**Evaluation of the knowledge society in the Danube region (2010-2020)**

June 2022 Version 1.0

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# **Acronyms**

|  |  |
| --- | --- |
| Acronyms – Danube region countries and regions | AT – Austria; BA – Bosnia and Herzegovina; BG – Bulgaria; CZ – Czechia; DE – Germany; HR – Croatia; HU – Hungary; MD – Moldova; ME – Montenegro; RO – Romania; RS – Serbia; SI – Slovenia; SK – Slovakia; UA – Ukraine; BAV – Bavaria; BW - Baden-Württemberg |
| Acronyms – other countries | BE – Belgium; CY – Cyprus; DK – Denmark; EE – Estonia; EL – Greece; ES – Spain; FI – Finland; FR – France; CH – Switzerland; IE – Ireland; IL – Israel; IS – Iceland; IT - Italy; LT – Latvia; LU – Luxembourg; LV – Lithuania; MT – Malta, NL – Netherland; NO – Norway; PL – Poland; PT – Portugal; SE – Sweden; TR – Turkey; UK – United Kingdom |
| ERC | European Research Concil |
| MSCA | Marie Skłodowska-Curie Actions |
| SME | Small and medium-sized enterprise |

# **Introduction**

The *Analysis of the Evaluation of the Knowledge Society Development in the Danube Region for the period 2010 - 2021* has been commissioned by the Ministry of Education, Science, Research and Sport of the Slovak Republic and contracted to the Slovak Centre of Scientific and Technical Information. This document is a continuation of the analysis that covered the development of the knowledge society in the Danube region between 2010-2018.

The aim of the study is to assess the current state and progress in knowledge society in the Danube Strategy countries, as well as to make recommendations for improving the situation in the region. The analysis focuses on Priority Area 7 - Knowledge Society (Research, Education, and ICT), which is jointly coordinated by Slovakia and Serbia.

The study contains four parts:

The chapter *Analytical evaluation of the knowledge society* is the basis of the whole evaluation focuses on the quantitative and qualitative description and evaluation of the current state and progress that has occurred in the analysed period. It is divided into four parts that reflect the innovation process - inputs, activities, outputs, and short and long-term effects.

In the chapter *Fulfilment of Objectives from 2016* we will focus on the evaluation of the set objectives as well as their fulfilment.

The chapter *Evaluation of the Best Practice to Date* *and* a *SWOT Analysis of PA7* contains summaries of what has been done in the region so far and especially the evaluation of strengths, weaknesses, opportunities, and threats.

The last chapter, *Recommendation to improve the current state* contains a proposal for measures that could strengthen the cooperation between countries in the region under PA7 in the next programme period.

# **Methodology**

The analysis focuses primarily on the comparison of the knowledge society (especially research and innovation) in the Danube region since 2010. For some indicators and comparisons where data for 2010 are not available, we used data for 2014.

The comparison was based primarily on data available in the databases of Eurostat, OECD, UNESCO, European Patent Office, WIPO, E-corda, and the Web of Science Core Collection. In the evaluation, we combined quantitative and qualitative methods, focusing primarily on the countries of the Danube region. In some cases, if a better comparison required it, we also used comparisons with other European countries. The analysis is partly influenced by the availability of data for individual countries and regions. First, data for non-EU countries are more difficult to access or are not available. This concerns mainly comparisons in the European Innovation Scoreboard.

The Member States of the Danube Strategy can be divided into four groups:

* **Member states** (Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia);
* **Accession countries** (Bosnia and Herzegovina, Montenegro and Serbia);
* **Neighbouring countries** (Moldova and Ukraine);
* **Regions** (Bavaria and Baden-Württemberg).

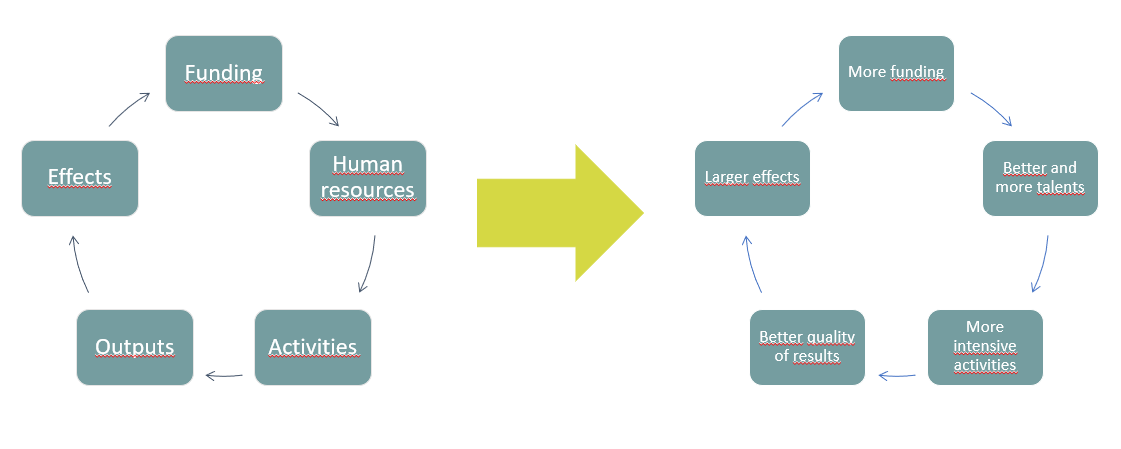
The analysis focuses on measuring the progress of individual countries. However, based on the data availability, at certain points Bavaria and Baden-Württemberg were also included in the comparison. The Danube Region constitutes a mixture of countries that are at various stages of development in research and innovation. Each country gives research and innovation a different importance – this is reflected primarily in the amount of investment. These notable differences between countries also have a certain effect on the analysis, as countries are difficult to compare even in qualitative evaluation.

# **Analytical assessment of the knowledge society in the Danube region**

We have divided the progress in the development of the knowledge society into five elements, which are connected to each other and should form an innovation chain. We focused primarily on the changes that occurred in comparison with 2010, or with 2014, if the data for 2010 was not available. We divided the evaluation of the innovation process into five elements:

* Investments in research and innovation
* Investments in talent and human resources
* Activities (cooperation between various stakeholders, mobility);
* Outputs of research and innovation (publications, citations and patents);
* Short-term and long-term effects (more innovation, higher productivity, export).

**Scheme 1 Five main elements**



The European Commission has been publishing a comprehensive assessment of countries’ innovation performance. It uses a composite indicator, which consists of 32 indicators. These indicators cover the entire innovation chain. It is an effort to provide feedback to the countries and compare them with others. The indicators cover various areas from education, through research, innovation to market activities. The compilers then divide the countries into four categories:

* Innovation Leaders
* Strong Innovators
* Moderate Innovators
* Emerging Innovators.

The EIS also covers all countries of the Danube region except for Moldova. Of the countries that are part of the Danube region, Germany and Austria have the highest innovation index. Slovenia and the Czech Republic follow at a greater distance. On the contrary, the lowest innovation index was recorded in Ukraine, Romania and Bosnia and Herzegovina. Most of the states of the Danube region can thus be classified as Moderate and Emerging Innovators.

**Graph 1 European Innovation Scoreboard - Summary Innovation Index**

*Source: European Innovation Scoreboard 2021*

A similar dispersion of countries can be observed if we focus on the innovation performance of regions. This performance is compared by the Regional Innovation Scoreboard. However, it only compares EU Member States and Serbia is the only non-EU country from the Danube region which is included this scoreboard. The regions are ranked according to innovation performance compared to the EU average. German regions have the highest performance of the regions compared, namely: Oberbayern, Karlsruhe and Tübingen. Of the new Member states, Only Prague as a representative of the new Member states has a higher innovation performance than the EU average, while only one German region has a lower innovation rate: Niederbayern. Sud-Vest Oltenia, Sud-Est and Sud-Muntenia regions in Romania have the lowest innovation performance.

We compared a total of 58 regions of the Danube region, of which only 14 are above the EU average - all others are below average. As many as 15 regions do not even reach 50% of the EU average.

**Graph 2 Regional Innovation Scoreboard - Innovation Index**

*Source: Regional Innovation Scoreboard 2021*

## **Investments to research and innovation**

In thirteen out of the 16 countries and regions surveyed, R&D expenditures in relation to GDP increased over the analysed period, and we observed a decrease in three countries. Compared to 2014, 12 states increased their investments. We can thus observe that investment in research and innovation in most countries of the Danube region is gradually increasing or at least not decreasing. The highest increases were recorded in Baden-Württemberg (0.86% compared to 2010) and Croatia (0.49%). On the other hand, we can see a decline in Ukraine, Moldova and Bosnia and Herzegovina.

The two German regions have the highest investment in research and innovation - Baden-Württemberg (5.76% of GDP) and Bavaria (3.42% of GDP), followed by Germany and Austria. On the contrary, the lowest investments were recorded in the Ukraine, Moldova and Bosnia and Herzegovina. The comparison shows that EU Member States invest more in research and innovation than non-Member countries.

**Graph 3 R&D investments (%GDP)**

*Data: Eurostat [rd\_e\_gerdtot],[rd\_e\_gerdreg]; UNESCO*

*Note: ME (2011,2018); BA (2012,2019); UA (2018); MD (2018); BAV and BW (2011,2015,2019)*

There is an especially significant difference in the total volume of investments - without converting investments to the amount of GDP. The size of the country, its population, as well as its economic performance play a significant role in this aspect. Therefore, it is not surprising that Germany (€ 105 billion), two German states - Baden-Württemberg (€ 30.26 billion) and Bavaria (€ 21.68 billion) and Austria (€ 12.14 billion) invest the most in research and innovation among the countries of the Danube Strategy. Czech Republic and Hungary rank next, but a considerable distance away from the first four regions and countries. Other countries invest less than one billion € per year with Bosnia and Herzegovina, Moldova, and Montenegro even less than 40 mil. € per year. In comparison with the absolute investments in R&D, we can observe that two countries recorded a decrease compared to 2010 and 2014, namely Ukraine and Bosnia and Herzegovina. While in Ukraine it is a significant decrease of more than 135 mil. € (2010) and. 330 mil. € (2014), in Bosnia and Herzegovina it is a decrease in the range of 0.8-2 mil. €.

**Graph 4 R&D investments (mil. €)**

*Data: Eurostat [rd\_e\_gerdtot],[rd\_e\_gerdreg]; UNESCO*

*Note: ME (2011,2018); BA (2012,2019); UA (2018); MD (2018); BAV and BW (2011,2015,2019)*

The volume of funding that goes to research and innovation from private sources indicates the ability to use the results of research and development in practice. At the same time, the volume points to the competitiveness capabilities of each country. The long-term goal of the EU in R&D financing is that 2/3 of all R&D investment will be funded by private sources. However, all EU Member States have not met this target for a long time. Germany (2.04% of GDP), Austria (1.61%) and Slovenia (1.26% of GDP) have the highest share of private investment in R&D among the Danube region countries. By contrast, in Serbia (0.02% of GDP), Moldova (0.04%) and Bosnia and Herzegovina (0.07%) the private sector has the lowest investment rates.

**Graph 5 R&D investments in the business sector**

*Data: Eurostat [RD\_E\_GERDFUND], UNESCO*

*Note: missing data for BAV a BW and MD (2010, 2014); BG, CZ, DE, HU, RO, SI, SK, BA (2019); ME (2011, 2018); BA (2012, 2019)*

## **Investments in talent and human resources**

Moldova has the highest share of bachelor's and master's degree graduates (49.33%), ahead of Bulgaria (49.24%) and Germany (48.31%). On the other hand, Bosnia and Herzegovina (28.56%) and Slovakia (32.32%) have the smallest share. The data shows that Seven Member States have this share of more than 40%.

**Graph 6 Gross graduation ratio from first degree programmes (ISCED 6 and 7) in tertiary education, both sexes (%)**

*Data: UNESCO*

*Note: Missing data for BAV, BW and UA; AT, MD, (2010); BA, ME (2010,2014); RS (2014 a 2019); DE (2015); BA a MD (2020).*

Slovenia (45.4%), Austria (41.4%) and Montenegro (40.4%) have the highest share of university graduates. By contrast, the lowest shares are in Romania, Hungary, and Serbia. We observed the highest increase in tertiary education graduates compared to 2010 in Austria (20.7%).

**Graph 7 Graduation ratio in tertiary education, 25-34 years (%)**

*Data: Eurostat [EDAT\_LFS\_9903\_\_custom\_2357423]*

Completion of doctoral studies is a basic prerequisite for a scientific career. However, to observe development in this area does not mean to only look at the total number of PhD holders, but also at the quality of their education. Germany (1.2%), Austria (0.9%) and the Czech Republic (0.8%) have the highest share of doctoral graduates among 25–34-year-olds. On the other hand, Romania (0.2%) and Hungary (0.3%) are at the bottom of the list. Serbia (0.2%) is the only country, which has recorded an increase in the share of graduates compared to 2014. On the contrary, we can observe a decrease in only five cases, with the two most significant examples being Slovenia and Slovakia.

**Graph 8 New doctorate graduates in STEM (25-34 years)**

*Data: Eurostat [EDUC\_UOE\_GRAD07]*

Austria (1.16%) has the highest share of researchers in total employment, ahead of Germany (1.07%) and Slovenia (1.01%). By contrast, Bosnia and Herzegovina (0.12%), Montenegro (0.17%) and Moldova (0.19%) have the lowest share of researchers in the country’s workforce. The 11 Member states of the Danube region recorded an increase in the share of researchers in total employment, while three countries saw a smaller decline. The highest increase can be observed in the case of Hungary (0.41), Austria and the Czech Republic (both at 0.28%).

**Graph 9 Share of researchers in the labour force (% FTE)**

*Data: Eurostat [RD\_P\_PERSLF ], UNESCO*

*Data: missing data for BAV and BW; ME (2011,2019); RS (2010); MD, UA (2018); BA (2012)*

One of the EC’s goals is that the share of female researchers should be at least 40% of the total number of researchers. Up to 8 countries from the Danube region have reached this number. Serbia has the highest share of women, followed by Moldova and Croatia. At the same time, Serbia is the only country that has more female than male researchers (51.36%). The lowest share of female researchers is in Germany (22.58%), the Czech Republic (23.16%) and Austria (23.66%). We observed a decrease in the share of female researchers compared to 2010 in 8 countries. The highest decrease was in Slovenia (3.7), and the highest increase in Bosnia and Herzegovina (13.6).

**Graph 10 Female researchers (%, FTE)**

*Data: UNESCO*

*Note: AT, DE (2011;2017); BA (2012); BG, HR, HU, RO, SI (2017); ME (2011; 2017); UA (2016)*

## **Activities (cooperation between stakeholders and mobility)**

In monitoring of activities, we focus primarily on cooperation between different stakeholders and on mobility. These data are available primarily on EU Member states and on Serbia.

The highest share of innovative companies among the countries of the Danube region is in Germany (67.8%) and Austria (62.6%). Slovenia (48.6%) and the Czech Republic (46.8%) place next in the ranking. At the other end of the list, the lowest share of innovative companies has been recorded in Romania (14.6%) and Hungary (28.7%).

**Graph 11 Innovative companies (%)**

*Data: Eurostat [INN\_CIS11\_BAS; INN\_CIS8\_TYPE]*

Austria (16.01%) and Germany (15.36%) have the highest share of small and medium-sized enterprises that cooperate with other companies. SMEs from Ukraine (1.7%), Romania (2.69%) and Bulgaria (4.24%) cooperate the least. Cyprus (43.13%), Estonia (27.63%) and Finland (27.57%), all EU-Member states dominate this list.

**Graph 12 Innovative SMEs collaborating with others (percentage of SMEs)**

*Source: EIS [3.2.1]*

The ability of start-ups to have access capital is key to their development. From this point of view, it is possible to measure the size of venture capital expenditures on the country level. At EU level, Cyprus dominates, where venture capital accounts for up to 0.43% of GDP. Germany has the highest investment (0.11%) of the Member countries of the Danube region, ahead of Hungary (0.10%) and Romania (0.10%). The lowest investments have been measured in Slovenia (0.01%), Serbia (0.01%) and Slovakia (0.02%).

**Graph 13 Venture capital expenditures (% of GDP)**

*Source: EIS [2.1.2]*

The ability of research institutions and companies to succeed in international competition reveals a substantial part about their quality. Horizon 2020 was the programme with the highest competition in history. The success rate has long been at 13.5%, so only the best and most prepared institutions from the EU, but also from all over the world, could succeed in it. From a quantitative point of view, the most successful country was Germany, which received more than 10 billion €. Within the Danube region Bavaria ranks second (€ 3 billion) and Austria (€ 1.96 billion) holds the third place. Montenegro (€ 4.58 million), Moldova (€ 7.35 million) and Bosnia and Herzegovina (€ 8.62 million) received the lowest EU contributions. The countries of the region are clearly divided between EU Member States and non-EU Member States. The only country that has managed to get closer to the EU Member states is Serbia (€ 132.19 million).

In terms of the number of participations in projects, Germany (20,921) is again the most successful country, ahead of Austria (5,141) and Bavaria (5,030).

**Graph 14 EU contribution and participation in Horizon 2020**

*Data: E-corda*

This comparison based on quantitative data did not consider the size of countries or the size of their research and innovation ecosystem. However, even with the recalculated EU contribution per capita, the old EU Member states dominate. The highest contribution per capita was achieved by Bavaria (€ 218.58), Austria (€ 218.06) and Slovenia (€ 182.55). Ukraine (€ 1.02), Moldova (€ 1.82) and Bosnia and Herzegovina (€ 2.63) are at the bottom of this list. In this comparison EU Member States again received higher contributions than non-EU countries. In terms of participation per million inhabitants Slovenia (719.58) is followed by Austria (570.84) and Bavaria (364.41).

**Graph 15 EU contribution and participation in Horizon 2020 per capita**

*Data: E-corda*

If we compare the participation in Horizon 2020 with the number of researchers, the most successful country is Austria (€ 37,912 per researcher) ahead of Slovenia (€ 37,011) and Bavaria (€ 33,854). Ukraine received just over € 1,000 per researcher, followed by Moldova (€ 2,984) and Bosnia and Herzegovina (€ 5,678). Austria (145) dominates Montenegro (140) and Austria (99) in terms of participation per thousand researchers. On the other hand, Ukraine has the lowest participation (7.79), followed by Baden-Württemberg (21.94) and Hungary (37).

**Graph 16 EU contribution and participation in Horizon 2020 per researcher (FTE)**

*Data: E-corda; Eurostat, UNESCO*

As we have already mentioned, the success rate in Horizon 2020 was significantly lower than in the 7th Framework Programme. On average, the rate reached only 13.58%. Germany had the highest success rate (16.95%), ahead of Austria (15.15%) and the Czech Republic (12.19%). Bosnia and Herzegovina (4.22%), Moldova (6.3%) and Montenegro (6.41%) have recorded the lowest success rates.

If we compare success in obtaining projects (participations), the most successful countries are Austria (17.34%), ahead of Germany (16.89%) and Montenegro (16.41%). Slovenia (11.93%), Bulgaria (12.69%) and Hungary (12.79%) had the lowest success rates.

This data shows, that while EU Member States have been significantly more successful in converting their financial requirements into real EU contributions, while the differences in applications from Member States and non-Member States are minimal. Some EU Member states have a lower success rate than non-Member countries. Non-Member countries thus participate in a smaller number of applications, which, however, have a higher chance of success.

**Graph 17 Success rate in Horizon 2020**

*Data: E-corda*

The most natural and common cooperation among the countries of the Danube region occurs between Austria and Germany (14,298). The countries from of the region most often cooperate with research institutions from Germany. Cooperation between non-EU countries is low, even if they are regionally close.

**Table 1 Cooperation between countries in the Danube region**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AT** | **DE** | **BG** | **CZ** | **HR** | **HU** | **RO** | **SI** | **SK** | **ME** | **RS** | **BA** | **MD** | **UA** |
| **AT** | 3 989 | 14 298 | 497 | 1 488 | 594 | 996 | 896 | 1 016 | 598 | 24 | 299 | 52 | 28 | 128 |
| **DE** | 14 298 | 31 082 | 1 577 | 4 553 | 1 325 | 3 486 | 2 725 | 2 642 | 1 411 | 52 | 823 | 117 | 72 | 527 |
| **BG** | 497 | 1 577 | 1 192 | 283 | 251 | 324 | 470 | 307 | 172 | 36 | 136 | 30 | 34 | 95 |
| **CZ** | 1 488 | 4 553 | 283 | 755 | 283 | 619 | 477 | 500 | 482 | 12 | 133 | 17 | 26 | 164 |
| **HR** | 594 | 1 325 | 251 | 283 | 537 | 269 | 361 | 386 | 191 | 35 | 158 | 45 | 26 | 73 |
| **HU** | 996 | 3 486 | 324 | 619 | 269 | 713 | 498 | 456 | 282 | 21 | 166 | 23 | 31 | 142 |
| **RO** | 896 | 2 725 | 470 | 477 | 361 | 498 | 1 390 | 486 | 240 | 35 | 156 | 27 | 65 | 174 |
| **SI** | 1 016 | 2 642 | 307 | 500 | 386 | 456 | 486 | 853 | 216 | 37 | 186 | 33 | 22 | 88 |
| **SK** | 598 | 1 411 | 172 | 482 | 191 | 282 | 240 | 216 | 308 | 10 | 53 | 15 | 18 | 67 |
| **ME** | 24 | 52 | 36 | 12 | 35 | 21 | 35 | 37 | 10 | 39 | 54 | 17 | 13 | 5 |
| **RS** | 299 | 823 | 136 | 133 | 158 | 166 | 156 | 186 | 53 | 54 | 345 | 50 | 19 | 32 |
| **BA** | 52 | 117 | 30 | 17 | 45 | 23 | 27 | 33 | 15 | 17 | 50 | 115 | 7 | 7 |
| **MD** | 28 | 72 | 34 | 26 | 26 | 31 | 65 | 22 | 18 | 13 | 19 | 7 | 27 | 29 |
| **UA** | 128 | 527 | 95 | 164 | 73 | 142 | 174 | 88 | 67 | 5 | 32 | 7 | 29 | 198 |

*Data: E-corda*

Horizon 2020 strongly supports the mobility of researchers and scientists through the activities of Marie Skłodowska-Curie. In these projects, researchers can spend a part of their career at foreign institutions or return to their country of origin after their stays abroad. As can be seen from the comparison, German researchers and institutions make the most of these opportunities, followed by Austria and Bavaria. By contrast, Montenegro, Moldova and Bosnia and Herzegovina have participated in the fewest number of MSCA projects.

**Table 2 Participation in MSCA**

|  |  |  |
| --- | --- | --- |
|  | **Participations** | **EU contribution** |
| **DE** | 3 420 | 751 542 228,69 |
| **AT** | 734 | 171 920 080,75 |
| **BAY** | 729 | 181 380 553,36 |
| **BW** | 440 | 128 415 269,56 |
| **CZ** | 230 | 46 424 397,21 |
| **HU** | 178 | 24 281 343,49 |
| **RO** | 172 | 16 927 326,94 |
| **SI** | 157 | 26 138 912,11 |
| **BG** | 134 | 9 339 519,85 |
| **RS** | 110 | 10 848 801,80 |
| **UA** | 83 | 12 158 250,60 |
| **SK** | 82 | 17 096 634,68 |
| **HR** | 72 | 10 122 149,03 |
| **BA** | 21 | 1 199 106,80 |
| **MD** | 14 | 1 556 000,00 |
| **ME** | 10 | 415 391,50 |

*Data: E-corda*

Since its inception in 2007, the European Research Council (ERC) has become synonymous with excellent research. Receiving an **ERC grant** is considered extremely prestigious in the scientific community. At the same time, success in the ERC is increasingly being used to measure the excellence of countries, research institutions and researchers. Within Europe, the United Kingdom has traditionally had the most ERC projects. Germany ranks second with a total of 1,595 participations and an EC contribution exceeding 2.35 billion €. In the Danube region, Germany is followed by Bavaria with 568 participations and Austria with 296. Other countries in the region lag far behind in this comparison. Hungary has 52 participations, the Czech Republic 46. The four associated countries (Ukraine, Bosnia and Herzegovina, Moldova, and Montenegro) do not have a single ERC project.

After Germany the highest contribution, was received by Bavaria - 865 mil. €, Austria - 418 mil. € and Baden-Württemberg - 366 mil. €.

**Table 3 Participation in ERC**

|  |  |  |
| --- | --- | --- |
|  | **Participations** | **EU contribution** |
| **DE** | 1 595 | 2 359 203 580,40 |
| **BAY** | 568 | 865 162 468,24 |
| **AT** | 296 | 418 080 003,78 |
| **BW** | 255 | 366 923 357,42 |
| **CZ** | 46 | 64 704 531,18 |
| **HU** | 52 | 63 126 540,89 |
| **SI** | 25 | 24 896 862,25 |
| **RO** | 13 | 12 845 033,70 |
| **HR** | 8 | 10 802 790,50 |
| **RS** | 4 | 3 185 485,00 |
| **BG** | 3 | 2 420 195,00 |
| **UA** | 1 | 1 997 500,00 |
| **SK** | 3 | 562 499,93 |
| **BA** | 0 | 0,00 |
| **ME** | 0 | 0,00 |
| **MD** | 0 | 0,00 |

*Data: E-corda*

## **Outputs from research and innovation activities**

The main output of basic research is publications and related citations. The quality of scientific publications can be measured in numerous ways, one of which is to compare the share of country’s publications among the 10% most cited publications. In such comparison, the Netherlands is the best among the EU countries. Among the member countries of the Danube Strategy Austria and Germany are the most successful states in this regard. Ukraine, Bulgaria and Bosnia and Herzegovina have the lowest shares. In the following graph we can observe that in comparison with other EU countries, the countries of the Danube region are in the second half of the list.

**Graph 18 Scientific publications among the top 10% most cited**

*Source: EIS [1.2.2]*

Baden-Württemberg has the highest number of publications per million inhabitants for the period 2010-2021, while Austria and Slovenia rank second and third, respectively. Moldova, Ukraine and Bosnia and Herzegovina have the lowest numbers. The differences between the individual member countries are significant. Moldova has more than twenty-two times less publications per million inhabitants than Baden-Württemberg.

**Table 4 Number of publications per million population**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **Total** |
| **BW** | 2 509 | 2 629 | 2 685 | 2 727 | 2 828 | 2 846 | 2 986 | 3 013 | 3 038 | 3 186 | 3 023 | 2 771 | 34 241 |
| **AT** | 2 347 | 2 419 | 2 501 | 2 610 | 2 805 | 2 884 | 3 073 | 3 104 | 3 160 | 3 343 | 3 277 | 3 050 | 34 573 |
| **SI** | 2 228 | 2 447 | 2 480 | 2 567 | 2 598 | 2 697 | 2 828 | 2 833 | 2 881 | 3 053 | 3 049 | 2 995 | 32 656 |
| **BAV** | 2 095 | 2 165 | 2 210 | 2 271 | 2 408 | 2 445 | 2 594 | 2 590 | 2 669 | 2 801 | 2 695 | 2 495 | 29 437 |
| **DE** | 1 750 | 1 825 | 1 870 | 1 921 | 2 010 | 2 045 | 2 124 | 2 147 | 2 162 | 2 281 | 2 167 | 1 991 | 24 292 |
| **CZ** | 1 635 | 1 639 | 1 710 | 1 798 | 2 098 | 2 279 | 2 315 | 2 326 | 2 245 | 2 343 | 2 119 | 1 847 | 24 352 |
| **HR** | 1 118 | 1 213 | 1 197 | 1 185 | 1 268 | 1 292 | 1 387 | 1 520 | 1 599 | 1 731 | 1 604 | 1 548 | 16 664 |
| **SK** | 934 | 893 | 1 028 | 1 086 | 1 370 | 1 407 | 1 541 | 1 556 | 1 421 | 1 462 | 1 322 | 1 075 | 15 096 |
| **HU** | 841 | 861 | 926 | 977 | 1 072 | 1 067 | 1 101 | 1 149 | 1 194 | 1 241 | 1 210 | 1 110 | 12 748 |
| **RS** | 772 | 835 | 1 077 | 1 001 | 1 010 | 1 052 | 1 065 | 1 081 | 1 056 | 1 181 | 1 071 | 1 004 | 12 206 |
| **RO** | 686 | 673 | 709 | 791 | 842 | 911 | 859 | 865 | 840 | 925 | 760 | 629 | 9 489 |
| **BG** | 454 | 440 | 472 | 478 | 505 | 502 | 590 | 646 | 659 | 744 | 625 | 537 | 6 653 |
| **ME** | 326 | 357 | 405 | 493 | 489 | 627 | 683 | 729 | 712 | 805 | 920 | 780 | 7 325 |
| **BA** | 194 | 203 | 191 | 176 | 187 | 236 | 269 | 325 | 326 | 357 | 334 | 285 | 3 083 |
| **UA** | 133 | 145 | 148 | 151 | 163 | 165 | 181 | 199 | 197 | 206 | 202 | 141 | 2 030 |
| **MD** | 99 | 112 | 115 | 118 | 126 | 123 | 152 | 138 | 154 | 150 | 146 | 102 | 1 536 |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

When comparing the number of publications (per million inhabitants) that countries have published together with the other countries of the Danube region, Austria (10,585) and Slovenia (8,849) are the leaders. Ukraine (353), Moldova (537) and Romania (1,114) have the fewest publications, which stem out of this kind of cooperation. The positive trend is that the number of joint publications in the region is increasing. Compared to 2010, we observe up to a twofold increase. The highest growth of joint publications was recorded in Montenegro (3.00-fold), Serbia (2.8) and Bosnia and Herzegovina (2.5). The smallest increase occurred in Baden-Württemberg and Bulgaria (Table 5).

**Table 5 Number of scientific publications in cooperation with countries in the Danube region per million population**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **Total** | **2010-2021** |
| **AT** | 619 | 652 | 709 | 741 | 828 | 849 | 937 | 966 | 1 013 | 1 104 | 1 103 | 1 065 | 10 585 | 1,7 |
| **SI** | 443 | 492 | 555 | 586 | 629 | 746 | 781 | 821 | 906 | 973 | 942 | 975 | 8 849 | 2,2 |
| **SK** | 237 | 244 | 265 | 270 | 332 | 355 | 410 | 419 | 428 | 486 | 489 | 439 | 4 374 | 1,9 |
| **CZ** | 235 | 247 | 280 | 296 | 355 | 392 | 420 | 456 | 491 | 531 | 533 | 509 | 4 743 | 2,2 |
| **HR** | 199 | 220 | 264 | 256 | 300 | 330 | 359 | 408 | 425 | 504 | 497 | 486 | 4 248 | 2,4 |
| **BW** | 183 | 206 | 224 | 228 | 239 | 251 | 277 | 286 | 307 | 318 | 310 | 280 | 3 108 | 1,5 |
| **HU** | 170 | 190 | 212 | 217 | 251 | 261 | 295 | 309 | 329 | 357 | 339 | 318 | 3 248 | 1,9 |
| **BAV** | 161 | 167 | 188 | 194 | 224 | 234 | 256 | 256 | 273 | 303 | 290 | 283 | 2 828 | 1,8 |
| **ME** | 158 | 174 | 176 | 206 | 201 | 256 | 299 | 310 | 323 | 442 | 495 | 472 | 3 512 | 3,0 |
| **RS** | 109 | 136 | 178 | 175 | 186 | 210 | 227 | 246 | 272 | 310 | 298 | 306 | 2 653 | 2,8 |
| **DE** | 104 | 112 | 120 | 125 | 136 | 142 | 154 | 158 | 164 | 180 | 180 | 173 | 1 749 | 1,7 |
| **BG** | 92 | 94 | 110 | 109 | 113 | 117 | 153 | 160 | 149 | 158 | 175 | 147 | 1 576 | 1,6 |
| **BA** | 68 | 75 | 72 | 70 | 82 | 104 | 120 | 146 | 158 | 165 | 167 | 169 | 1 397 | 2,5 |
| **RO** | 49 | 56 | 70 | 80 | 87 | 92 | 101 | 107 | 112 | 123 | 126 | 112 | 1 114 | 2,3 |
| **MD** | 20 | 29 | 31 | 31 | 45 | 48 | 49 | 51 | 55 | 68 | 62 | 48 | 537 | 2,3 |
| **UA** | 19 | 21 | 22 | 24 | 26 | 27 | 30 | 34 | 36 | 42 | 39 | 34 | 353 | 1,8 |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

A significant increase in the number of publications can also be observed when comparing the number of publications over a five-year period (Table 6). Within the region, the number of publications increased by 1.59 times. Montenegro, the Czech Republic, and Moldova have the highest increases. By contrast, Bulgaria and Germany have the lowest increases.

**Table 6 Number of scientific publications in cooperation with countries in the Danube region (five years periods)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2010-2014** | **2011-2015** | **2012-2016** | **2013-2017** | **2014-2018** | **2015-2019** | **2016-2020** | **2017-2021** |
| **DE** | 48 220 | 51 226 | 54 896 | 58 297 | 61 851 | 65 759 | 69 215 | 70 931 |
| **AT** | 29 896 | 32 011 | 34 705 | 37 218 | 39 891 | 42 627 | 45 160 | 46 520 |
| **CZ** | 14 831 | 16 499 | 18 339 | 20 225 | 22 322 | 24 241 | 25 809 | 26 824 |
| **HU** | 10 335 | 11 206 | 12 203 | 13 129 | 14 195 | 15 208 | 15 954 | 16 146 |
| **SK** | 7 282 | 7 930 | 8 839 | 9 682 | 10 555 | 11 407 | 12 154 | 12 322 |
| **RO** | 6 859 | 7 703 | 8 570 | 9 261 | 9 861 | 10 515 | 11 110 | 11 246 |
| **RS** | 5 657 | 6 351 | 6 968 | 7 418 | 8 063 | 8 895 | 9 466 | 9 960 |
| **SI** | 5 559 | 6 191 | 6 796 | 7 352 | 8 017 | 8 745 | 9 180 | 9 623 |
| **HR** | 5 296 | 5 834 | 6 396 | 6 960 | 7 613 | 8 394 | 9 017 | 9 472 |
| **UA** | 5 071 | 5 365 | 5 694 | 6 128 | 6 533 | 7 132 | 7 609 | 7 749 |
| **BG** | 3 796 | 3 953 | 4 351 | 4 681 | 4 935 | 5 223 | 5 597 | 5 518 |
| **BA** | 1 412 | 1 549 | 1 683 | 1 918 | 2 200 | 2 459 | 2 644 | 2 813 |
| **ME** | 568 | 629 | 707 | 791 | 864 | 1 014 | 1 163 | 1 270 |
| **MD** | 556 | 653 | 724 | 795 | 879 | 962 | 1 012 | 1 008 |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

Table 7 provides an overview of joint publications between the states of the Danube region from 2010 to 2021. These are absolute numbers. Austria and Germany have the most joint publications (75,774), followed by Germany and the Czech Republic (28,664). Countries outside the EU have done the least joint publications. For example, Montenegro and Moldova only have thirty-five. Moldova and Bosnia and Herzegovina only report forty-seven publications. The data shows that researchers naturally publish more with partners from innovation-strong countries (Germany and Austria). The second interesting observation is that there exist some historical connections. Slovak researchers, for example, have 14,101 joint publications with their Czech counterparts but only 7,732 with their German colleagues.

**Table 7 Number of publications among countries in the Danuber region (2010-2021)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AT** | **BA** | **BG** | **HR** | **CZ** | **DE** | **HU** | **MD** | **ME** | **RO** | **RS** | **SK** | **SI** | **UA** | **BAV** | **BW** |
| **AT** | - | 434 | 3 210 | 4 384 | 12 049 | 75 774 | 8 943 | 137 | 319 | 5 254 | 4 345 | 5 016 | 5 501 | 3 096 | 23 059 | 19 997 |
| **BA** | 434 | - | 248 | 1 842 | 364 | 743 | 252 | 47 | 274 | 354 | 2 560 | 190 | 757 | 157 | 157 | 146 |
| **BG** | 3 210 | 248 | - | 2 183 | 3 429 | 7 144 | 3 135 | 104 | 292 | 2 557 | 2 785 | 1 575 | 1 405 | 1 953 | 1 708 | 2 777 |
| **HR** | 4 384 | 1 842 | 2 183 | - | 3 784 | 8 131 | 3 435 | 89 | 580 | 2 175 | 4 125 | 1 416 | 4 065 | 2 081 | 2 092 | 3 074 |
| **CZ** | 12 049 | 364 | 3 429 | 3 784 | - | 28 664 | 7 544 | 139 | 278 | 4 732 | 4 052 | 14 101 | 4 255 | 3 948 | 8 322 | 9 188 |
| **DE** | 75 774 | 743 | 7 144 | 8 131 | 28 664 | - | 19 987 | 877 | 387 | 13 264 | 7 799 | 7 732 | 8 383 | 10 146 | - | - |
| **HU** | 8 943 | 252 | 3 135 | 3 435 | 7 544 | 19 987 | - | 133 | 223 | 6 378 | 4 048 | 4 236 | 3 344 | 2 902 | 5 456 | 6 751 |
| **MD** | 137 | 47 | 104 | 89 | 139 | 877 | 133 | - | 35 | 856 | 108 | 75 | 60 | 232 | 228 | 120 |
| **ME** | 319 | 274 | 292 | 580 | 278 | 387 | 223 | 35 | - | 213 | 1 466 | 133 | 320 | 210 | 99 | 221 |
| **RO** | 5 254 | 354 | 2 557 | 2 175 | 4 732 | 13 264 | 6 378 | 856 | 213 | - | 3 133 | 3 312 | 3 036 | 2 432 | 4 084 | 4 917 |
| **RS** | 4 345 | 2 560 | 2 785 | 4 125 | 4 052 | 7 799 | 4 048 | 108 | 1 466 | 3 133 | - | 2 378 | 3 773 | 1 811 | 2 288 | 3 327 |
| **SK** | 5 016 | 190 | 1 575 | 1 416 | 14 101 | 7 732 | 4 236 | 75 | 133 | 3 312 | 2 378 | - | 2 641 | 2 454 | 2 982 | 3 197 |
| **SI** | 5 501 | 757 | 1 405 | 4 065 | 4 255 | 8 383 | 3 344 | 60 | 320 | 3 036 | 3 773 | 2 641 | - | 937 | 3 272 | 3 283 |
| **UA** | 3 096 | 157 | 1 953 | 2 081 | 3 948 | 10 146 | 2 902 | 232 | 210 | 2 432 | 1 811 | 2 454 | 937 | - | 1 805 | 3 764 |
| **BAV** | 23 059 | 157 | 1 708 | 2 092 | 8 322 | - | 5 456 | 228 | 99 | 4 084 | 2 288 | 2 982 | 3 272 | 1 805 | - | - |
| **BW** | 19 997 | 146 | 2 777 | 3 074 | 9 188 | - | 6 751 | 120 | 221 | 4 917 | 3 327 | 3 197 | 3 283 | 3 764 | - | - |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

Citation of published articles is one of the basic ways of measuring the response of the scientific community to published research results. Put simply, the more a publication is cited, the greater its impact on a particular area of research. In the Danube region, in the period 2010-2021, Baden-Württemberg (671,124) recorded the highest number of citations per mil. inhabitants, followed by Austria (571,240) and Bavaria (537,166). Ukraine, Moldova and Bosnia and Herzegovina have the least citations (Table 8). The differences between countries are even more noteworthy than in the comparison of publications. Researchers from Baden-Württemberg have up to 41 times more citations per million inhabitants than researchers from Ukraine.

**Table 8 Number of citations per million population**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **Total** |
| **BW** | 81 716 | 79 403 | 81 388 | 78 503 | 74 219 | 69 172 | 60 990 | 51 752 | 42 768 | 30 619 | 17 222 | 3 371 | 671 124 |
| **AT** | 67 378 | 66 056 | 66 054 | 63 190 | 60 238 | 57 624 | 54 182 | 47 261 | 39 832 | 28 272 | 17 545 | 3 609 | 571 240 |
| **BAV** | 67 244 | 63 675 | 63 000 | 62 038 | 56 848 | 53 288 | 51 334 | 43 016 | 34 534 | 24 934 | 14 353 | 2 902 | 537 166 |
| **DE** | 48 706 | 47 934 | 46 964 | 45 153 | 42 414 | 39 898 | 35 274 | 30 615 | 24 292 | 18 107 | 10 817 | 2 150 | 392 325 |
| **SI** | 42 451 | 43 626 | 51 302 | 45 561 | 44 515 | 43 175 | 45 056 | 36 717 | 35 018 | 23 397 | 14 208 | 3 371 | 428 396 |
| **CZ** | 27 875 | 26 158 | 28 453 | 27 867 | 27 646 | 27 256 | 25 993 | 23 368 | 19 390 | 14 972 | 8 999 | 1 930 | 259 906 |
| **HR** | 20 102 | 19 520 | 20 373 | 18 098 | 17 563 | 18 689 | 15 924 | 16 256 | 14 686 | 10 884 | 6 874 | 1 495 | 180 463 |
| **HU** | 17 958 | 17 722 | 20 361 | 18 000 | 17 553 | 17 299 | 17 686 | 16 853 | 12 852 | 9 480 | 5 634 | 1 217 | 172 612 |
| **SK** | 12 903 | 11 672 | 14 412 | 12 886 | 12 858 | 14 488 | 15 389 | 13 620 | 10 308 | 7 910 | 4 110 | 952 | 131 507 |
| **RS** | 9 791 | 10 612 | 14 145 | 12 746 | 13 470 | 13 448 | 12 373 | 12 030 | 10 170 | 7 109 | 3 858 | 1 016 | 120 767 |
| **BG** | 6 853 | 6 916 | 7 708 | 6 671 | 7 355 | 7 720 | 6 274 | 6 308 | 6 652 | 4 168 | 2 377 | 488 | 69 489 |
| **RO** | 5 459 | 5 837 | 6 839 | 7 131 | 7 650 | 7 121 | 7 128 | 6 710 | 5 514 | 4 345 | 2 827 | 657 | 67 218 |
| **ME** | 3 821 | 6 626 | 4 245 | 3 245 | 4 631 | 3 827 | 3 423 | 7 584 | 3 662 | 5 637 | 2 923 | 449 | 50 073 |
| **BA** | 1 662 | 1 354 | 1 259 | 1 542 | 1 732 | 1 759 | 3 369 | 3 611 | 1 965 | 1 800 | 867 | 247 | 21 167 |
| **MD** | 1 507 | 1 014 | 1 100 | 1 108 | 1 429 | 1 209 | 1 431 | 1 960 | 593 | 1 002 | 326 | 59 | 12 738 |
| **UA** | 1 376 | 1 846 | 1 769 | 1 623 | 1 731 | 1 936 | 1 631 | 1 622 | 1 283 | 943 | 479 | 96 | 16 336 |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

If we focus only on citations of publications from countries of the Danube region, then Austria, Slovenia and the Czech Republic have the highest number of citations. Moldova, Ukraine and Bosnia and Herzegovina are again at the bottom of the list (Table 9).

**Table 9 Number of citations with countries in the Danube region per million population**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **Total** |
| **AT** | 28 841 | 28 297 | 30 476 | 28 406 | 27 005 | 27 019 | 26 819 | 23 197 | 20 721 | 14 163 | 8 784 | 1 815 | 265 543 |
| **SI** | 15 259 | 15 512 | 23 253 | 18 296 | 18 427 | 20 530 | 23 111 | 20 639 | 21 599 | 12 329 | 7 153 | 1 712 | 197 819 |
| **CZ** | 10 571 | 8 590 | 11 223 | 10 642 | 10 240 | 10 975 | 10 958 | 10 105 | 8 905 | 6 843 | 3 868 | 830 | 103 751 |
| **BAV** | 10 124 | 7 793 | 10 374 | 9 188 | 9 663 | 9 327 | 10 402 | 7 751 | 7 515 | 4 684 | 2 794 | 598 | 90 214 |
| **BW** | 9 928 | 9 709 | 13 205 | 10 648 | 10 914 | 11 429 | 11 640 | 10 050 | 9 375 | 5 624 | 3 009 | 556 | 106 087 |
| **HR** | 9 849 | 7 989 | 11 390 | 9 482 | 9 238 | 10 480 | 8 747 | 9 901 | 8 416 | 6 474 | 3 736 | 799 | 96 501 |
| **SK** | 7 234 | 5 592 | 8 261 | 6 861 | 7 042 | 8 594 | 10 276 | 8 831 | 6 782 | 5 049 | 2 329 | 545 | 77 395 |
| **HU** | 7 054 | 7 569 | 10 311 | 8 108 | 8 293 | 8 465 | 9 940 | 10 155 | 7 011 | 5 139 | 2 813 | 633 | 85 491 |
| **DE** | 4 572 | 4 574 | 4 807 | 4 602 | 4 642 | 4 475 | 4 520 | 4 094 | 3 364 | 2 432 | 1 461 | 320 | 43 863 |
| **BG** | 3 449 | 3 659 | 4 879 | 3 890 | 4 474 | 5 311 | 4 026 | 4 052 | 4 904 | 2 736 | 1 536 | 280 | 43 196 |
| **RS** | 3 068 | 3 816 | 6 926 | 5 259 | 6 125 | 6 950 | 6 677 | 7 377 | 6 109 | 3 726 | 1 949 | 551 | 58 535 |
| **ME** | 2 725 | 5 035 | 1 988 | 1 921 | 2 328 | 2 398 | 2 287 | 6 094 | 2 346 | 4 915 | 2 253 | 358 | 34 649 |
| **RO** | 1 560 | 1 700 | 2 816 | 2 702 | 3 404 | 2 752 | 3 009 | 3 063 | 2 365 | 1 639 | 1 033 | 278 | 26 323 |
| **BA** | 1 024 | 747 | 653 | 924 | 1 245 | 1 127 | 2 655 | 2 873 | 1 446 | 1 454 | 613 | 172 | 14 933 |
| **UA** | 472 | 933 | 922 | 781 | 755 | 1 081 | 891 | 883 | 697 | 510 | 231 | 46 | 8 203 |
| **MD** | 363 | 444 | 492 | 448 | 849 | 714 | 849 | 1 582 | 370 | 835 | 229 | 46 | 7 221 |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

Just as with publications, a positive trend in citations can be observed; the number of citations in the citation window 2017 – 2021 increased in all countries compared to the period 2010 - 2014. This growth represents an average growth of more than 2.26-fold for the whole region. The second positive aspect is that citations have grown the most in the non-EU countries. In Bosna and Herzegovina citations increased 6.13 times, in Moldova 5.09 times and in Montenegro 4.88 times. On the other hand, the lowest increases were measured in Ukraine (2.06), Germany (2.1) and Austria (2.1).

**Table 10 Number of citations with countries in the Danube region (five years period)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2010-2014** | **2011-2015** | **2012-2016** | **2013-2017** | **2014-2018** | **2015-2019** | **2016-2020** | **2017-2021** |
| **DE** | 460 432 | 499 224 | 557 588 | 598 697 | 670 874 | 755 825 | 877 130 | 966 085 |
| **AT** | 286 578 | 311 636 | 348 560 | 368 329 | 411 315 | 471 238 | 547 545 | 605 981 |
| **CZ** | 137 009 | 151 896 | 179 894 | 192 248 | 213 272 | 248 081 | 288 081 | 324 386 |
| **HU** | 105 787 | 122 369 | 142 585 | 146 181 | 170 968 | 201 217 | 236 201 | 251 863 |
| **RO** | 63 048 | 80 817 | 101 938 | 107 874 | 120 552 | 127 129 | 147 092 | 163 451 |
| **HR** | 54 927 | 58 523 | 68 918 | 69 194 | 76 630 | 88 140 | 100 790 | 120 439 |
| **SK** | 52 267 | 56 574 | 69 160 | 73 561 | 88 093 | 107 158 | 123 795 | 128 094 |
| **RS** | 48 434 | 62 407 | 79 193 | 79 574 | 93 571 | 107 931 | 122 550 | 137 928 |
| **UA** | 48 407 | 60 574 | 67 297 | 70 164 | 78 555 | 90 569 | 94 101 | 99 749 |
| **SI** | 47 476 | 56 533 | 68 292 | 69 516 | 80 425 | 97 487 | 116 798 | 131 520 |
| **BG** | 43 862 | 49 610 | 59 130 | 60 023 | 68 647 | 75 991 | 82 349 | 95 074 |
| **BA** | 3 745 | 3 762 | 5 048 | 7 498 | 10 755 | 14 893 | 21 149 | 22 945 |
| **MD** | 2 135 | 2 831 | 3 577 | 4 680 | 6 323 | 7 166 | 9 100 | 10 864 |
| **ME** | 2 034 | 2 111 | 1 792 | 2 134 | 2 870 | 4 065 | 6 640 | 9 931 |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

Table 11 provides an overview of the number of citations to publications produced between the Danube region countries. Just as with publications, Austria and Germany have most such citations in common. Czech Republic and Germany rank second. Germany has the most common citations with all countries in the region, the only exceptions being Bosnia and Herzegovina and Montenegro, which have the most citations with Serbia.

**Table 11 Number of citations among countries in the Danube region (2010-2021)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AT** | **BA** | **BG** | **HR** | **CZ** | **DE** | **HU** | **MD** | **ME** | **RO** | **RS** | **SK** | **SI** | **UA** | **BAV** | **BW** |
| **AT** | - | 21 208 | 152 610 | 178 074 | 406 090 | 2 050 623 | 322 937 | 5 317 | 8 263 | 218 172 | 223 242 | 193 520 | 194 156 | 153 623 | 746 544 | 725 093 |
| **BA** | 21 208 | - | 11 663 | 29 459 | 22 305 | 28 049 | 18 110 | 4 249 | 5 623 | 18 864 | 29 547 | 17 887 | 22 146 | 10 001 | 12 438 | 13 060 |
| **BG** | 152 610 | 11 663 | - | 100 662 | 130 602 | 261 054 | 123 804 | 4 586 | 7 830 | 100 975 | 123 392 | 68 823 | 49 664 | 101 051 | 104 792 | 166 911 |
| **HR** | 178 074 | 29 459 | 100 662 | - | 158 097 | 312 701 | 144 041 | 4 628 | 7 894 | 105 190 | 136 425 | 72 987 | 88 597 | 117 466 | 112 158 | 170 129 |
| **CZ** | 406 090 | 22 305 | 130 602 | 158 097 | - | 852 690 | 311 374 | 5 779 | 8 213 | 192 998 | 189 731 | 247 433 | 159 816 | 149 179 | 322 990 | 362 901 |
| **DE** | 2 050 623 | 28 049 | 261 054 | 312 701 | 852 690 | - | 687 296 | 18 747 | 11 632 | 419 970 | 326 061 | 270 432 | 282 908 | 309 795 | - | - |
| **HU** | 322 937 | 18 110 | 123 804 | 144 041 | 311 374 | 687 296 | - | 6 007 | 7 856 | 197 860 | 177 760 | 153 342 | 138 639 | 134 445 | 245 797 | 294 392 |
| **MD** | 5 317 | 4 249 | 4 586 | 4 628 | 5 779 | 18 747 | 6 007 | - | 4 027 | 9 777 | 5 517 | 4 645 | 4 555 | 3 338 | 6 639 | 5 809 |
| **ME** | 8 263 | 5 623 | 7 830 | 7 894 | 8 213 | 11 632 | 7 856 | 4 027 | - | 8 080 | 13 722 | 6 416 | 6 854 | 5 480 | 7 062 | 7 987 |
| **RO** | 218 172 | 18 864 | 100 975 | 105 190 | 192 998 | 419 970 | 197 860 | 9 777 | 8 080 | - | 157 777 | 157 765 | 117 270 | 123 031 | 178 143 | 230 199 |
| **RS** | 223 242 | 29 547 | 123 392 | 136 425 | 189 731 | 326 061 | 177 760 | 5 517 | 13 722 | 157 777 | - | 145 619 | 121 371 | 126 349 | 146 354 | 221 949 |
| **SK** | 193 520 | 17 887 | 68 823 | 72 987 | 247 433 | 270 432 | 153 342 | 4 645 | 6 416 | 157 765 | 145 619 | - | 113 547 | 90 726 | 146 502 | 176 014 |
| **SI** | 194 156 | 22 146 | 49 664 | 88 597 | 159 816 | 282 908 | 138 639 | 4 555 | 6 854 | 117 270 | 121 371 | 113 547 | - | 38 766 | 149 546 | 157 455 |
| **UA** | 153 623 | 10 001 | 101 051 | 117 466 | 149 179 | 309 795 | 134 445 | 3 338 | 5 480 | 123 031 | 126 349 | 90 726 | 38 766 | - | 82 723 | 183 132 |
| **BAV** | 746 544 | 12 438 | 104 792 | 112 158 | 322 990 | - | 245 797 | 6 639 | 7 062 | 178 143 | 146 354 | 146 502 | 149 546 | 82 723 | - | - |
| **BW** | 725 093 | 13 060 | 166 911 | 170 129 | 362 901 | - | 294 392 | 5 809 | 7 987 | 230 199 | 221 949 | 176 014 | 157 455 | 183 132 | - | - |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

**Table 12 Percentage of publications created in cooperation with the countries of the Danube region and citations to these publications in the total number of publications and citations of each Danube region country**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** |  | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| DE | % co-publications | 6 | 6 | 6 | 6 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 9 |
| % citations | 9 | 10 | 10 | 10 | 11 | 11 | 13 | 13 | 14 | 13 | 14 | 15 |
| RO | % co-publications | 7 | 8 | 10 | 10 | 10 | 10 | 12 | 12 | 13 | 13 | 17 | 18 |
| % citations | 29 | 29 | 41 | 38 | 45 | 39 | 42 | 46 | 43 | 38 | 37 | 42 |
| RS | % co-publications | 14 | 16 | 17 | 18 | 18 | 20 | 21 | 23 | 26 | 26 | 28 | 30 |
| % citations | 31 | 36 | 49 | 41 | 45 | 52 | 54 | 61 | 60 | 52 | 51 | 54 |
| UA | % co-publications | 14 | 14 | 15 | 16 | 16 | 16 | 17 | 17 | 18 | 21 | 19 | 24 |
| % citations | 34 | 51 | 52 | 48 | 44 | 56 | 55 | 54 | 54 | 54 | 48 | 48 |
| CZ | % co-publications | 14 | 15 | 16 | 16 | 17 | 17 | 18 | 20 | 22 | 23 | 25 | 28 |
| % citations | 38 | 33 | 39 | 38 | 37 | 40 | 42 | 43 | 46 | 46 | 43 | 43 |
| HR | % co-publications | 18 | 18 | 22 | 22 | 24 | 26 | 26 | 27 | 27 | 29 | 31 | 31 |
| % citations | 49 | 41 | 56 | 52 | 53 | 56 | 55 | 61 | 57 | 59 | 54 | 53 |
| SI | % co-publications | 20 | 20 | 22 | 23 | 24 | 28 | 28 | 29 | 31 | 32 | 31 | 33 |
| % citations | 36 | 36 | 45 | 40 | 41 | 48 | 51 | 56 | 62 | 53 | 50 | 51 |
| HU | % co-publications | 20 | 22 | 23 | 22 | 23 | 24 | 27 | 27 | 28 | 29 | 28 | 29 |
| % citations | 39 | 43 | 51 | 45 | 47 | 49 | 56 | 60 | 55 | 54 | 50 | 52 |
| BG | % co-publications | 20 | 21 | 23 | 23 | 22 | 23 | 26 | 25 | 23 | 21 | 28 | 27 |
| % citations | 50 | 53 | 63 | 58 | 61 | 69 | 64 | 64 | 74 | 66 | 65 | 57 |
| MD | % co-publications | 21 | 26 | 27 | 27 | 36 | 39 | 32 | 37 | 36 | 46 | 42 | 47 |
| % citations | 24 | 44 | 45 | 40 | 59 | 59 | 59 | 81 | 62 | 83 | 70 | 78 |
| SK | % co-publications | 25 | 27 | 26 | 25 | 24 | 25 | 27 | 27 | 30 | 33 | 37 | 41 |
| % citations | 56 | 48 | 57 | 53 | 55 | 59 | 67 | 65 | 66 | 64 | 57 | 57 |
| AT | % co-publications | 26 | 27 | 28 | 28 | 30 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| % citations | 43 | 43 | 46 | 45 | 45 | 47 | 49 | 49 | 52 | 50 | 50 | 50 |
| BA | % co-publications | 35 | 37 | 38 | 40 | 44 | 44 | 45 | 45 | 48 | 46 | 50 | 59 |
| % citations | 62 | 55 | 52 | 60 | 72 | 64 | 79 | 80 | 74 | 81 | 71 | 70 |
| ME | % co-publications | 49 | 49 | 43 | 42 | 41 | 41 | 44 | 43 | 45 | 55 | 54 | 61 |
| % citations | 71 | 76 | 47 | 59 | 50 | 63 | 67 | 80 | 64 | 87 | 77 | 80 |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

On the other side of the spectrum lies the applied research and its basic output: patents. If we compare the number of patent applications per billion GDP, the most successful countries are Sweden and Finland. Germany and Austria are the main leaders of this area in the Danube region. However, we can observe significant differences between countries. While Germany has 6.18 applications, Bosnia and Herzegovina only 0.1. Only four countries from the region have more than 1 patent application per billion GDP.

**Graph 19 PCT patent applications per billion GDP (in PPS)**

*Source: EIS [3.3.1]*

If we recalculate the number of applications in EPO per million inhabitants, the highest number of was recorded in Germany (309.77) and Austria (255.72). These leaders are followed at a greater distance by Slovenia (79.37) and the Czech Republic (19.14). Moldova, Ukraine and Bosnia and Herzegovina remain at the end.

**Table 13 European patent applications per million population**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| **DE** | 312,73 | 325,23 | 316,41 | 305,94 | 296,08 | 297,57 | 304,82 | 318,23 | 319,42 | 309,77 |
| **AT** | 192,54 | 208,08 | 221,30 | 218,08 | 220,85 | 224,74 | 245,28 | 253,28 | 260,49 | 255,72 |
| **SI** | 62,05 | 51,95 | 64,94 | 60,13 | 56,76 | 54,35 | 47,14 | 48,10 | 58,68 | 79,37 |
| **CZ** | 15,13 | 13,07 | 14,10 | 15,59 | 19,89 | 17,65 | 19,24 | 23,16 | 18,96 | 19,14 |
| **HU** | 9,94 | 10,87 | 10,66 | 11,80 | 10,04 | 11,08 | 9,83 | 12,22 | 10,04 | 11,08 |
| **SK** | 7,88 | 6,41 | 5,31 | 4,76 | 8,61 | 8,06 | 7,51 | 9,34 | 7,69 | 10,07 |
| **BG** | 2,30 | 1,87 | 3,31 | 4,89 | 4,75 | 2,88 | 4,61 | 4,46 | 5,04 | 7,48 |
| **HR** | 4,38 | 4,63 | 2,44 | 2,92 | 2,19 | 3,90 | 2,44 | 3,41 | 4,63 | 5,36 |
| **ME** | 0,00 | 1,59 | 1,59 | 0,00 | 0,00 | 1,59 | 1,59 | 3,18 | 0,00 | 3,18 |
| **RO** | 1,04 | 1,82 | 1,72 | 1,46 | 1,56 | 1,61 | 2,70 | 2,60 | 2,08 | 2,81 |
| **RS** | 0,68 | 0,57 | 1,25 | 1,25 | 0,46 | 0,11 | 1,14 | 1,03 | 1,03 | 0,91 |
| **BA** | 0,00 | 0,33 | 0,11 | 0,00 | 0,00 | 0,22 | 0,00 | 0,11 | 0,22 | 0,44 |
| **UA** | 0,25 | 0,27 | 0,57 | 0,32 | 0,43 | 0,27 | 0,45 | 0,50 | 0,48 | 0,39 |
| **MD** | 0,00 | 0,25 | 0,50 | 0,50 | 0,25 | 0,00 | 0,25 | 0,50 | 0,50 | 0,25 |

*Source: EPO, Status: 1.2.2021*

We found an identical trend in **the number of granted patents per million inhabitants.** Germany (239.38) leads the list before Austria (194.98) and Slovenia (45.7). Bosnia and Herzegovina has not obtained a single patent in the last five years. Montenegro has not been granted a single patent since 2011.

**Table 14 European patents per million population**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| **DE** | 162,06 | 158,92 | 160,23 | 156,19 | 168,46 | 223,53 | 224,54 | 248,31 | 253,01 | 239,38 |
| **AT** | 81,83 | 88,39 | 92,94 | 98,93 | 115,48 | 152,12 | 162,67 | 183,77 | 184,65 | 194,98 |
| **SI** | 20,20 | 18,28 | 25,01 | 24,53 | 31,27 | 38,48 | 44,25 | 36,56 | 34,63 | 45,70 |
| **CZ** | 5,23 | 5,23 | 6,26 | 6,16 | 6,91 | 8,87 | 11,49 | 11,77 | 16,06 | 14,38 |
| **HU** | 4,76 | 3,93 | 5,18 | 4,24 | 3,93 | 6,42 | 6,11 | 6,83 | 7,66 | 8,18 |
| **SK** | 0,55 | 2,38 | 0,92 | 2,01 | 2,01 | 2,75 | 3,30 | 5,13 | 6,23 | 2,75 |
| **BG** | 1,15 | 0,72 | 0,72 | 1,01 | 1,01 | 1,58 | 3,17 | 2,59 | 2,30 | 2,59 |
| **HR** | 1,22 | 2,68 | 1,71 | 1,71 | 1,46 | 1,22 | 1,46 | 1,46 | 3,17 | 2,44 |
| **RO** | 0,10 | 0,16 | 0,10 | 0,21 | 0,47 | 0,99 | 0,68 | 0,47 | 0,73 | 1,20 |
| **RS** | 0,46 | 0,23 | 0,34 | 0,23 | 0,00 | 0,11 | 0,11 | 1,03 | 0,68 | 0,57 |
| **MD** | 0,00 | 0,25 | 0,25 | 0,25 | 0,00 | 0,00 | 0,00 | 0,25 | 0,00 | 0,50 |
| **UA** | 0,00 | 0,07 | 0,11 | 0,11 | 0,05 | 0,18 | 0,09 | 0,25 | 0,14 | 0,16 |
| **BA** | 0,30 | 0,30 | 0,30 | 0,00 | 0,30 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **ME** | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |

*Source: EPO, Status: 1.2.2021*

## **Short-term and long-term effects**

While short-term effects represent the immediate outcomes of interventions, long-term effects are a result of interventions that affect society and the economy in a broader sense. Long-term effects can be seen in the way Small and medium-sized enterprises (SMEs) are able to create innovative products.

One important indicator is the number of SMEs which introduced at least one product innovation either new to the enterprise or new to their market. Product innovation is a key ingredient to innovation as they can create new markers and improve competitiveness. Higher shares of product innovators reflect a higher level of innovation activities.

Among EU countries, Estonia has the highest share of such companies (48.87%). Montenegro (42.89%), Serbia (42.56%) and Germany (38.67%) have the highest share in the Danube region, while Romania (9.35%), Poland (12.18%) and Slovakia have the least (14%).

**Graph 20 SMEs introducing product innovations (% share)**

*Source: EIS [3.1.1]*

Another area, which can reveal the state of innovation in each country is the number of employees working in knowledge-intensive activities. Knowledge-intensive activities provide services directly to consumers, such as telecommunications, and provide inputs to the innovative activities of other firms in all sectors of the economy.

Luxembourg has the highest share of employees in knowledge-intensive activities in the EU (25.7%). Among the countries we have monitored in the Danube region the leaders are Germany (15%), Austria (14.9%) and Slovenia (14.6%). Romania (7.6%), Serbia (9.7%) and Poland (10.6%) have the lowest shares.

**Graph 21 Employment in knowledge-intensive activities (% share)**

*Source: EIS [4.1.1]*

Another dataset which further shows the state of innovation is the sale of new or significantly improved products by innovative companies, namely the turnover, and includes both products which are new to the enterprise and products which are also new to the market. The indicator thus captures both the creation of state-of-the-art technologies (new-to-market products) and the diffusion of these technologies (new-to-enterprise products).

In the EU, Greece has the largest share of such companies (23.81%). Austria (14.93%), Germany (14.84%) and the Czech Republic (12.3%) are the leaders in this indicator in the Danube region, while Ukraine (3.3%), Bulgaria (6.34%) and Poland (6.43%) have the lowest shares.

**Graph 22 Sales of new-to-market and new-to-firm innovations (%share)**

*Source: EIS [4.2.3]*

Finally, we focused also on the ability of the countries to export knowledge-intensive services. This indicator measures the competitiveness of the knowledge-intensive services sector. Competitiveness-enhancing measures and innovation strategies can be mutually reinforcing for the growth of employment, export shares, and turnover at the company level. The indicator reflects the ability of an economy, notably resulting from innovation, to export services with high levels of value added, and successfully take part in knowledge-intensive global value chains.

Ireland has the largest share of exports of knowledge-intensive services in the EU. Among the countries of the Danube region, Germany (74.32%) is on the forefront, followed by Hungary (51.5%) and Serbia (51.39%). Bosnia and Herzegovina (18.74%), Montenegro (19.32%) and Croatia (21.64%) export the least number of knowledge-intensive services.

**Graph 23 Knowledge-intensive services exports (% share)**

*Source: EIS [4.2.2]*

# **Meeting the Danube strategy objectives**

Priority Area 7 of the Danube Strategy - Knowledge Society (Research, Education and ICT) is coordinated jointly by Slovakia and Serbia. In 2016, with the aim of better monitoring, the Steering Committee revised its objectives. The following five objectives are defined in this analysis:

1. Increase the efficiency of funding research and innovations by setting up a coordinating funding network to initiate at least two activities per year (e.g., joint calls; proposals for joint strategic project applications (within a multilateral framework)).
2. Increase by 20% the number of EPO and PCT patent applications filed in the Danube region by 2020.
3. Enhance regional research and educational collaboration with a view to achieving 20% of academic mobility by 2020.
4. Increase the annual share of joint publications by 15% by 2020.
5. Develop RIS3 in each country (and its regions) by 2020.

In our analysis from 2019, we evaluated the ongoing evaluation of these objectives as follows:

1. The objective has been met.
2. The objective has not been met.
3. The objective is being met.
4. The objective was met already in 2018.
5. The objective was met.
   1. **Effectiveness of investment in research and innovation**

Three calls were announced under the Interreg Danube Transnational Programme. The first in September 2015, the second in May 2017 and the third in January 2019. The second round of the third call was concluded in November 2019 and the chosen projects were approved in May 2020.

Seventeen projects were supported in the first call in the Innovation and Social Responsibility priority. Eight projects were supported in the second call. The third call included nine implemented projects.

Within the framework of the EUREKA programme, three dedicated calls were launched for the Danube Region. The first call was launched in March 2015. It was a joint initiative of Austria, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Montenegro, Romania, Serbia, and Slovakia. The second call was open to institutions from Austria, Croatia, the Czech Republic, Germany, Hungary, and Romania. Projects could be submitted up to March 2017. The third call with a deadline in March 2018 was a joint activity of Austria, Croatia, the Czech Republic, Hungary, and Romania. EUREKA continues to support innovation in the Danube region and has launched a new call for proposals in 2022.

* 1. **Increase the number of patents**

The second objective of PA7 is to achieve a 20% increase in the number of EPO and PCT patent applications filed by the Danube region countries by 2020. With **the number of EPO patent applications filed** this objective **has not been met.** While in our previous analysis we stated that the number of EPO patent applications increased by 0.33%, if we compare the data for 2010 and 2020, the number of patent applications even decreased, by 2.09 %.

As we have mentioned previously, this objective does not appear to be optimally adjusted, since, to meet the objective, the number of patent applications would have to increase by 4,435. The number of such patent applications, excluding Germany, attained 2,932. In other countries, except for Austria, the number of patent applications can be calculated mostly on two hands, sometimes there are dozens.

The fact that the fulfilment of this objective is dependent on Germany is also evidenced by the fact that the number of EPO applications from the member states of the Danube region has increased by more than 20%. In Germany, however, we recorded a decrease of 5.03%, which also led to an overall decrease in the entire region.

**Table 15 EPO patent applications and growth (2010-2020)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **Growth** |
| **AT** | 1 744 | 1 734 | 1 874 | 1 993 | 1 964 | 1 989 | 2 024 | 2 209 | 2 281 | 2 346 | 2 303 | **32,05%** |
| **BA** | 2 | 0 | 3 | 1 | 0 | 0 | 2 | 0 | 1 | 2 | 4 | **100,00%** |
| **BG** | 11 | 16 | 13 | 23 | 34 | 33 | 20 | 32 | 31 | 35 | 52 | **372,73%** |
| **CZ** | 167 | 162 | 140 | 151 | 167 | 213 | 189 | 206 | 248 | 203 | 205 | **22,75%** |
| **DE** | 27 328 | 26 202 | 27 249 | 26 510 | 25 633 | 24 807 | 24 932 | 25 539 | 26 663 | 26 762 | 25 954 | **-5,03%** |
| **HR** | 17 | 18 | 19 | 10 | 12 | 9 | 16 | 10 | 14 | 19 | 22 | **29,41%** |
| **HU** | 107 | 96 | 105 | 103 | 114 | 97 | 107 | 95 | 118 | 97 | 107 | **0,00%** |
| **MD** | 2 | 0 | 1 | 2 | 2 | 1 | 0 | 1 | 2 | 2 | 1 | **-50,00%** |
| **ME** | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 0 | 2 | **200,00%** |
| **RO** | 14 | 20 | 35 | 33 | 28 | 30 | 31 | 52 | 50 | 40 | 54 | **285,71%** |
| **RS** | 8 | 6 | 5 | 11 | 11 | 4 | 1 | 10 | 9 | 9 | 8 | **0,00%** |
| **SI** | 131 | 129 | 108 | 135 | 125 | 118 | 113 | 98 | 100 | 122 | 165 | **25,95%** |
| **SK** | 25 | 43 | 35 | 29 | 26 | 47 | 44 | 41 | 51 | 42 | 55 | **120,00%** |
| **UA** | 11 | 11 | 12 | 25 | 14 | 19 | 12 | 20 | 22 | 21 | 17 | **54,55%** |
| **Total** | **29 567** | **28 437** | **29 600** | **29 027** | **28 130** | **27 367** | **27 492** | **28 314** | **29 592** | **29 700** | **28 949** | **-2,09%** |

*Source: EPO, Status: 1.2.2021*

PCT doplniť

In order to produce a better comparison, we also focused on already granted patents. In this case, we encounter a similar problem as in patent applications and we can illustrate it one example: in 2020, out of a total of 22,220 patents granted for the countries of the Danube region, up to 20,056 were obtained by Germany and another 1,756 by Austria. Other countries thus obtained only a few, sometimes dozens of patents. Here, however, we can state that ten countries obtained more than 20% more patents in 2020 than in 2010. In most cases, this increase was more than 100%. Since Germany also increased its number of patents, by as much as 59.81%, the total number of patents in the region increased by 65.83%.

**Table 16 Number of EPO patents and growth (2010-2020)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **Growth** |
| **AT** | 671 | 737 | 796 | 837 | 891 | 1 040 | 1 370 | 1 465 | 1 655 | 1 663 | 1 756 | **161,70%** |
| **BA** | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **-100,00%** |
| **BG** | 3 | 8 | 5 | 5 | 7 | 7 | 11 | 22 | 18 | 16 | 18 | **500,00%** |
| **CZ** | 45 | 56 | 56 | 67 | 66 | 74 | 95 | 123 | 126 | 172 | 154 | **242,22%** |
| **DE** | 12 550 | 13 578 | 13 315 | 13 425 | 13 086 | 14 114 | 18 728 | 18 813 | 20 804 | 21 198 | 20 056 | **59,81%** |
| **HR** | 10 | 5 | 11 | 7 | 7 | 6 | 5 | 6 | 6 | 13 | 10 | **0,00%** |
| **HU** | 58 | 46 | 38 | 50 | 41 | 38 | 62 | 59 | 66 | 74 | 79 | **36,21%** |
| **MD** | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | **200,00%** |
| **ME** | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0,00%** |
| **RO** | 3 | 2 | 3 | 2 | 4 | 9 | 19 | 13 | 9 | 14 | 23 | **666,67%** |
| **RS** | 2 | 4 | 2 | 3 | 2 | 0 | 1 | 1 | 9 | 6 | 5 | **150,00%** |
| **SI** | 33 | 42 | 38 | 52 | 51 | 65 | 80 | 92 | 76 | 72 | 95 | **187,88%** |
| **SK** | 12 | 3 | 13 | 5 | 11 | 11 | 15 | 18 | 28 | 34 | 15 | **25,00%** |
| **UA** | 11 | 0 | 3 | 5 | 5 | 2 | 8 | 4 | 11 | 6 | 7 | **-36,36%** |
| **Total** | **13 399** | **14 482** | **14 282** | **14 460** | **14 172** | **15 367** | **20 394** | **20 616** | **22 809** | **23 268** | **22 220** | **65,83%** |

*Source: EPO, Status: 1.2.2021*

* 1. **Increase academic mobility**

In assessing mobility, we again focused on joint projects within the framework of Marie Skłodowska-Curie activities which entailed the **mobility of researchers** and in which at least two Danube region countries collaborated. The most active was country Germany, which collaborated in at least one project with each of the Danube region country. Austria, Bulgaria and Romania follow in the list, each cooperating with twelve countries. Montenegro has the lowest number of collaborations (5). Bulgaria and Romania, the Danube region member countries which are in the middle of the region, collaborate with almost every country.

**Table 17 Common MSCA mobility projects**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **AT** | **DE** | **BG** | **CZ** | **HR** | **HU** | **RO** | **SI** | **SK** | **ME** | **RS** | **BA** | **MD** | **UA** | **Total** |
| **AT** | 290 | 1 137 | 5 | 90 | 20 | 91 | 37 | 60 | 28 | 3 | 7 | 0 | 1 | 10 | **1 779** |
| **DE** | 1 137 | 3 232 | 48 | 295 | 56 | 282 | 90 | 132 | 82 | 1 | 29 | 16 | 5 | 81 | **5 486** |
| **BG** | 5 | 48 | 553 | 3 | 6 | 1 | 6 | 3 | 4 | 0 | 11 | 1 | 1 | 1 | **643** |
| **CZ** | 90 | 295 | 3 | 48 | 2 | 35 | 20 | 8 | 16 | 0 | 8 | 0 | 0 | 12 | **537** |
| **HR** | 20 | 56 | 6 | 2 | 149 | 5 | 4 | 7 | 5 | 0 | 7 | 2 | 0 | 0 | **263** |
| **HU** | 91 | 282 | 1 | 35 | 5 | 104 | 25 | 8 | 11 | 0 | 9 | 0 | 2 | 3 | **576** |
| **RO** | 37 | 90 | 6 | 20 | 4 | 25 | 376 | 7 | 8 | 2 | 1 | 0 | 3 | 15 | **594** |
| **SI** | 60 | 132 | 3 | 8 | 7 | 8 | 7 | 82 | 2 | 2 | 0 | 3 | 0 | 2 | **316** |
| **SK** | 28 | 82 | 4 | 16 | 5 | 11 | 8 | 2 | 47 | 0 | 4 | 0 | 2 | 7 | **216** |
| **ME** | 3 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 6 | 2 | 0 | 0 | 0 | **16** |
| **RS** | 7 | 29 | 11 | 8 | 7 | 9 | 1 | 0 | 4 | 2 | 126 | 2 | 0 | 1 | **207** |
| **BA** | 0 | 16 | 1 | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 2 | 14 | 0 | 0 | **38** |
| **MD** | 1 | 5 | 1 | 0 | 0 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 6 | 9 | **29** |
| **UA** | 10 | 81 | 1 | 12 | 0 | 3 | 15 | 2 | 7 | 0 | 1 | 0 | 9 | 37 | **178** |
| **Total** | **1 779** | **5 486** | **643** | **537** | **263** | **576** | **594** | **316** | **216** | **16** | **207** | **38** | **29** | **178** | **10 878** |

* 1. **Increase the number of joint publications**

The fourth PA7 objective was to achieve a 15% increase in the number of joint publications of the Danube region countries by 2020. **This objective was met.** The number of joint publications increased on average by 102.93%. It grew the most in Montenegro, Slovakia and Bosnia and Herzegovina. However, it significantly exceeded the level of 50% in all countries. Hence, we can conclude that the production of joint publications between the Danube region countries has intensified.

**Graph 24 Number of publication and growth by country with other countries in the Danube region**

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

The growth in the total number of publications is obvious even when we compare the total number of publications in countries over 5-year-periods. On average, their number increased by 59.22%. We recorded the most significant increases in Montenegro, Bosnia and Herzegovina and Moldova.

**Table 18 Number of publication and growth by country with other countries in the Danube region**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2010-2014** | **2011-2015** | **2012-2016** | **2013-2017** | **2014-2018** | **2015-2019** | **2016-2020** | **2017-2021** | **Growth** |
| **DE** | 48 220 | 51 226 | 54 896 | 58 297 | 61 851 | 65 759 | 69 215 | 70 931 | **47,10%** |
| **AT** | 29 896 | 32 011 | 34 705 | 37 218 | 39 891 | 42 627 | 45 160 | 46 520 | **55,61%** |
| **CZ** | 14 831 | 16 499 | 18 339 | 20 225 | 22 322 | 24 241 | 25 809 | 26 824 | **80,86%** |
| **HU** | 10 335 | 11 206 | 12 203 | 13 129 | 14 195 | 15 208 | 15 954 | 16 146 | **56,23%** |
| **SK** | 7 282 | 7 930 | 8 839 | 9 682 | 10 555 | 11 407 | 12 154 | 12 322 | **69,21%** |
| **RO** | 6 859 | 7 703 | 8 570 | 9 261 | 9 861 | 10 515 | 11 110 | 11 246 | **63,96%** |
| **SR** | 5 657 | 6 351 | 6 968 | 7 418 | 8 063 | 8 895 | 9 466 | 9 960 | **76,07%** |
| **SI** | 5 559 | 6 191 | 6 796 | 7 352 | 8 017 | 8 745 | 9 180 | 9 623 | **73,11%** |
| **CR** | 5 296 | 5 834 | 6 396 | 6 960 | 7 613 | 8 394 | 9 017 | 9 472 | **78,85%** |
| **UA** | 5 071 | 5 365 | 5 694 | 6 128 | 6 533 | 7 132 | 7 609 | 7 749 | **52,81%** |
| **BG** | 3 796 | 3 953 | 4 351 | 4 681 | 4 935 | 5 223 | 5 597 | 5 518 | **45,36%** |
| **BA** | 1 412 | 1 549 | 1 683 | 1 918 | 2 200 | 2 459 | 2 644 | 2 813 | **99,22%** |
| **ME** | 568 | 629 | 707 | 791 | 864 | 1 014 | 1 163 | 1 270 | **123,59%** |
| **MD** | 556 | 653 | 724 | 795 | 879 | 962 | 1 012 | 1 008 | **81,29%** |
| **Total** | **145 338** | **157 100** | **170 871** | **183 855** | **197 779** | **212 581** | **225 090** | **231 402** | **59,22%** |

*Data: InCites, Web of Science Core Collection (31. 12. 2021)*

* 1. **RIS in each country**

The fifth objective is to develop a Strategy for Smart Specialisation (RIS3) for each country and region within the Danube Strategy by 2020. The evaluation is based on the Smart Specialisation Platform operated by the Joint Research Centre of the European Commission. All the Danube Region countries developed and approved the RIS3 strategies or other strategic documents for research and innovation. In some countries, the national RIS3 strategy applies to all the regions (e.g., Slovakia). For more information, see the table below. Therefore, the objective was met.

**Table 19 RIS in the Danube region countries and regions**

|  |  |  |  |
| --- | --- | --- | --- |
| **AT** | **CZ** | **HU** | **RO** |
| **Lower Austria** | **Karlovy Vary Region** | **South Great Plain** | **Centre** |
| **Upper Austria** | **Moravian Silesian Region** | **South Transdanubia** | **North-East** |
| **Salzburg** | **Olomouc Region** | **North Great Plain** | **North-West** |
| **Styria** | **Prague** | **North Hungary** | **South-Muntenia** |
| **Vienna** | **South Bohemian Region** | **Central Transdanubia** | **South-East** |
| **BA** | **South Moravian Region** | **Central Hungary** | **South-West Oltenia** |
| **BG** | **Centra Bohemian Region** | **West Transdanubia** | **West** |
| **Ruse Pprovince** | **Zlín Region** | **MD** | **SK** |
| **Sofia City** | **DE** | **ME** | **Bratislava** |
| **HR** | **Baden-Württemberg** | **RS** | **SI** |
|  | **Bavaria** | **Vojvodina** | **UA** |

*Source:* <https://s3platform.jrc.ec.europa.eu/s3-platform-registered-regions>

# **Evaluation of current best practice and SWOT analysis of PA7**

As we have already stated in our previous analysis, the countries of the Danube region are quite heterogeneous in terms of research and innovation performance. Based on all the comparisons we made in Chapter 3, we can divide these countries into 4 groups:

1. Germany and Austria;
2. Slovenia, the Czech Republic and Hungary;
3. Slovakia, Croatia, Serbia, Bulgaria and Romania;
4. Ukraine, Montenegro, Bosnia and Herzegovina, and Moldova.

This distribution largely reflects the division based on the EU Innovation Index.

The region is thus heterogeneous not only in terms of the size of countries, their population, but also in terms of innovation performance. This is a constraint that limits cooperation between countries.

In terms of investment in research and innovation, only two Member States have investments higher than 3% of GDP - Austria and Germany. These are followed by countries that are around 2% of GDP - Slovenia and the Czech Republic and countries between 1-2% of GDP - Hungary and Croatia. In the next group are countries between 0.5-1% of GDP - Slovakia, Serbia, Bulgaria and Montenegro. The last group consists of countries, which invest less than 0.5% of GDP - Romania, Ukraine, Moldova and Bosnia and Herzegovina.

There are three countries in the region that have a higher share of tertiary graduates than 40% - Slovenia, Austria, and Montenegro. Austria, Germany, and Slovenia have a share of researchers in the workforce amounting to more than 1%. Another five countries have more than 0.5%. On the positive side, up to nine countries have a higher proportion of female researchers than the EU target of 40%.

In terms of research and innovation activities, Austria and Germany have the highest share of innovative companies, while Romania has an almost negligible share. In Austria, more than 16% of innovative SMEs work with other SMEs. In terms of access to venture capital, Germany leads the list together with Hungary and Romania. Serbia and Slovakia trail at the other end.

Austria, Slovenia and Germany (or its regions of Bavaria and Baden-Württemberg), respectively, are the best participants in Horizon 2020 per capita and per researcher. Non-EU countries have a very low participation. The influence of the EU membership is also reflected in the success of obtaining both projects and the EC contributions. The success rate of non-EU countries is exceptionally low, especially in terms of EU contributions. However, in terms of participation, non-EU countries are comparable to EU countries.

The low participation of non-EU countries in Horizon 2020 projects also results in their low cooperation in joint projects. Cooperation among non-EU countries is very low. These states are more often involved in projects with institutions from Germany and Austria, which is natural, as the success rate increases with the cooperation of research-intensive countries. The fact that the best research within the region is conducted in Germany and Austria is evidenced by a comparison of ERC projects obtained by researchers from these countries, as well as from data on mobility within the MSCA.

Researchers from Austria and Germany have the best results in terms of the number of publications: they are highly represented among the 10% most cited publications. Baden-Württemberg, Austria and Slovenia also have the highest number of publications per million inhabitants. On the positive side, the number of publications published jointly by several countries in the region is growing. We also recorded an increase of citations to publications (up to 2.26 times).

Germany and Austria have the most PCT patent applications per billion GDP, while other countries lag far behind. The same situation applies to the number of patent applications to the EPO, but also to the number of granted patents.

Montenegro and Serbia have the highest share of SMEs with innovative products. However, Germany, Austria and Slovenia have the highest employment in knowledge-intensive services. Germany also dominates in knowledge-intensive services export.

**Table 20 SWOT Analysis**

|  |  |
| --- | --- |
| **STRENGHTS** | **WEAKNESSES** |
| ·       Existing national smart specialisation strategies to support research and innovation (RIS3) | ·       The region is notably heterogenous |
| ·  Strong position of Germany and Austria in the European Research Area | ·       Innovation performance varies widely between countries in the region |
| ·       Improving position of some countries – Slovenia and Czechia | ·       Very low levels of investment in research and innovation in up to 9 countries in the region |
| ·       Established cooperation based on calls announced in PA7 | ·       Low private sector investment in research and innovation in most countries |
|  | ·      Low patent activity in all countries, except for Germany and Austria |
|  | ·      Low levels of collaboration in Horizon 2020 |
|  | ·      Low number of researchers in most countries |
|  | ·      Inadequate research infrastructure in non-EU Member States |
| **OPPORTUNITIES** | **THREATS** |
| ·       Increasing number of joint publications | ·       Insufficient support for research and innovation activities at political level in most of the countries |
| ·       Increasing citations to joint publications | ·       Increasing disparities in the quality of research and innovation between countries in the region |
| ·       Increasing share of population with higher education | ·       Non-EU countries in the Danube region trailing further behind |
| ·       Increasing investment in research and innovation in most countries in the region | ·       War in Ukraine |
| ·       Common calls for proposals, which fund innovation activities |  |

# **Recommendations for improving the current situation**

Based on the presented analysis we recommend that the following suggestions and recommendations be considered:

1. Projects supported within the Danube Region should focus on interconnection and capacity building, which would in turn allow for greater joint participation in other instruments and programmes at European level.
2. A separate part of the Danube programme should focus on the mobility of researchers and students within the region, while maintaining a balanced brain circulation and preventing brain drain.
3. Projects should support the networking of different stakeholders from a variety of sectors - e.g., academic, private, public but also social stakeholders.
4. Short-term placements of researchers, innovators as well as project managers could also be supported within the region to disseminate best practice.
5. The exchange of best practices between public institutions should be encouraged within the region.
6. Separate part of the Danube programme should address the issue of technology and knowledge transfer.