is above the EU average, but below the level of the innovation leaders (because of the Netherlands). A slight upward trend can be seen here for Austria, following a fall in 2020. In the comparison, since 2015 the top 3 exhibit a continuous upward trend and this year achieve a value of approximately 6.1 (measured as GDP per ton of material use), compared with 2.1 for Austria. The energy intensity (measured as energy consumption, which is accompanied by the annual production performance of the Austrian economy) runs relatively consistently over the observation period (2000-2021), and with an average of approximately 4.7 over the total period, is below the level of the innovation leaders and that of the EU average (latter trend falling). The value of the top 3 has also been falling continuously since 2009 and most recently was as 2.3. The indicator for measuring greenhouse gases[139] since the beginning of the time series (2000) and this year once again is above that of the innovation leaders, the EU average and far above that of the top 3, however with a slight downward trend (previous year: 104.2, this year: 94.1 – for this see also C.2 and C.3).

137 RTI Monitor, "Health" composite indicator (Eurostat [hlth_hlye]).
138 RTI Monitor, "Resource productivity" indicator (Eurostat [sdg_12_20]).
139 RTI Monitor, "Greenhouse gases" indicator (Eurostat [sdg_13_10]).

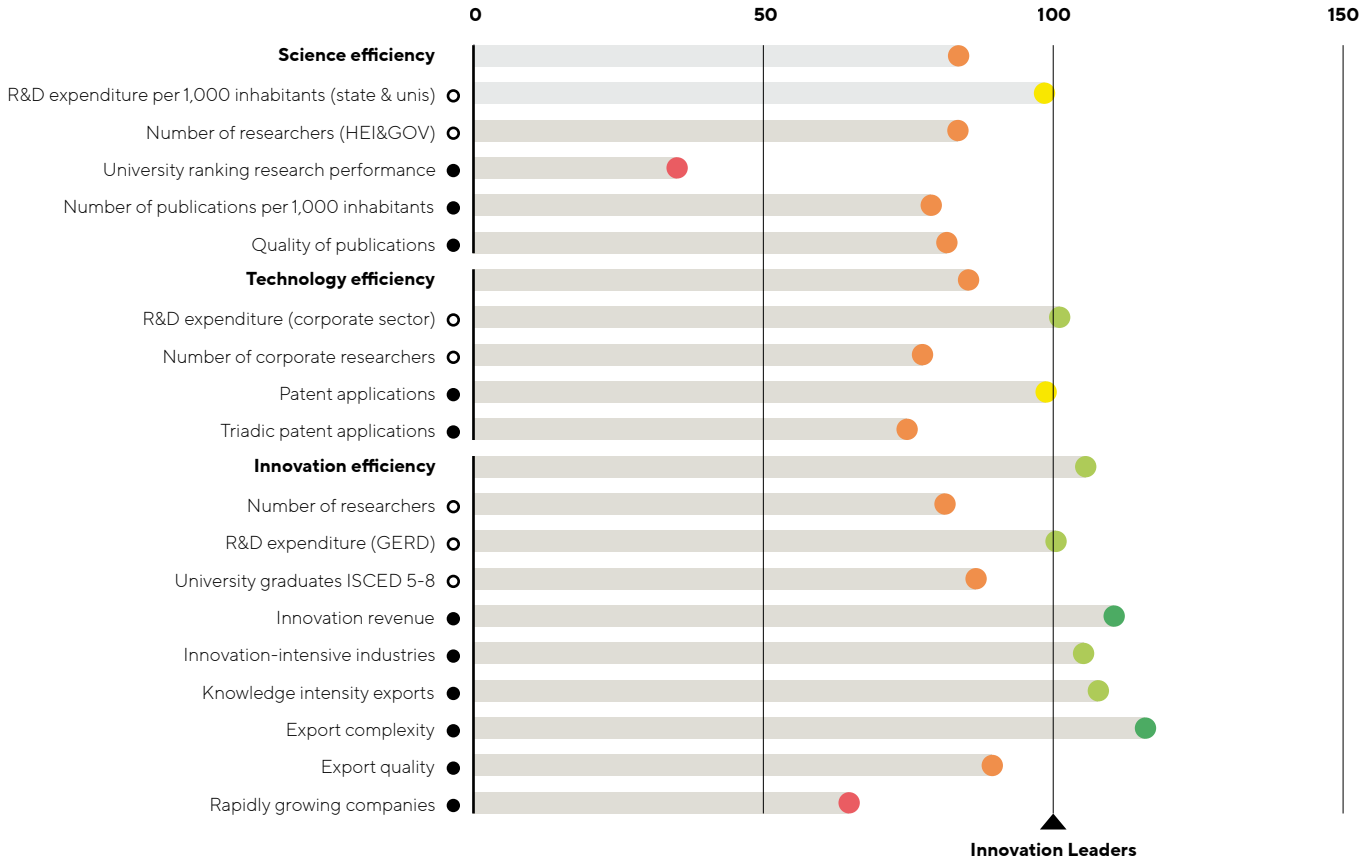

Figure 18: Austria's strengths and weaknesses in the D.1 area: Effectiveness compared with the innovation leaders

○ Input ● Output

Data at:
fti-monitor.rfte.at/B/D.2

Efficiency

Composite indicator

downward trend

With the efficiency analysis[140], input indicators (R&D expenditure, number of researchers, among others) are correlated with output indicators in the three performance dimensions, science (publications), technology (patents) and innovation (high-tech sectors, innovation revenue, export quality and complexity). Austria saw a decrease in all three dimensions, and in "science efficiency" and "innovation efficiency" in particular, whereas the top 3 countries show a strong upward trend in each of these dimensions.

On the whole, the efficiency of knowledge production in the core areas of science and technology compared with the innovation leaders is considerably improvable. One option is to increase the outputs (publications, patents) instead of reducing the inputs, as this would have negative effects for the location. By way of example, an increase could be triggered by leveraging the allocation of funds in competitive basic research funding, for example (see B.2 Academic research).

In the "science efficiency" dimension, R&D expenditure in particular fell compared with the previous year (state sector and universities)[141]. The international positioning of Austrian universities with regard to their research performance[142] also fell slightly compared to the previous year. Austria continues to lag here far below the top 3 and the innovation leaders and slightly below the EU average (see section B.2 Academic research). Nor has Austria managed since 2009 (consistently) to rise to the group of innovation leaders. With the number of researchers[143] and the quality of publications[144], Austria remains largely unchanged and nevertheless significantly below the level of the innovation leaders. The increase in the number of publications[145] by contrast is very welcome, although Austria shows the same upward trend as all other countries.

Several factors must be considered for the negative development in the area of innovation efficiency. Employment in gazelles[146] is falling, while the top

140 For a more precise discussion of the methods of the DEA efficiency analysis used here, see Janger/Kügler 2020.
141 RTI Monitor, "R&D expenditure per 1,000 inhabitants" indicator (state & unis, OECD MSTI).
142 RTI Monitor, "University ranking research performance" indicator (CWTS Leiden Ranking).
143 RTI Monitor, "Number of researchers" indicator (HEI&GOV, OECD MSTI).
144 RTI Monitor, "Quality of publications" indicator (EIS).
145 RTI Monitor, "Number of publications per 1,000 inhabitants" indicator (Scimago, World Bank).
146 RTI Monitor, "Rapidly growing start-ups" indicator (Eurostat [bd_9pm_r2]).

3 recently showed an upward trend. The "Innovation revenue"[147] indicator reflects innovation performances, which are new for both businesses and for the market. In the time comparison (2018-2020) Austria exhibits a development above the EU average and the innovation leaders, however with a slight downward trend since 2019. Third level graduates[148] (including the higher vocational schools sector[149]) are more or less on a par with the level of the EU average. Due to the slight upward trend (last value 42.4 measured as the amount of 25 to 34 year-old third level graduates in % of the age cohort), Austria can reduce the distance to the innovation countries somewhat.

In the area of innovation efficiency, the "Number of researchers", "Innovation-intensive industries", "Knowledge intensity", "Export complexity" and "Export quality" indicators must be rated as positive, whereby the latter saw a decrease this year. With the "Innovation-intensive industries"[150] indicator, Austria is more or less on the same level as the innovation leaders and the EU average with approximately 0.3% (measured as share of innovation-intensive sectors in a country's total value creation). In the 2019 to 2020 period, only the top 3 saw a sharp increase and currently have a value of 0.7%. The "Knowledge intensity exports"[151] indicator has remained relatively constant since 2000. This year's indicator value of 56.3% (measured as the share of the highest price segment in exports of a product category) is above that of the innovation leaders and the EU average. With a value of 73.9%, this year the top 3 countries saw a slight fall compared with the previous year. Noteworthy in this context is the consistently good performance of the export complexity[152] (allocation of product lines to countries, whereby diversification profiles become visible): Austria achieves good export performance here with complex products – so those that excel with high knowledge content.[153]

The number of patent applications per 1,000 inhabitants[154] in Austria in 2019 was on a par with the innovation leaders. However, in the international comparison a slight downward trend is seen here, as it is with the top 3. In the case of the triadic patents,[155] especially relevant for commercial use, Austria still has not joined the innovation leaders group. However, the latest data does not (yet) map possible effects of the pandemic.

147 RTI Monitor, "Innovation revenue" indicator (Eurostat CIS).
148 RTI Monitor, "Higher education graduates ISCED 5–8" indicator (OECD Education at a Glance & Eurostat [edat_ifse_03]).
149 With the adjustment in the ISCED classification, the two last higher vocational school age groups are now included in the tertiary sector.
150 RTI Monitor, "Innovation-intensive industries" indicator (OECD, Eurostat).
151 RTI Monitor, "Knowledge intensity exports" indicator (Eurostat Comext, UN COMTRADE).
152 RTI Monitor, "Export complexity" indicator (BACI).
153 For this see also section C, "Transformation opportunities for Austria in the Tech4Green area".
154 RTI Monitor, "Patent applications at the EPO according to the inventor's place of residence" indicator.
155 RTI Monitor, "Triadic patent applications" indicator (PATSTAT, World Bank).

V

Outlook

Outlook

The climate crisis requires large-scale, macrosocial and radical transformative activities, and the capacity building and expansion necessary for this is enormous. Recent geopolitical developments also make it both more complex and more urgent to combat this crisis. China, for example, politically has therefore been able to unilaterally instrumentalise its dominance in the production of environmental technologies, batteries or solar panels, and as a result inhibit Europe in its efforts to achieve climate neutrality. Not least of all the topics of sovereignty in technology and energy, but also in the production of and access to (secondary) raw materials, therefore increasingly become more urgent. The question as to which stakeholders, regions or countries Austria and the EU want to or must cooperate with in the RTI area in the future and how such collaborations will have to be arranged to reduce unilateral dependencies and to produce a *level playing field* is of key importance here, especially in those areas in which the creation of own competencies is not efficiently possible or is not feasible (see BKA (2022b:5). The science diplomacy and research security topical areas will gain importance accordingly.

Europe's most logical answer to the current challenges is to strengthen the European single market as a location for green investments, and that with horizontal measures in key areas, as well as with specific measures that promote clean technologies. Such measures include better regulation, green/innovation-promoting public procurement and EU-wide funding support for early phase development (see Kleimann et al. 2023:19). Sight must not be lost here of the respective strategic interests – securing the location quality, prosperity and competitiveness of the European federation of states (see Felbermayr 2023:4).

With regard to pan-European topics, Austria's area of action is by its very nature restricted. The already mentioned location attractiveness factor will, however, also become more important in the future. Factors and measures that have an influence on location attractiveness and which therefore must in particular focus on the Austrian RTI policy, include, among others, the promotion of transformative (key) technologies, the provision of an appropriate environment with framework conditions aligned with it, investments in education successes and educational equity, human resources, research excellence, the regions' innovation and research capacities, public sector R&D incentives, as well as the removal of environmentally harmful funding connected with a systemic alignment of the RTI funding and taxation system (for this see the recommendations for action for the individual areas in this report).

To ensure the massive transformative efforts actually succeed, ultimately it will be necessary to integrate society better than it has been to date, to increase its trust in science, research and technologies and to create the conditions required for increased participation. When there is broad understanding of science and its methods among the general public, de-

cision makers, politicians and other stakeholders can better communicate complex correlations, especially those that affect the climate crisis, and therefore increase trust in and acceptance of the respective measures. This also allows society in general to participate in the discussion and decision-making for such measures, as well as for technologies and innovations. The strengthening of science in the public perception and its embedding in social discourse are at any rate a key lever to answer pressing economic, labour market and democratic policy questions and to develop macrosocial solutions for a climate-neutral future. Part of every transformation strategy, be it green or digital, must therefore also be science communication, as applied in the BMBWF "TruSD: 10-point programme for increasing trust in science and democracy in Austria" strategy developed in 2022 (see BMBWF 2022c).

In times of transition, which require action in a new, dynamically developing framework and the rethinking of structures and processes, an evidence-based and therefore data-supported RTI policy is essential. Measures that are based on empirical data and are not driven by interests, can be used specifically and effectively and increase the probability that their intended effect will be achieved. This report is also committed to following this very logic. With the accompanying web-based RTI monitor in its new 2.0 version, the Austrian Council provides a tool which, along with the continuous monitoring of input and output indicators in various RTI areas, also makes the achievement and achievability of the goals of the RTI Strategy 2030 evaluable on the basis of more comprehensive time series analyses. This interconnected systemic view of the RTI system and its development over time will optimally support the further development and dynamism of a cross-department holistic RTI portfolio management in the future.

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