Technology Trends, Artificial Intelligence and Economic Development in the Danube Region

Policy paper on future development areas

December 2021

Prepared by:

Renata Anna JAKSA

Oliver KOVACS

Preface

This report has been prepared in the framework of the project aiming to support AI and economic developments in the Danube Region. The project is titled **Danube S3 Cluster (contract number: DTP2-004-1.1)** within the Danube Transnational Programme.

A first version of the paper was prepared in early 2019, summing up the state-of-the-art aspects and conditions relevant for artificial intelligence in the region. Before stakeholders could act on our findings and recommendations, the global pandemic of COVID-19 hit, and its impacts have reshaped in many aspects of our societies and economies.

This report, updated and re-written to reflect on the changes and challenges of the last 2.5 years aims to continue the work of AI perspectives in the Danube Region, taking into account not only the regional specificities but also the lessons we have learnt from the pandemic.

Table of Contents

List of Graphs

List of Tables

List of Abbreviations

Technological

AAI: Applied AI

AI: Artificial Intelligence

AGI: Artificial General Intelligence

DL: Deep Learning

ICT: Information Communication Technologies

IoT: Internet of Things

FET: Future and Emerging Technologies

FoF: Factory of the Future (Industry 4.0 and more)

HPC: High Performance Computing

ML: Machine Learning

NLG: Natural Language Generation

NLP: Natural Language Processing

RL: Reinforced Learning

RS: Recommendation System

Economic-political

AI HLEG: Artificial Intelligence High Level Expert Group

CORDIS: Community Research and Development Information Service

COVID-19: The SARS-CoV2 coronavirus that broke out in 2019.

DESI: Digital Economy and Society Index

DIH: Digital Innovation Hub

DSM: Digital Single Market

FAQ: Frequently Asked Questions

FP: Framework Programme (Research Framework Programmes of the EU)

GDP: Gross Domestic Product

H2020: Horizon2020, the 8th Research Framework Programme of the EU

IMD: Institute for Management Development (Switzerland)

IPTS: Institute for Prospective Technological Studies

JRC: Joint Research Centre (of the European Commission)

NACE: Nomenclature statistique des Activités économiques dans la Communauté Européenne, Statistical Nomenclature of the Economic Activities of the European Community

NIS: National Innovation System

OECD: Organisation for Economic Co-operation and Development

R&D: Research and Development

R&D&I: Research, Development and Innovation

SME: Small and Medium size Companies

VA: Value Added

Territorial-political

AT: Austria

BA: Bosnia and Herzegovina

BU: Bulgaria

CR: Croatia

CZ: Czech Republic

DE: Germany / Deutschland

DR: Danube Region

EU: European Union

EU: The European Union with 28 member states as of 1 Jan 2019, and with 27 members after the Brexit in 2020.

ENP: European Neighbourhood Policy

HU: Hungary

MD: Moldova

ME: Montenegro

NUTS: Nomenclature of Territorial Units for Statistics

RS: Republic of Serbia

RO: Romania

SI: Slovenia

SK: Slovakia

UKR: Ukraine

Map of the Danube Region

The **Danube Region covers regions** both from some Member States of the European Union (EU) (from Germany: Baden-Württemberg and Bayern; Austria, Slovakia, Czech Republic, Hungary, Slovenia, Croatia, Romania and Bulgaria)[1], and some non-EU countries (Serbia, Bosnia-Herzegovina, Montenegro, Moldova and Ukraine - within that, Odessa, Ivano-Frankivsk, Chernivtsy and Zakarpatya)[2].

1. Graph Territorial coverage of the Danube Region

Source: https://ec.europa.eu/regional_policy/archive/cooperation/danube/images/danube_nuts2.png

[1] For the purposes of this analysis, also called: EU-Danube regions
[2] For the purposes of this analysis, also called: Non-EU Danube regions

Executive Summary

We delve into the **role of Artificial Intelligence** can play in the next 10-15 years in the development of the **Danube Region**, with the proper policy support and adequate financial measures.

Artificial Intelligence (AI) is a pervasive technology, built on a new way of looking at computing. Classic computing provided an initial dataset, a set of rules and expected a new dataset as an outcome of the computing exercise. **In AI technologies, an initial input and output dataset are provided and the machine determines the proper algorithms** to describe the relationship between the two datasets - this is the learning phase. Once the algorithm is defined, it can be applied to new datasets to get the results needed.

Artificial Intelligence is spreading because of three major technological achievements: **i.) fast (parallel) computing technologies, ii.) Big Data availability and iii.) modern sensor technologies.** Fast computing and Big Data add up to new Machine Learning technologies, while modern sensors allow us to measure even more details about our world than before.

Artificial Intelligence technologies are **transforming all walks of life from education, health, public services, to transport, manufacturing and social media**. Although in most areas humankind cannot rely on Artificial Intelligence only, the inclusion of such technologies are bringing value to the economy and society.

Policies regarding AI development are also formulating, on the **supranational, national** but also on **regional level** as well. Policies tackle the **legal and ethical aspects** and foresee the trend of development. Nevertheless, as this technology is fast- changing and pervasive, legislation will have to be formed underway. Special attention should be given to **i.) data and privacy protection, ii). the role and re-use of public sector data, iii.) cybersecurity issues.**

The **Danube Region is a complex and heterogeneous macro-region**, encompassing EU-members, candidate countries and member countries of the European Neighbourhood Policy. Countries vary according to size, population, development level and innovativeness and many other factors. But there are similarities as well.

Very importantly, **industry still plays a significant role in their economies**. Within that**, high-tech industries are on the rise and manufacturing industries have similar features and focus in many of the Danube Region countries**. Within manufacturing industries**, food and beverages production** is top priority in almost each of the countries. **Fabricated metal products, machinery and motor vehicles** are common interest subsectors across the regions. In addition, **rubber and plastic**, as well as **textile and leather industry** are also in top 5 manufacturing industries in several countries.

A general hardship is the increase **in labour shortage**, as many of these countries face lack of workers in several regions. Innovation and automation can handle that to some extent. **But rising wages may lead to middle income trap, unless innovation and increasing productivity can counterweigh**.

A further set of challenges arise from the COVID pandemic of 2020-21. **First, the economic downturn** hit the countries of the Danube Region as well, with no exceptions, in measures comparable to those of the 2008-09 economic and financial crisis. General problems, such as limitations of travel of the workforce, obstacles in international trade and reduction of household income impacted all economic sectors.

Second, the COVID crisis has specific sectoral targets, such as the tourism and hospitality segment, where a complete halt was enforced on the companies.

Third, due to the specific characteristics of the lockdown, **IT and AI has transformed our lives, businesses, perspectives in unbelievable pace**. Home office working, tele-schooling were just the beginning. Several services, previously always conducted in person, had to find their way on to the internet. In paradox, the pandemic that locked people's doors, opened the window for globalisation, both in terms of global services and products. The impacts of these changes and full roll-out of reshaped services can only be estimated at this point (for example the immense spread in use of bots in services).

Fourth, and a bit counterbalancing what has been said before, countries also started to look more inward, being frightened by the possible full-stop of global trade and production. Voices calling for **national autarky** emerged in many countries, and although classical, full autarky is not a realistic scenario, especially for the small and mid-size countries of the Danube Region, steps taken towards increasing national competencies in – at least key – segments and industries are seen and foreseen in many cases. Sectors on top of that list are the energy, the health sector, agriculture and food industries.

Important to highlight, the COVID-19 is not yet over and there is no guarantee that in the next 10-20 years no similar threat will emerge. **Therefore the lessons we learn from the pandemic are crucial to be used for finding solutions and being prepared for a next round.**

Looking at the SME (small and medium size enterprises) demography of the Region, it is rather vivid and complex. The **biggest challenges of SME development are access to finance and labour shortage**. Local SME development can benefit from the **proximity of large industrial enterprises** of the Region and the capacity to take part in supply-chains and clusters.

In the **AI-related research, development and innovation (R&D&I) Danube countries underperform in the Horizon 2020 Framework Programme**, in terms of their share of population. But there is a **significant number of innovators**, originating from the region, who have already added to the AI-assisted world with their new ideas and solutions.

Regarding policy measures and intervention targeting SMEs and AI development, efforts should focus at AI-application, rather than only R&D&I. In case of R&D&I, significant EU funds are allocated for the thematic area, and will be there for the upcoming budgetary period as well. But **specific complementary programmes** should help to prepare the research and innovation actors of the region **to perform better at the European Research scene** and take home a higher share of coordinated research projects.

In terms of **AI application, the focus should be at the uptake of new technologies - regardless of where those had been invented - and the wider use of AI solutions.** True for all technologies that it is not only the investment in the R&D that counts but also the **investment into the application** of that technology.

Due to their pervasive nature, **AI technologies and tools** - such as machine learning technologies, natural language technologies, virtual agents, recognition technologies, biometrics, recommendation systems, decision management tools, fuzzy logic, algorithmic game theory, AI-powered hardware and robotics - **can and will penetrate all aspects of life** from agriculture, manufacturing, services, sales, business management, governance, health, transport, smart homes, aging society challenges, environment and security issues.

The Danube Region shall focus at i.) where its advantages are, ii.) where its most crucial needs are.

As **advantages and strengths**, we can list certain **economic areas** such as **agriculture, manufacturing industries, within those the food industry, machinery and motor vehicles**. **The SMEs** of the region can serve as a basis of AI application, starting from the mid-sized ones, and building on the importance of locality (clusters, hubs, etc.). A European strength in the global AI scene is a favourable **public sector data re-use legislation**, due to the amount of data gathered by public actors. As mentioned before, lessons learnt from the COVID pandemic points toward building stronger national competencies – even if they are not global champions – in the energy, the health sector, agriculture and the food industries.

In terms **of crucial needs**, the countries of the Danube Region must tackle the **challenge of labour shortage** and use **AI-enhanced technologies as well as automation and robotics** in the production chains. Furthermore, AI shall be put to good use not only in industries but **in private and public services** correspondingly, answering the challenges of **public health, aging societies and growing need for modernised education**. The pandemic affected the labour sector two-ways, first, the introduction of general teleworking in many sectors, second, the spread of bots and other AI solutions to replace and/or complement human labour capacities are the most important trends.

Finally, the **complex topic of the environment** must be mentioned. Artificial intelligence, building on high performance computing and vast data storage and processing, does have an **environmental footprint in terms of computing infrastructure**. But it may be overruled by the gains AI can play in increasing **energy efficiency, operating smart homes and smart cities**. The Danube Region should also put efforts on this aspect of AI. Interestingly, the pandemic and the arising need for more self-sustaining economies also draw attention to renewable and more environment-friendly energy sources, simply because a.) many of them have better availability in the Danube Region than classical carbon-based resources, b.) due to the distributed nature of these energy sources a higher resilience can be achieved.

All in all, AI solutions should be **integrated into business and public life** with the appropriate **time and training given to those working and living** with those solutions. Introduction of AI application is not only an infrastructural or technical matter, given its manifold relations to humankind, economy and society.

The Danube Region has the opportunity to be **at the right time, at the right place** to explore the effects of Artificial Intelligence, to invest into innovative solutions and to **gain a foothold in the global AI race** that will - to a large extent - determine who the winners of this century will be.

1. Introduction

This paper supports the **Danube Region Artificial Intelligence Working Group** in a.) identifying the role of technology and Artificial Intelligence in the future of the Danube Region and b.) determining the potential of public intervention and funds for furthering the spread of AI technologies for the benefit of SME and economic development of the region.

The paper looks at the **key questions and definitions related to Artificial Intelligence technologies**, then provides **a concise picture of the main economic trends of the Danube Region, with a special focus at the role of SMEs** and their innovation capacities. The paper **identifies those areas where policy intervention and financial support can provide added value to the economic and technological trends.** The focus is twofold:

a.) it aims to identify **those technology areas** where the Danube Region's R&D and innovation capacities are outstanding, and where technology-oriented, innovative SMEs – collaborating with research institutions and other actors – can create innovations relevant on the European and on the global scene.

b.) it aims to identify **those application areas** where the Danube Region has established its stakes and support would make the most value added for the economy and the society. Several industries and application areas are expected to be transformed by AI in the next 10-15 years, the key question is which have the highest potential specifically.

Taking into account the timeframe of 2021-2027, the analysis works with a **foresight approach**, aiming at identifying those technologies that are emerging now and will be in the focus of technological innovation 5-10 years from now, and also those technologies that will be on the mainstream in that time period, penetrating and transforming the economy and the relevant application areas (transport, health, etc) on a large scale.

The paper also takes into account the impact of the pandemic on these application areas. The most important impacts are identified as:

a.) **The general and sector-specific economic impact** of the COVID-19 pandemic on the countries of the Danube Region (GDP, labour economics, selected sectors, etc.)
b.) The **transformative nature** of the pandemic in terms **of use of IT and AI technologies** (distant working, distant schooling, distancing needs in services, spread of bots, further emergence of the sharing economy, changing trends in the entertainment sector, etc.)
c.) The internal need for security in the nation states call for a **higher level of autarky/self-sustaining in many key industries**, such as the energy, the health, and the agri-food industries. This also brings on a conceptual change in economic development and industrial policy: the switch from global/international competitiveness to local availability.

The paper does not only analyse the potential of the economic actors but also the potential role the **public sector** can play in widespread AI applications of the future.

The paper will, nevertheless, call for – besides sector- and AI specific supports for these key domains – the creation and development of a general innovation and R&D friendly environment in these countries. **Creating a favourable innovation framework is even more important than identifying selected key technology areas to innovate in**, due to the unpredictable nature of innovations. A good basic R&D system with measures to support innovative ideas, start-ups, companies and investors into innovation create the backbone for competitiveness in innovation.

Creating innovative solutions is largely based on two complementary systems: first, a well functioning R&D and innovation system that functions with excellent skilled, talented human resources and proper laboratory and test infrastructure. Second, this must be **embedded into a well-functioning ecosystem** where ideas can be developed into products and services, be tested, get financed and marketed and shared on the global market.

2. Definitions and FAQ

2.1. What are pervasive technologies?

Pervasive technologies are those inventions and developments that **change completely the way we think about technology, economy and life**. Such technologies were fire, steam, electricity, and - emerging in the last half century - ICTs (Information and Communication Technologies). ICTs themselves have different waves of pervasive elements. In information technologies it were for example chips, computation, data storage, in communication it was the emergence and widespread use of various mobile technologies. These technologies transform almost all aspects of our work and life. 15 years ago e-Business, e-Government and e-Health were emerging, today there is no business, government or health without the "e-". **Artificial Intelligence is expected to be the next wave of pervasive technologies** within ICTs.

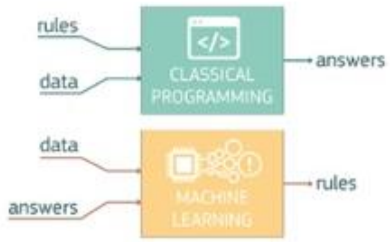
2.2. What is Artificial Intelligence (AI)?

According to the definition used by the European Commission, "*Artificial intelligence (AI) refers to **systems that display intelligent behaviour by analysing their environment and taking actions** – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)."(COM(2018) 237)*

The definition of OECD is: "*The term AI is [...] used when **machines perform human-like cognitive functions such as learning, understanding, reasoning and interacting.** For example, machines understanding human speech, competing in strategic game systems, driving cars autonomously or interpreting complex data are currently considered to be AI applications."* (OECD(2016))

A very helpful explanation on the nature of AI is provided by the experts of IPTS JRC, EC[3]: Artificial Intelligence builds on Machine Learning (ML) that represents a paradigmatic shift in computing. *"Traditionally, a programmer would write computer code setting the rules needed to process data inputs to get an answer as output. **In ML, the computer receives input data as well as the answers expected from the data, and the ML agent needs to produce the rules** (see Graph 2). These rules can then be applied to new data to produce original answers. **An ML system is trained rather than explicitly programmed**.*(Craglia et al (2018))

2. Graph The difference between classical programming and machine learning



Source: Craglia et al, 2018, p.20

[3] IPTS JRC, EC: Institute for Prospective Technological Studies, Joint Research Centre of the European Commission

2.3. What is the timeframe for AI to become part of our life?

Artificial Intelligence **is already influencing our days**. Use email filters, web search engines, social media or streaming services, use your smartphone's camera in portrait mode, it is all AI-based. Intelligent drones, autonomous driving and robotics are also building on AI solutions. AI is more and more present in household technologies as well. The OECD claims that the time needed for new solutions to get **from the lab to the market shrinked progressively in the last five years**, as the private sector is eager to push new products and services on the market. (OECD 2017, p.5.)

Furthermore, we have to take into account not only the AI solutions currently on the market, but also **the expected trends of technological development and the potential of AI-based products and services in 2-10 years time**.

2.4. What are the key tools, technologies of AI?

Artificial Intelligence is built on various Machine Learning technologies. Machine Learning was made possible by two major developments:

A. An accelerating speed of **computing capacities**

B. The enormous amount of information, data gathered (**Big Data**)

Furthermore, AI developments are heavily supported by the spread of various **sensor technologies**, generating all that data that we can build on.

Hereby the most frequent technologies in Artificial Intelligence are presented. Some of these are connected, or sub-sets of each other. Some are pure technologies, others are closer to application areas.

Table 1. Key AI technologies

Machine Learning (ML): algorithms and statistical models derived from training data and used for further analysis. Within that: **Supervised Learning:** ML where the input and output data is precisely labelled, supervised. **Reinforcement Learning:** RL is a dynamic ML with feedback loops, where input and output data are not labelled precisely but the machine receives feedback while it discovers the proper algorithm. **Deep Learning:** DL is a form of Machine Learning, mimicking the working of a human brain, with artificial neural networks/circuits. It is applied for very large and unlabelled, unstructured data sets. Often used for pattern recognition.
Natural Language Technologies: technologies to imitate the use of natural languages. Within that: **Natural Language Processing (NLP):** understanding the structure of sentences, meaning and intention. **Natural Language Generation (NLG):** to generate text that imitates the way natural language is used, naturally-sounded sentences are formulated.

Recognition technologies: until recognition technologies, it was easier for a computer to calculate the thousandth power of a number than to recognize a chair on a picture. Recognition technologies work on that. Within that: **Image Recognition:** detecting and identifying specific objects in a picture (or video). Within that: **Face Recognition, Body language recognition,** etc. **Speech Recognition:** to transcribe human language, with different speakers, accents, various conditions
Biometrics analysis: an intelligent analysis (with ML) built on recognition technologies. Identifying and interpreting human physical features and behaviour.
Recommendation Systems (RS): already widely used technology for recommending ads, search hits, media services based upon previous usage and presumed preferences
Virtual Agents: a technology designed to interact with humans (used in customer services, managers, etc.)
Decision management: as a sub-set of AI technologies, Decision management include those technologies that help to arrive to the right conclusions and to understand the "black box" of AI. At a higher level, Decision management also refers to the role AI plays in a decision making/decision support service.
Algorithmic Game Theory and Computational Mechanism Design: algorithms built on multiple agents' behaviour, on game theory. Designed to analyse complex socio-economic systems.
Fuzzy logic: introduced in 1965 by Lotfi Zadeh, fuzzy logic is a special logic that takes into account not only 1-0 (yes-no) but other values between 0 and 1 as well - 1/3, 1/2, 4/5, etc. In AI it is used for algorithms building on not just black-and-white parameters. A typical application is AI in a washing machine, measuring and adjusting the amount of washing powder needed for cleaning the clothes. It does not only differentiate "clean" and "dirty" but also values in between.
AI-enhanced/powered hardware and robotics: any "traditional" tools, hardware and robot that has an integrated AI element.

Source: own compilation

2.5. What are the key application areas of AI?

Artificial Intelligence technologies penetrate all aspects of our lives, businesses and technologies. The table below gives a short introduction to that.

Table 2. Key application areas of AI

Application area/ Technology	Services, business management, sales	Production	Agriculture	Governance	Health	Transport	Smart Home	Aging society challenges	Environment	Security
Machine Learning Technologies	Communication, filter technologies , social media, personalised banking and finance, predicting costumer behaviour	Lean management, optimalisation of production, identification of opportunities	Better understanding of production conditions, soil, fertilization, chemical treatments, weather, etc.	Improving efficiency of govt. services, better understanding of the citizen	Early diagnosis, treatment options, patent monitoring, pharmaceutical development	Autonomous driving and transport, intelligent drones . Increasing security of transport	Next generation of Internet of Things (IoT)	Care and support of the elderly	Calculation of climate change trends determining key factors	Analysis of security, disaster and terrorism risks
Natural Language Technologies and Virtual Agents	Automatic responses, communication, predictive writing, chatbots, Sales VA	Communication with workforce	Communication with workforce	Automated communication in public services	Automated communication in the health services	Enhanced navigation and comfort	Communication and Household VA	Communication with the elderly, disabled	Shopping assistant for environment-friendly solutions	Crisis/disaster management tools
Recognition Technologies, Biometrics	Image recognition for sales	Workforce security	Plant and animal identification for production and prevention	New personal identification systems for IDs, passports, etc.	Disease recognition from images and behaviour	Identification of environment for autonomous transport	Home security, identification of household members and their preferences	Aids and support for hearing or visually impaired	Mapping environmental trends	Identification of perpetrators and victims
Recommendation Systems	Marketing recommendations, streaming services, video games	Optimising supply chains	Recommen-dation of actions	Better navigation to the public services needed	Early diagnosis and treatment recommen-dation	Enhanced navigation	Energy efficiency recommen-dations	Better services at elderly care centres	Energy efficiency recommen-dations	Emergency solutions recommen – dations
Decision management	Business management, ERP	Optimising supply chains	Production assistance	Personalised protocols	Early diagnosis and treatment options	Autonomous driving and transport Drones	Energy efficiency decisions	Better services at elderly care centres	Identifying potential intervention opportunities	Fast and good decisions in disaster management
Fuzzy Logic, Algorithmic Game Theory	Analysis of business and economic environment, market analysis	Production optimalisation	Production optimalisation	Understanding and predicting complex socioeconomic behaviour	Epidemic control and social behaviour	Analysis of complex social behaviour in transport	Optimal use of cleaning materials	Elderly care people monitoring	Scenario-building	Analysing terrorism, security threats
AI-powered hardware and robotics	Warehouse servicing with drones	Enhanced manufacturing production (Industry 4.1? 5.0?)	AI-powered farm machinery and equipment	Smart city robotic tools, smart infrastructure management	AI-powered medical technologies, surgical tools, AI-based care tools	Autonomous driving and transport Intelligent drones	Next generation of IoT tools	AI care and social companion robots	Smart, AI-enhanced energy efficiency and renewables tools	Disaster management tools

Source: own compilation

2.6. What are the upcoming trends in AI?

There are several technology foresight experts claiming that **AI will dominate almost all areas of our lives**. The question is, though, what will be realised within the next 10-15 years from all the science fiction promises regarding the future relationship of artificial intelligence and humankind. Experts of the **OECD Technology Foresight Forum** agreed that we can expect AI to gain ground in various fields, but mostly as **"Applied AI" (AAI)**, artificial intelligence designed "to accomplish a specific problem-solving or reasoning task". They also coined **"Artificial General Intelligence (AGI)** whereby machines would become capable of general intelligent action, like a human being". Most experts warned though that this may not happen in a realistic time-frame. (OECD(2016))

Many experts agree that the future of AI development for the next 10-15 years will lie in the **convergence process with other science areas**: as other on-the-edge science fields take up AI tools, we can expect a boom in **medical sciences, genetics, pharmaceutical research, environmental research, and also in socio-economic fields, from finance to politics**.

2.7. What is the COVID-19's impact on AI?

The **COVID-19 pandemic has brought AI solutions** even closer to everyday life and business, for several reasons:

a.) There was a **sudden increase in IT skills** in general, since many people were forced to adapt to home office work, online schooling and online leisure activities. Parallel to that, IT had to become even more user friendly than ever, to cater those with more limited IT skillsets to become and stay involved online.

b.) The restrictions posed in many countries on movement, imposing heavier or lighter curfews forced both employees and customers to conduct business from home. The lack of personal contact in shops made shop owners realise **how easy it is to use AI – namely chatbots and other AI-based e-commerce solutions (recommendation solutions, etc)** – instead of, or parallel to human workforce.

c.) The pandemic also caused labour shortage in several key sectors. The restrictions on migratory, short-term labour force **raised the bell for the need in more IT- and AI-based solutions in agriculture and transport.** Though in the current pandemic the crucial shortage was managed by lifting some of the heaviest regulation for agricultural short term workers and drivers in the transport sector, producers and transporters have elevated level of interest in robotisation and automation just to be prepared for the next pandemic.

d.) **The health and social care sectors were most heavily hit** by the COVID-19 because not only were the staff also subject to COVID-19 but the already overloaded human capacities were extremely overloaded with work in hospitals, medical institutions and care centers. The need for **AI assistance in diagnosis, treatment and elderly care is explicit and will drive R&D&I developments in the close future.**

e.) The lack of travel made society to take a significant step towards **Augmented and Artificial Reality**, both in work (teleconferences) and in entertainment (streaming culture experiences, etc.) Though the entry-level services, like simple videoconferencing apps do not rely heavily on AI solutions (apart from fancy background-generating solutions that need image recognition) but the next level services have also emerged, with holographic participants for events. Even Facebook decided to launch its **Metaverse** as its new key project and vision of the future.

f.) In addition to the trends above, another disturbing trend has increased in the last 3 years, though its basis is not purely pandemic-related: **the rise of fake information** is a real threat to societies. AI offers unfortunately aid to those preparing and spreading fake news, but AI can also be a key tool in detecting and neutralizing fake information spreading in the media, especially in social media.

The most important to keep in mind is that in **2018, COVID-19 was just one of the potentially dangerous pathogens circling around and waiting to mutate to a global catastrophe. The lessons learnt in the last three years must channel into both R&D and innovation and also governance** and social thinking, so the world – or at least Europe – can be prepared to some extent before the next crises hit.

2.8. How is AI related to robotics?

AI is about algorithms and learning methods, not about a physical form. **But AI can be added to almost any of our physical tools, machinery, furniture, equipment**, so therefore, to robots as well. Robotics in production (as key components of Industry 4.0[4]), in agriculture and the health sector are definitively benefitting from AI enhancement. Also, there are AI-enhanced humanoid robots, mostly used for social care with children and the elderly and in the tourism sector (as airport guides, etc).

2.9. How is AI relevant for the economy and society?

Artificial Intelligence provides knowledge, therefore added value humanity has not had before. **It provides added value for services, for business applications, for the manufacturing industry, for public services such as health and security.** This added value can be **commercialised** to create market value. Not only European societies will benefit from the spread of Ai technologies, but also - if Europe, and within that, the Danube Region can uphold in the global competition for AI R&D&I - such products and services can be exported.

There are concerns regarding the **effect of AI on employment**, whether AI-supported automation and robotics will eliminate jobs in a volume never seen before. According to a recent survey, conducted with 3,000 company executives across 14 sectors in ten countries (McKinsey Global Institute, 2018), **the effects of AI on inclusive growth will strongly depend** on whether countries will use AI for **i.) various kinds of innovations or ii) simple automation to reduce labour costs.** Furthermore, several countries - including countries of the Danube Region - suffer from **shortage in employment in various sectors**, introducing AI solutions would not hamper sustainable growth, rather contribute to it.

Nevertheless, there are **specific areas, sectors where the introduction of AI should be handled with caution**. We know from history and economics that there is a **complex relationship between the financial sector and the real economy** and the dynamic effects they have on each other. **AI-supported algorithm-based trading can fasten the process of bubble-generation** by leading to increasing criticality in the real economy, all the more, some argue that autonomous pricing algorithms that have

[4] Industry 4.0, also called Smart Factory, is a trend in manufacturing, enhancing - and streamlining - the traditional production methods with automation and the use of information and communication technologies: robotics, Internet of Things tools, sensors, Big Data applications and - more recently - Artificial Intelligence solutions.

been becoming the new norm among online vendors are sought to becoming able to learn how to collude in certain cases by distorting competition and by bringing volatility and criticality to new levels in the economic system. This is why **antitrust agencies are lobbying for preventing a broad-based AI-usage in the financial sector in the interest of a governable ecosystem**.[5]

2.10. Who are the key innovators in AI on the global scale?

The global competition is definitively "on" for AI primacy. The biggest actor is the United States, with such **Silicon Valley giants like Apple, Google, Facebook**. The key driving force is business but also governmental forces (mostly in the defence sector). **The other key actor in AI development is China**, launching its AI strategy that aims to make China the greatest global AI player by 2030. In case of China, the role of the state and public funding is the significant driving force behind. **Europe is also on the global AI map,** with both public and private actors in AI research and development, with the predomination of university and research institute actors over business players.

2.11. What is the institutional framework for R&D&I?

R&D and Innovation are created in a **complex multi-actor framework**, the **National Innovation System (NIS)**, or on a larger scale as the **European Innovation Ecosystem (European Research Area).** The actors include: legislative powers, specific policy and public finance stakeholders, universities and research institutes, large industrial actors, small and mid-size companies (including spin-offs and start-ups), intermediaries like innovation agencies, innovation centres and hubs, private financing actors like business angels and venture capital actors, and, finally, representatives of the civil sector and social innovation. This "soup" of actors is further seasoned by the international, global aspect of knowledge and innovation transfer and the pan-European backing behind the institutional and financial support for R&D&I investments in Europe.

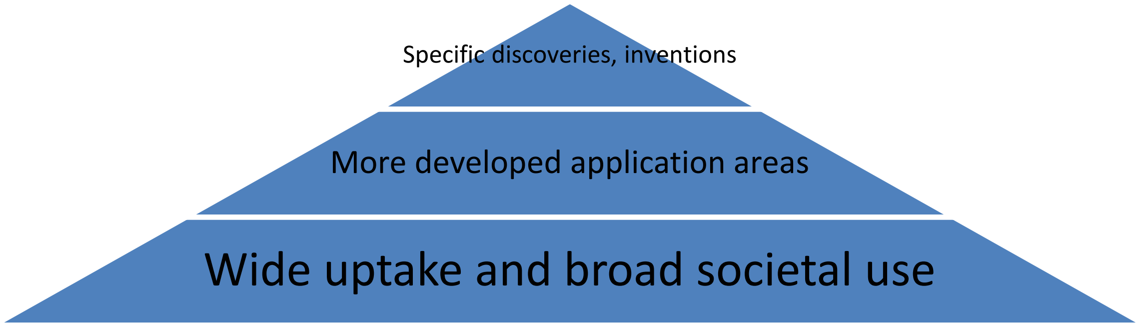
In the over-simplified model of a National Innovation System, the scientific output created by the basic research actors is further developed, then applied and commercialised by business actors of the NIS. Due to internationalisation of R&D and innovation**, this process does not necessarily stay within national or continental boundaries**.

2.12. How do inventions diffuse?

It is also important to note that **not all basic - or even applied - research output gets translated into business applications**, and that a good research output may translate into not one, but many commercialised solutions. **With the spread of a good innovation, more and more companies apply that into their products and services, and the socio-economical value and use of the invention multiplies.** It is not only the discovery or the invention that **creates economic potential but the wide uptake of the new, disruptive and pervasive technologies.**

[5] See: Ezrachi and Stucke (2015) or Calvano et al. (2018). In addition, AI-supported machine learning in credit markets can aggravate further inequalities in the society.

3. Graph The pyramid of R&D&I diffusion in society



Source: own compilation

3. Policy and strategic background for AI and the Danube Region

3.1. The European setting for AI

The **Digital Single Market (DSM) Strategy for Europe**, a policy document for digitisation of Europe, formulated in 2015, does not mention Artificial Intelligence. Yet, it is responsible for creating **the main digital and industrial framework** needed for the development and spread of AI in the future. (COM(2015) 192 final)

The DSM aims to:

- Ensure the **free movement** of goods, services, persons and capital in the digital arena as well, improve **online access** of people and businesses in terms of **infrastructure** but also in terms of **access rights and possibilities.**
- To create the **proper framework conditions, regulation** for the digital society, reinforce trusts and security, protect personal data.
- To maximise the growth potential of the Digital Economy, with special attention given to **data ownership, cloud services and Big Data developments** (which are **prerequisites of AI**).

On 25 April, 2018 the **European Commission issued its AI initiative, embracing Artificial Intelligence** as part of our European life, not just as science fiction.(COM(2018) 237 final)

It refers to the EU's advantages in AI such as:

- The **world-class research scene** of Europe that is active in AI (as well as in robotics).
- The excellent **European industries** that are eager to apply AI (**transport, healthcare and manufacturing** are highlighted).
- The **regulatory framework** of the **Digital Single Market** that provides data protection while allowing the free flow of data where it is necessary. The DSM also underpins cybersecurity and connectivity.
- An **immense amount of data from the public, the research and the health sector** that can be used for AI.

The AI initiative intend to:

- Further **develop the technological and industrial activities and capacities** in AI uptake (R&D&I, data access)
- Support **the societal changes** (in education and training, in the labour market, etc)
- Formulate the **proper ethical and legal framework** for AI

On **21 April, 2021, the European Union opened up its proposal for laying down harmonised rules on AI** and to amend to existing legislative acts. The document aims to:

- ensure that AI systems placed on the Union market and used are safe and respect existing law on fundamental rights and Union values;
- ·ensure legal certainty to facilitate investment and innovation in AI;
- ·enhance governance and effective enforcement of existing law on fundamental rights and safety requirements applicable to AI systems;

- ·facilitate the development of a single market for lawful, safe and trustworthy AI applications and prevent market fragmentation.

Regarding societal take-up, the initiative nominates the **AI-focused Digital Innovation Hubs** (DIHs) as key actors **in facilitating access to AI technologies for the larger public, especially for SMEs**. The EU will also target mobilising private investments into the area: the European Fund for Strategic Investments, the European Investment Bank and the VentureEU aim to support European industrial excellence in AI.

The **European Commission** set up a **High-Level Expert Group on Artificial Intelligence (AI HLEG)** [6], composed of 52 experts with various backgrounds (industry, academia, civil society) to work on strategic advice and policy recommendations in the field of AI (report expected in May 2019).

Parallel to the EC's efforts, the **OECD** has also set up its own **Expert Group on AI in Society**[7] to draw up the principles related to societal use of Artificial Intelligence. The OECD will form its OECD Council Recommendations based on the work of the Expert Group.

Several European countries have digital strategies that also address Artificial Intelligence. Germany has declared its AI strategy [8] The strategy addresses the two evident axes of AI development: supply (R&D) and demand (take-up, application areas) but also pinpoints the need "to develop a European solution for **data-based business models** and find **new ways of creating value from data** that correspond with our economic, value and social structure." [9] Even certain regions, such as Baden-Württemberg of Germany, decided to formulate their own Artificial Intelligence position.[10]

3.2. Legal and ethical considerations

The most common concerns for AI development are **legal and ethical considerations.**

First, Artificial Intelligence builds on learning from data, and **collection, storage and management of that data may be in conflict with our right to privacy**. The protection of such data needs even further emphasis once the use of Artificial Intelligence becomes more common.

Second, with the accelerated development of various **recognition algorithms, further sensitive data** can be generated from sources previously not used. Legislation must be ready to tackle that as well.

Third, specific fields such as **governance, political views, health, banking and finance** shall be given special attention regarding data collection, access and data sharing regulation, taking into account the counter-interest of personal privacy versus political and business interests.

Moreover, there are not only legal and ethical limitations to the use of data but also **obligations**. The **public sector** collects a tremendous amount of data that are often not utilised to the full capacity.

---

[6] See: https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence
[7] See: http://www.oecd.org/going-digital/ai/oecd-initiatives-on-ai.htm#expert-group
[8] See: https://www.bundesregierung.de/breg-en/news/ai-a-brand-for-germany-1551432
[9] See: https://ai-europe.eu/exclusive-german-ai-strategy-paper-in-english/
[10] See: https://www.digitorial.digital-bw.de/download/20181220_Positionspapier_KI_BW_Kurz_EN.pdf

Public sector data includes all information gathered, collected and stored by public bodies. Public sector data is paid for by the public. With the exception of specific data[11], **public data shall be made available for further analysis and use**, as the Directive on the re-use of public sector information (Directive 2003/98/EC, amended by Directive 2013/37/EU) states.[12]

Re-use of public data not only supports transparency of the public sector but also creates a fertile environment for developing various new services in the **framework of the internal market**. Since Artificial Intelligence requires vast amount of data for its learning process and the services offered, a **harmonised, cross-border availability of European public sector data can provide the key** momentum for European AI actors to promote their global position in AI research and applications.

3.4. Cybersecurity

The need for proper **(cyber)security measures and legislation** has to be highlighted. Whether private or public data, the protection of sensitive information must be ensured. But there is much more to cybersecurity in the field of AI applications. From the **protection of critical infrastructure (e.g. energy networks supported by AI solutions**) to the **prevention of harm and disservice in health AI solutions,** cybersecurity measures are expected to be one step ahead of cybercrime.

In terms of the Danube Region, it has to be examined in detail where are the **specific cyber-risks** for the region and how to tackle those: critical infrastructure of the region, particular security threats (e.g. geopolitical conflicts and their cybersecurity hazards).

3.5. Environmental considerations

Artificial intelligence requires **high performance computing and vast data storage**. As it happens, these two require **massive amounts of energy.** The **"data tsunami"** can consume **20% of global electricity by 2025** and all devices connected to the internet could produce 3,5% of global emissions by 2027 (Vidal, 2017).

There is a **European Code of Conduct for Data Centres[13]- a voluntary initiative** aimed at improving the energy efficiency in data centres across Europe. The Code of Conduct identifies key issues and challenges and offers a best practice guide. But, as a non-compulsory, non-legislative code, its effects are limited. European experts have found that Nordic countries have a better advantage to use natural cooling to reduce energy consumption at data centres (Bertoldi et al, 2017), the Danube Region does not have that advantage.

Researchers of the JRC (Craglia et al, 2018) see this trend as **an opportunity for innovation**: improved computing and graphic processing units, energy-saving and parallelisation computing, innovative and more efficient cooling systems/engineering solutions, innovative infrastructures, architectures and

[11] The Directive names grounds for exclusion: the protection of national security (i.e. State security), defence, or public security, statistical confidentiality, commercial confidentiality (e.g. business, professional or company secrets); protection of personal data, etc.
[12] For more information see: https://ec.europa.eu/digital-single-market/en/european-legislation-reuse-public-sector-information
[13] Fore more information, see: https://ec.europa.eu/jrc/en/energy-efficiency/code-conduct/datacentres

configurations can **help to reduce the environmental harm** caused by our technological development in ICTs.

Nonetheless**, AI development must take into account the need to reduce its environmental footprint**.

3.6. The Danube Region

The European Union prepared its first specific strategy for the Danube Region in 2010, realising the need to address the challenges and opportunities facing the people living along the EU's greatest river. **The Danube Region covers regions** both from some Member States of the European Union (from Germany: **Baden-Württemberg and Bayern; all regions from Austria, Slovakia, Czech Republic, Hungary, Slovenia, Croatia, Romania and Bulgaria**)[14], and some non-EU countries (all regions from Serbia, **Bosnia-Herzegovina, Montenegro, Moldova and four regions of Ukraine:** Odessa, Ivano-Frankivsk, Chernivtsy and Zakarpatya)[15].

Since the Danube Region accounts for **115 million inhabitants**, it is organically embedded into Europe and there is a mutually dependent relationship between the performance of the macro-region and that of the European Union in the age of digital knowledge economies. (COM(2015) 715 final)

The **region faces several challenges** in the areas of mobility, energy, environment, environmental risks, socio-economic development and security. **The region also has many opportunities**, such as its existing transport and trade links, its solid education system, cultural, ethnic and natural diversity, renewable energy sources and environmental assets.

3.7. The role of the Danube Region in AI policy and strategy setting

On the one hand, **the Danube Region does not need to create its specific regulation**: it can rely on the European legislation principles. The non-EU countries can decide on their level of harmonisation with the EU acquis.

On the other hand, **the Danube Region can work on its own AI-related strategy**, defining the key AI-related areas where public support - funding and other efforts, such as networking, awareness raising, etc - would focus. These strategic areas may contain **certain AI technologies, where European and Danube Region R&D&I actors have expertise**, but even more importantly, it can focus **at application areas that are crucially important for the socio-economic development of the region.**

Furthermore, the countries and regions of the Danube Region **can facilitate the local AI development by ensuring that public sector information is made ready for re-use**, both from legal as well as from technical points of view.

As already described above, the Danube Region has also learnt **significant lessons from the disruption the COVID-19 pandemic caused**. It is foreseen that in upcoming regulations, those impacts will be considered and included, let it be about labour regulation, mobility and transport solutions or increasing self-sustainability of local economies.

[14] For the purposes of this analysis, also called: EU-Danube regions
[15] For the purposes of this analysis, also called: Non-EU Danube regions

4. Economy and Innovation in the Danube Region

The aim of this section is twofold. **On the one hand, it gives an overview about the current condition as well as the strength of the Danube region's innovation ecosystem**. On the other hand, it outlines whether the Danube Region offers a fertile ground in terms of **SMEs' maturity for the wide and efficient use of Artificial Intelligence**.

In our analysis we use **quantitative as well as qualitative methods** (e.g. Digital Economy and Society Index, DESI, established by the European Commission; publically available databases such as Eurostat, World Bank Development Indicators, OECD etc.).[16]

This section is structured as follows. First, it presents shortly **the innovation ecosystem** of the Danube Region. Second, it gives a comprehensive account on the **socio-economic performance** of the Danube region and presents the **industrial milieu** of the macro-region relevant for **SMEs' development.** Finally, the **major prerequisites of ICT and AI development** are presented.

---

[16] **Methodological Note**

This paper aims to support its statements with proper statistical data and analysis. Nevertheless **there are major limits to collect updated, systematic and comparable datasets** on the Danube Region. The main reasons for this are twofold:

1. **Except for Germany and Ukraine**, all other countries participating in the Danube Regions are participating **with all their regions**. In order to present their socio-economic and technological development it would be enough to gather **national statistics**. But because **Germany and Ukraine** are the two biggest countries related to the Danube Region and they **participate only with selected regions**, it would be ideal to use the NUTS-2/regional level data specifically for Baden-Württemberg and Bayern, as well as for Odessa, Ivano-Frankivsk, Chernivtsy and Zakarpatya.

But the amount of data collected by Eurostat differs at the NUTS1 (country, national) and NUTS2 (regional) level. Furthermore, there is no comparable regional data collected for the Ukrainian regions. So the analysis **can either use national level data as a proxy to estimate Germany's and Ukraine's development, or it can use regional data with several gaps.**

2. Out of the non-EU regions, **some are candidate countries to the EU** (Serbia, Bosnia-Herzegovina, Montenegro) and **some are not** (Moldova, Ukraine, both being European Neighbourhood Policy, ENP countries). The EU member countries have their statistical methodology and data collection fully harmonised according to Eurostat standards. But that is not the case for non-EU countries.

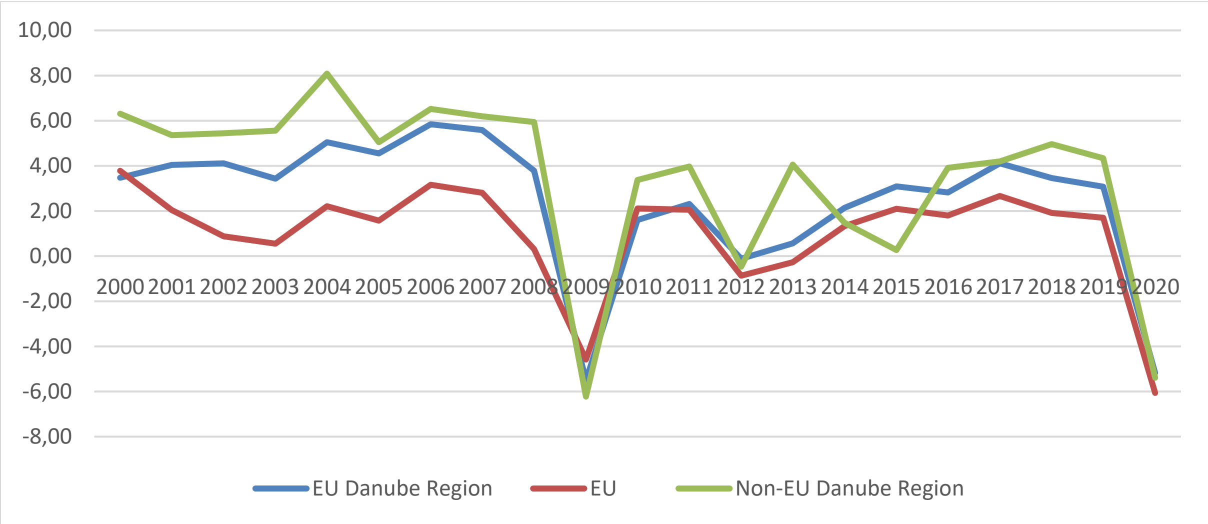
Even among non-EU countries, for candidate countries the data collection is on its way to harmonisation with Eurostat methodology while for non-candidate countries this is not the case. **So the best and most detailed data is available for EU-members, some limited data is available for candidate countries, and very limited comparative data is available for non-candidate non-members.** This limits all exercises building on the comparativeness of datasets.

The bottom-line is: our approach is to **a.) use national level data when NUTS-2 regional is not available**, as the indication of main socioeconomic trends and **b.) use only comparable data and if that is not available for certain countries, then those countries are left out of the given dataset**.

4.1. The innovation ecosystem in the Danube Region

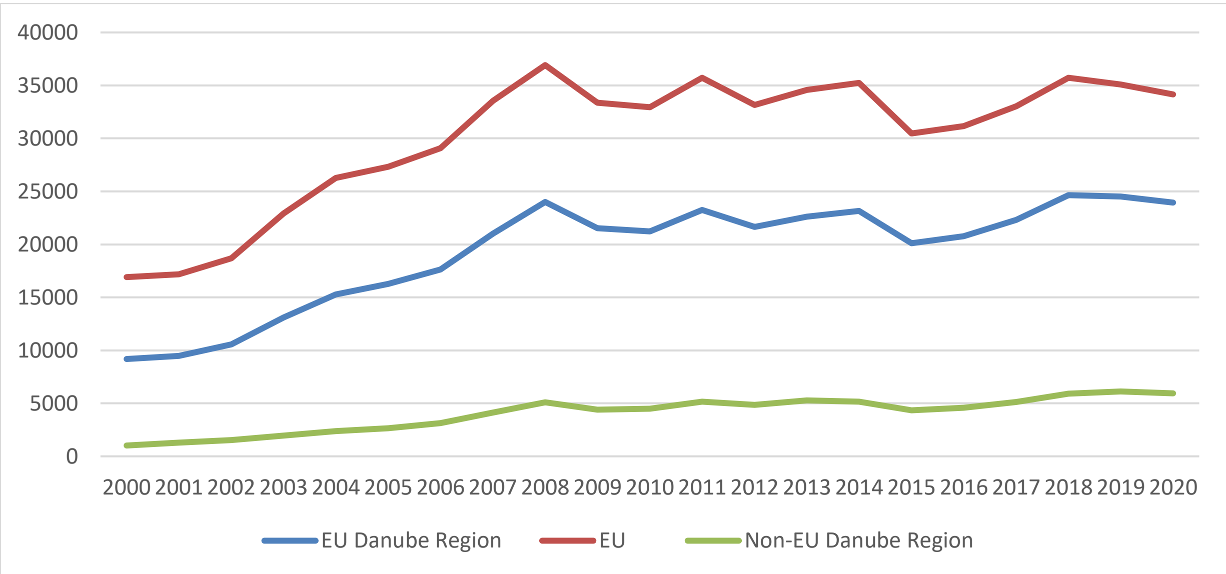
Before the 2008 financial and economic crisis EU-member Danube regions had hovered around 4% annual growth rate being somewhat behind that of the level of non-EU Danube regions (Graph 4). Nonetheless, **recovering from the crisis was relatively smoother in case of EU-member Danube region countries**. EU members only approached pre-crisis level by 2017, while non-EU members are still lagging behind. **The level of development - GDP per capita level** - differs significantly between the EU and non-EU members of the Danube Region. The average of both groups fall below that of the EU average, even though Austria and Germany pass that level individually. The **COVID-19 pandemic caused a drastic decrease in GDP levels in all three groups**.

4. Graph GDP per capita growth in EU and non-EU Danube regions (annual %)



Source: World Bank Development Indicators

5. Graph GDP per capita, PPP (current international $)



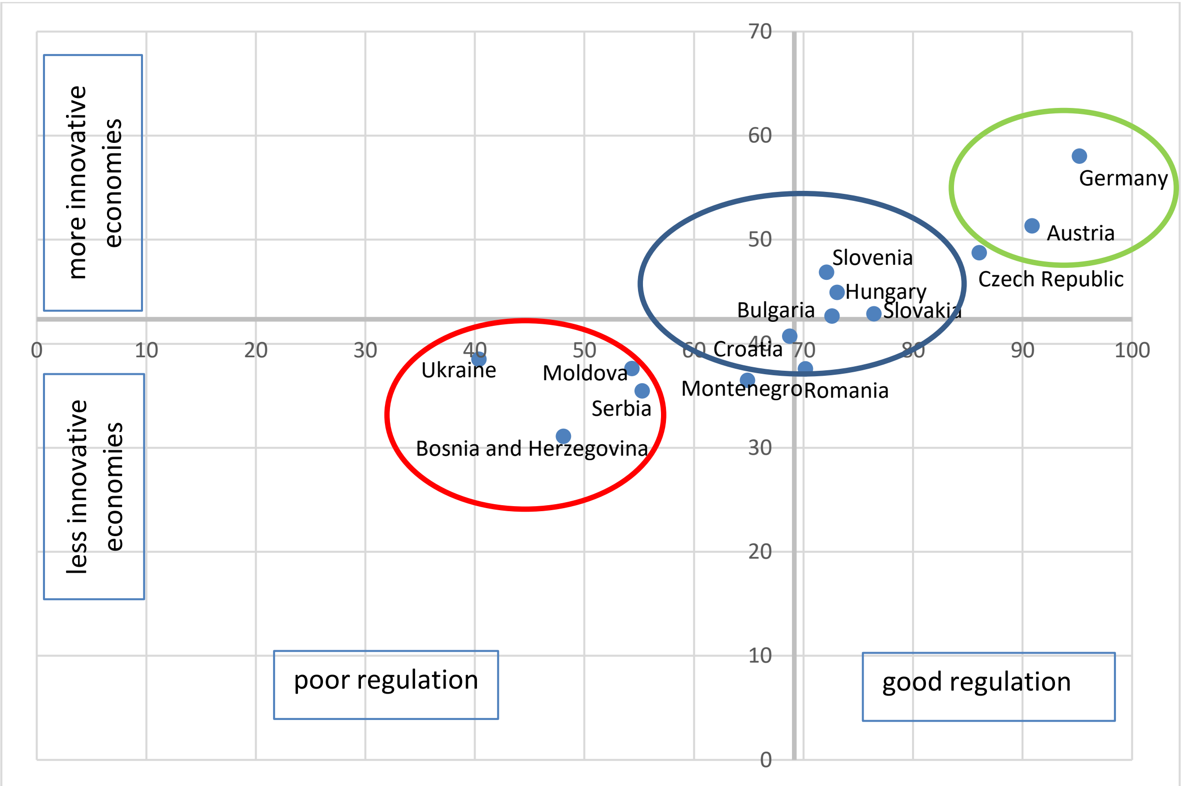
Source: World Bank Development Indicators 2019.

In an era of hyper-globalisation, modern economies have to pursue a healthy integration into the world economy in an effort to foster and maintain international competitiveness via innovations and smart adaptations of known practices to the local circumstances. This implies that **an innovation-oriented country requires a government with an improving regulatory quality** in supporting the risk-taking ability of the private sector, especially that of the SMEs.

Graph 6 depicts that there is **a great divide among Danube regions in terms of innovativeness and regulatory quality**. Innovativeness relies on how effective is the governance, ultimately on the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. According to this relationship, there are at least three clusters of regions:

(i) **good performers** (i.e. countries showing better regulatory quality and more innovativeness, such as Germany, Austria and the Czech Republic);
(ii) **moderate performers** (i.e. hovering around the averages: Slovenia, Hungary, Slovakia, Bulgaria, Romania, and Croatia); and
(iii) **lagging performers** (i.e. countries showing poor regulatory quality and less innovativeness such as Montenegro, Serbia, Moldova, Bosnia and Herzegovina and Ukraine).

6. Graph Regulatory quality and innovativeness of Danube Region countries

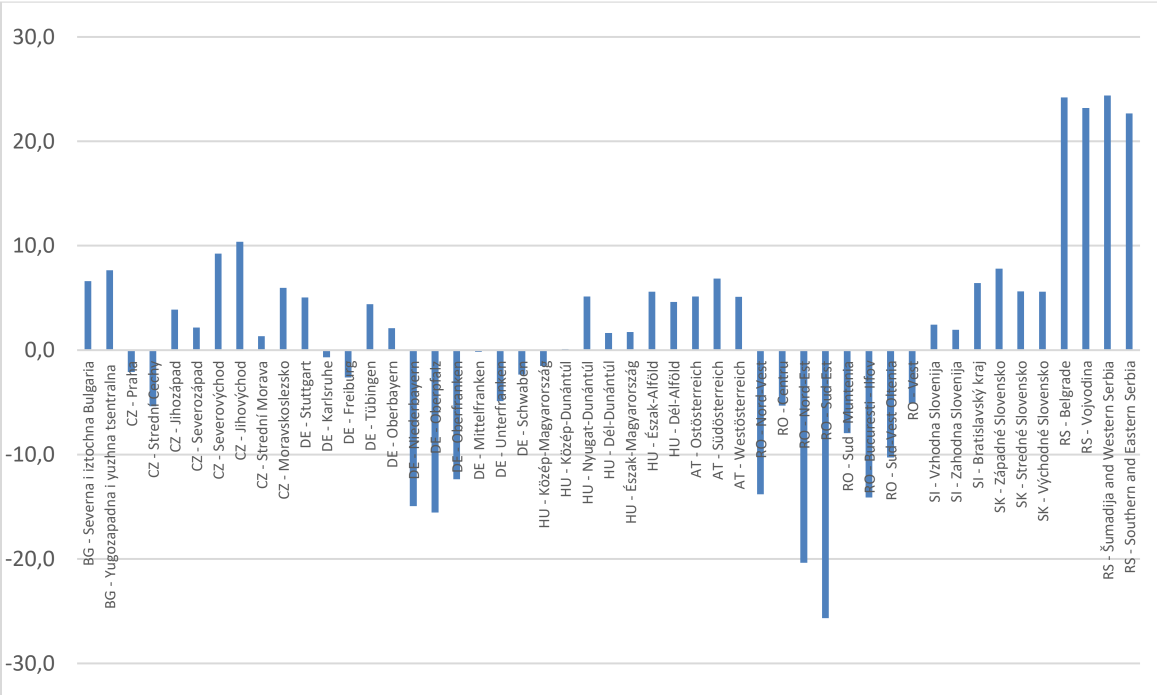


Note: horizontal axis refers to the indicator entitled as regulatory quality of the World Governance Indicators prepared by the World Bank for the year 2017. Regulatory quality reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Vertical axis captures the positions of the countries analysed in the Global Innovation Index 2018.
Source: World Bank, Global Innovation Index

Graph 7 offers a relatively more detailed (but also limited since some regions are not covered) look at **the innovation performance of the Danube regions**. According to the Regional Innovation Scoreboard dataset, 67% of the regions involved could register an improvement in terms of innovativeness between 2009 and 2017. (As the collection of time series ended, there is no available update on the data.)

Serbia showed one of the most striking improvements compared to other Danube regions analysed since the **innovation performance** of Serbian regions approached and even surpassed the levels of Bulgaria, two Czech regions, that of the Hungarian regions (except the Central Hungarian one), Romanian as well as Slovakian ones.[17] The relative rise of Serbian innovativeness might be surprising, however, more and more evidence suggest that Serbian companies recognised the central importance of investing in human capital (intellectual capital) in enhancing competitiveness.[18] The regions that seem to have not been able to cultivate innovativeness in a more dedicated way by resulting in big declines were as follows: mostly the German Bayern regions and the predominant part of Romanian regions.[19]

7. Graph The development of innovativeness of the Danube regions (relative to the EU, changes between 2009 and 2017)



Note: data represent the scores of the Regional Innovation Scoreboard 2017 - Relative performance to EU in "2011". The following countries and their regions are not covered by the scoreboard: Bosnia and Herzegovina, Moldova, Montenegro and Ukraine.
Source: European Commission, Regional Innovation Scoreboard.

Modern theories of competitiveness underlines the **importance of innovation poles**, i.e. a region (or a few regions) serving as the main engine of growth. By now it is widely accepted that the regional concentration of growth is high. Today, one third of the growth of a typical OECD country is given only

---

[17] For more on the documented improvement of innovation performance in Serbia, see: Cvetanović et al. (2018).
[18] See: Cabrilo et al. (2018).
[19] Let us add that the economic structure heavily influences the performance of regions that can be very close to each other by showing entirely different levels of innovativeness (e.g. one can see this by looking at Austria: Vienna with its industry-oriented structure and Burgenland coupled with its agriculture-orientation are very close to each other). See: Czakó et al. (2014).

by 5% of the regions.[20] Therefore the performance of these key regions or potential innovation poles is of crucial importance.

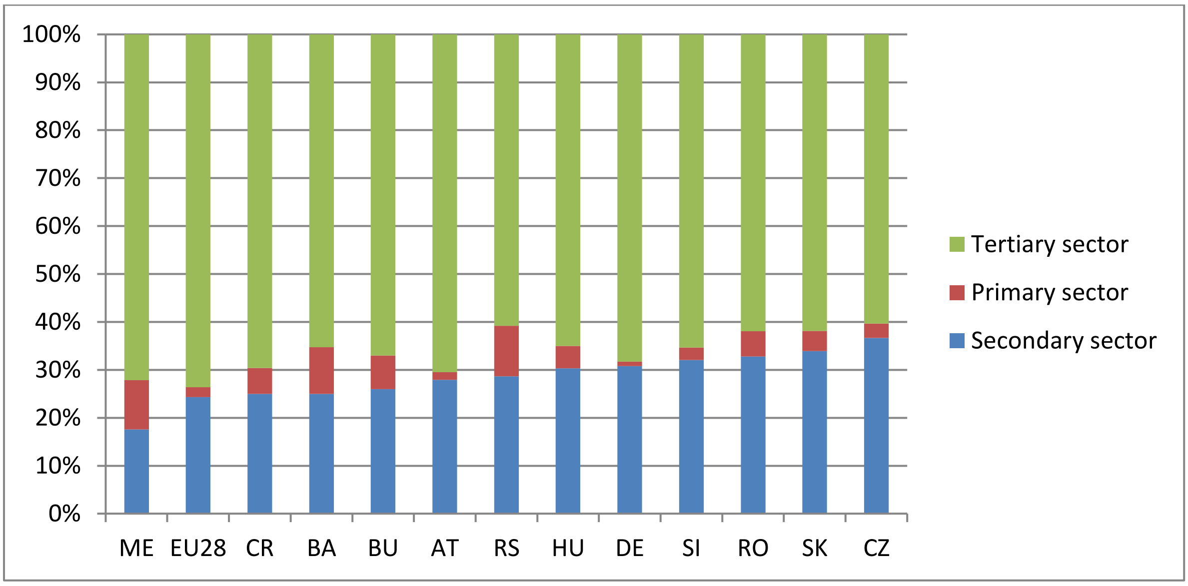
4.2. Sectoral patterns and labour market

4.2.1. Sectoral decomposition of GDP

The **sectoral decomposition of GDP** shows the level of development in terms of the share of the various sectors of the economy **in the total performance**. (see Graph 8)[21] **The primary sector** - agriculture, fisheries and mining - **reach 10% of the total economy only in Serbia, Montenegro and Bosnia and Herzegovina**. **In all other countries it stays below 10%,** being only 1% in Germany and 2% for the EU average.

The year 2016 is depicted below as a model year for these countries' performance in the 2010s.

8. Graph GDP decomposition by main sectors, 2016



Data for Ukraine and Moldova not included.
Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)

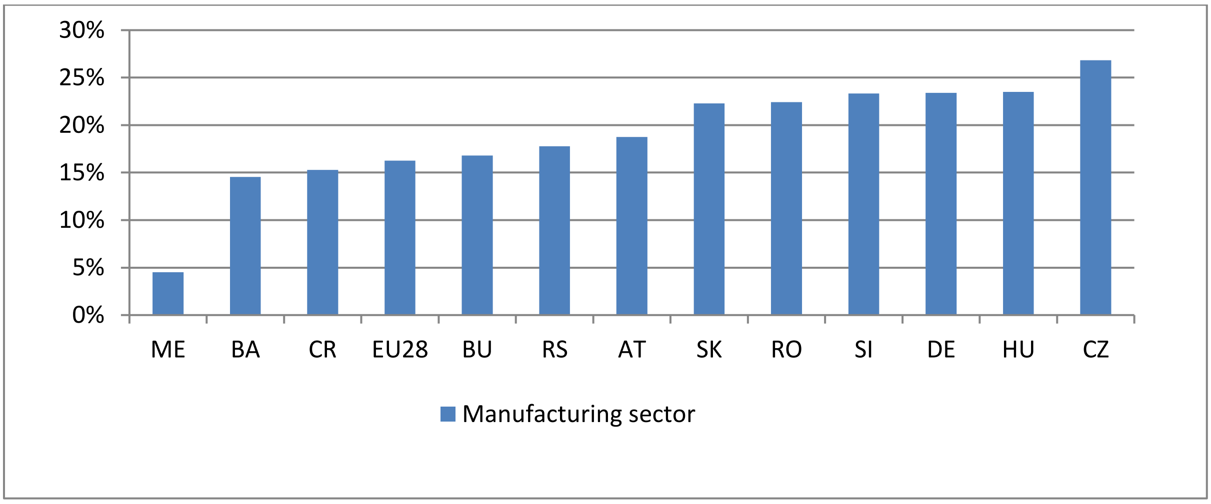
The secondary sector - **manufacturing, construction, energy and water supply** - carry a lot of weight in these countries, for the exception of Montenegro, **all countries have a larger share of secondary**

[20] See: OECD.Stats
[21] Primary sector in terms of NACE codes: A - Agriculture, forestry and fishing, B - Mining and quarrying
Secondary sector: C - Manufacturing, D - Electricity, gas, steam and air conditioning supply, E - Water supply; sewerage; waste managment and remediation activities, F - Construction
Tertiary sector: G - Wholesale and retail trade; repair of motor vehicles and motorcycles, H - Transporting and storage, I - Accommodation and food service activities, J - Information and communication, K - Financial and insurance activities, L - Real estate activities, M - Professional, scientific and technical activities, N - Administrative and support service activities, O - Public administration and defence; compulsory social security, P - Education, Q - Human health and social work activities, R - Arts, entertainment and recreation, S - Other services activities, T - Activities of households as employers; undifferentiated goods - and services - producing activities of households for own use, U - Activities of extraterritorial organisations and bodies

sector in the total GDP composition than the EU average (24%). The share of the tertiary sector - services - is between 60% and 72%, all below the EU average (74%). **The region is therefore clearly characterised by a larger-than EU average secondary, and a smaller-than-EU average tertiary sector.**

The **importance of the manufacturing sector** in these economies is even more conspicuous when presented alone, as share in total GDP (see Graph 9). The EU average is 16%, which is almost attained by Bosnia and Herzegovina as well as Croatia, and well surpassed by the rest of the countries except Montenegro.

9. Graph The share of the manufacturing sector in total GDP, gross value added, % (2016)



Data for Ukraine and Moldova not included.
Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)

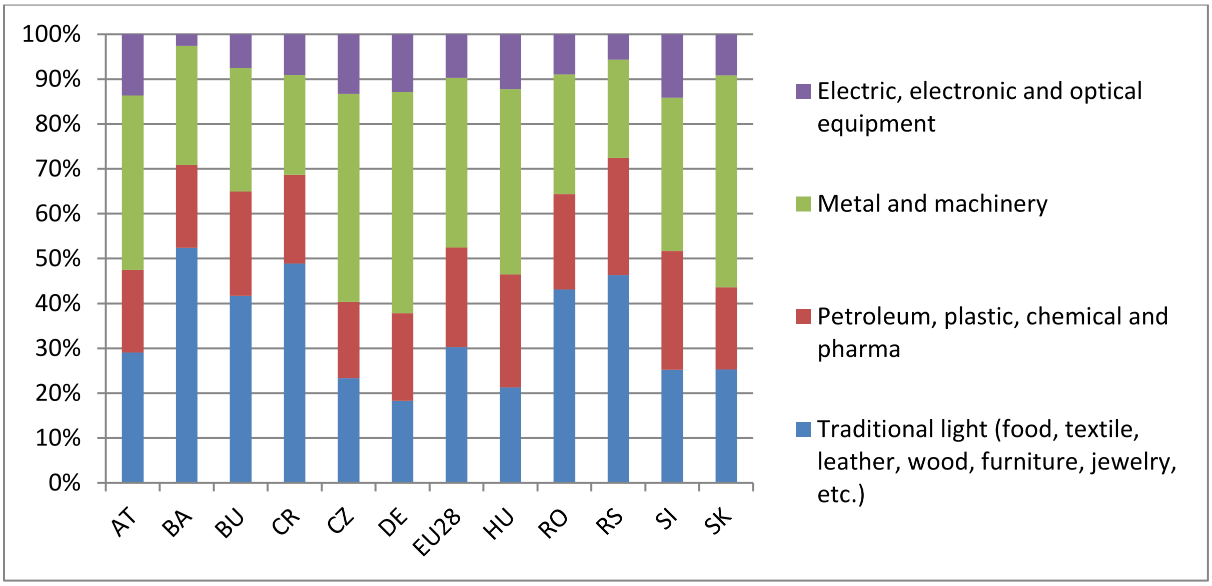
4.2.2. Sub-sectoral decomposition of GDP

Looking at the **composition of the manufacturing sector**[22] itself (Graph 10), the specificities of the region -in comparison with the EU main trends - are not that obvious.

In the Balkan countries, the **share of traditional light industries** is still more significant than elsewhere. The **chemical industries** have a share of 17-26% not only in the Danube Region countries but also in the EU average. **The metal and machinery industries are most important in Germany** (49%), Slovakia (47%), the Czech Republic (46%) and Hungary (41%) within the total manufacturing sector's contributions to GDP (EU average is only 38%). The **share of electric, electronic and optical equipments** vary between 3 and 14%, the EU average being 10%.

[22] For this analysis, the traditional light industries include NACE categories 10-18, 31-33. Petroleum, plastics, chemical and pharma industries cover NACE codes 19-23. Metal and machinery are composed of NACE 24-25 and 28-30. Electric, electronic and optical equipment are NACE 26-27 activities.

10. Graph Share of sub-sector groups within the manufacturing sector, % (2016)



Data for Montenegro, Ukraine and Moldova not included.
Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)

In order to better identify the common features across the Danube Region, the **top 5 subsectors** per country are presented, regarding their contribution to total manufacturing value added. Table 5 allows for identifying the commonalities even though each country has a specific manufacturing profile.[23]

Table 3. Top 5 sub-sectors within manufacturing, %of total manufacturing VA, 2016

BU	CZ	DE	CR	HU	AT	RO	SI	SK	RS	BA
Food & beverages	Motor vehicles	Motor vehicles	Food & beverages	Motor vehicles	Machinery	Food & beverages	Fabricated metal products	Motor vehicles	Food & beverages	Food & beverages
Textiles, leather	Fabricated metal products	Machinery	Fabricated metal products	Food & beverages	Fabricated metal products	Motor vehicles	Electrical equipment	Fabricated metal products	Fabricated metal products	Fabricated metal products
Fabricated metal products	Food & beverages	Fabricated metal products	Non-metallic minerals	Machinery	Food & beverages	Coke and refined petroleum	Pharmaceuticals	Rubber and plastic	Rubber and plastic	Textiles, leather
Machinery	Rubber and plastic	Chemicals	Pharmaceuticals	Comp., electronic and optical	Electrical equipment	Textiles, leather	Motor vehicles	Machinery	Textiles, leather	Wood and cork
Non-metallic minerals	Electrical equipment	Food & beverages	Textiles, leather	Fabricated metal products	Basic metals	Electrical equipment	Rubber and plastic	Food & beverages	Motor vehicles	Basic metals

Data for Montenegro, Ukraine and Moldova not included.
Source: Eurostat, National accounts aggregates by industry (up to NACE A*64)

Food and beverages are present in top 5 in each country except for Slovenia (where it takes the 6th place). **Fabricated metal products** are also represented in each country's top 5, except for Romania (7th position). **Motor vehicles** made top5 in 7 of the 11 countries analysed.

Textile and leather products are in the top5 on 5 occasions, but only in the five countries of the Balkan peninsula. **Machinery** is listed 5 times: for Germany, Austria, Hungary, Slovakia and Bulgaria. Electrical

[23] NACE codes: Food, beverages and tobacco products: 10-12, Textiles, wearing apparel, leather and related products: 13-15, Wood and cork: 16, Paper: 17, Printing: 18, Coke and refined petroleum products: 19, Chemicals: 20, Pharmaceuticals: 21, Rubber and plastic: 22, Non-metallic minerals: 23, Basic metals: 24, Fabricated metal products: 25, Computer, electronic and optical products: 26, Electrical equipment: 27, Machinery: 28, Motor vehicles: 29, Other transport equipment: 30, Furniture and other manufacturing: 31-32, Repair and installation: 33

equipments are in top5 for the Czech Republic, Austria, Slovenia and Romania. **Rubber and plastic** are also key industries in 4 countries: Czech Republic, Slovakia, Slovenia and Serbia.

Based on this, the following lines of manufacturing activities seem to emerge as **commonalities across the Danube Region's economies:**

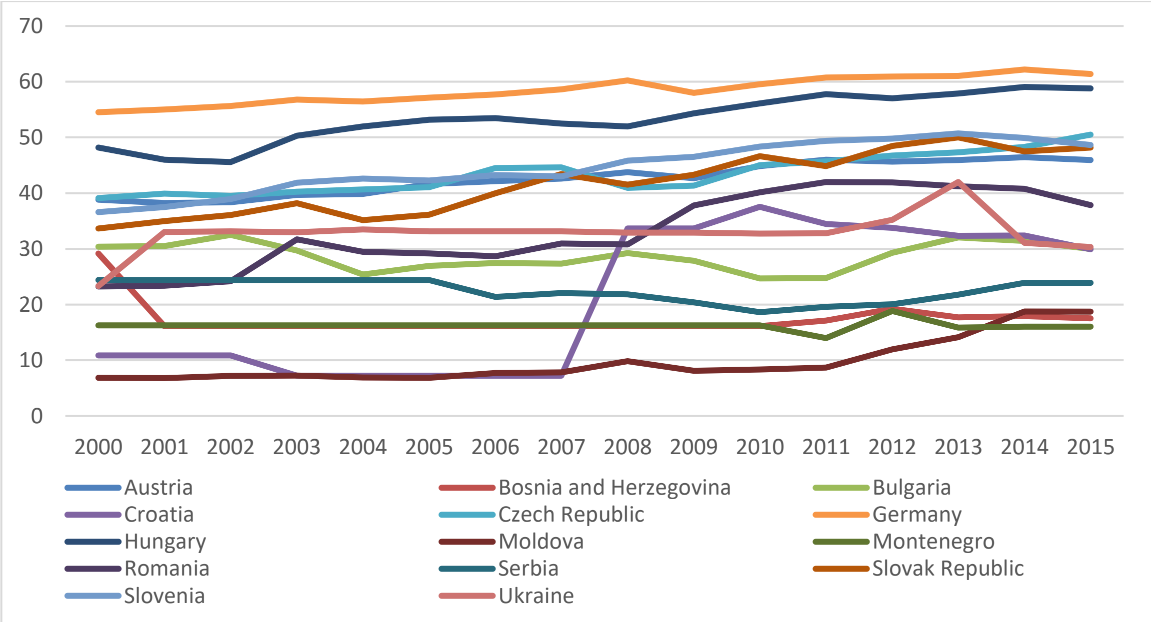
- Local **agriculture and related food and beverages production**
- **Fabricated metal products, machinery, motor vehicles**

In addition, **rubber and plastics** production and **textile and leather industry** are also in place in several countries.

Selected other manufacturing areas, like **pharmaceuticals, computer, electronic and optical products, wood and cork industry** are not common across all the Danube region but weigh significantly in the local economies' performance in certain countries.

What is more, there has been a real progress in **medium and high-tech industrial activity** in most of the Danube regions as Graph 11. shows.

11. Graph Medium and high-tech industry (including construction) (% manufacturing VA, 2015)



Source: World Bank, World Development Indicators.

Of course the dynamics are different for each country. For instance Croatia quadrupled, while Moldova doubled their annual industrial value added in the period 2007 and 2017 while others stayed at a more constant level. **The general ameliorating trend can cultivate and industrial system along the Danube regions being a potential candidate for the effective use of AI related pervasive technologies.**

4.2.3. Labour market

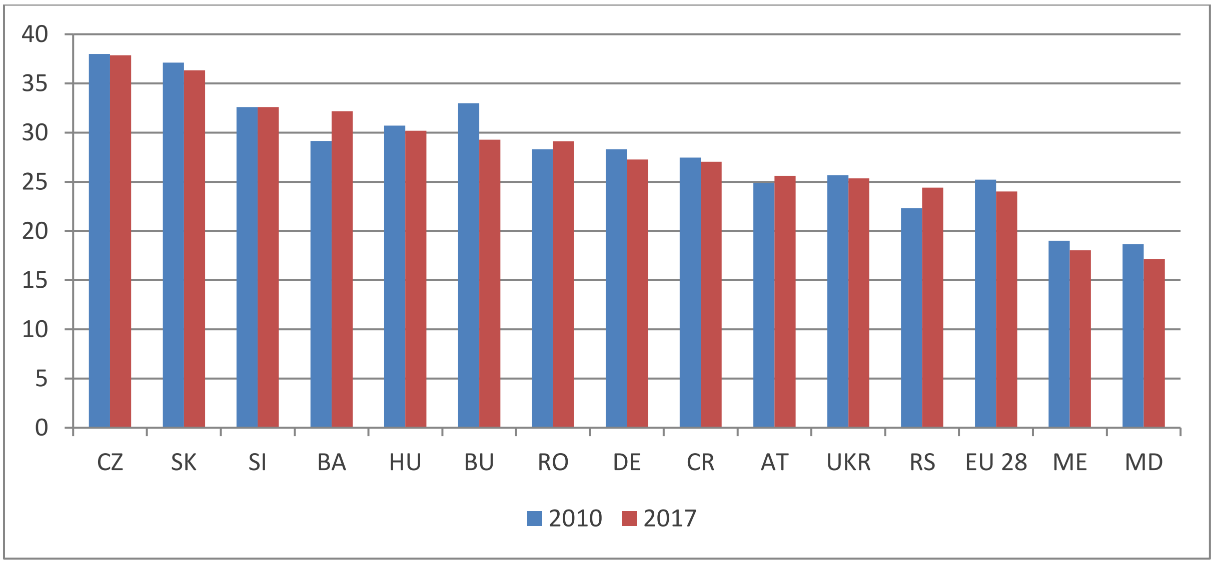
Labour shortage is one of the main challenges for the industries of the Danube Region. By intentionally omitting the case of Ukraine (due to the military conflict with Russia), one can report **that active labour force** of Danube regions has been mostly declining not only because of demographic aging but also because of emigration (regions where labour force could increase were as follows: Austria, Czech Republic, Hungary, and Slovakia; while labour force has been conspicuously declining in case of Bosnia and Herzegovina, Bulgaria, Croatia, Moldova, Romania, and Serbia).

One of the central moot points of recent studies on technology developments: AI, Industry 4.0 and Digital Economy is **whether the digitalisation of the economy will end up with a non-inclusive growth trajectory** which is at first not quite conducive to healthy socio-economic development unless people, that are to be replaced by automation and robotisation, can be absorbed easily and rapidly elsewhere. This is not exactly the case due to the more radical impacts of the current industrial revolution (Kovács, 2018).

This is why the **longer trend in industrial employment** is of paramount importance. Up until 2013-2014, downward trends have been dominating in all Danube regions. Since 2013-2014, Bosnia and Herzegovina and Slovenia showed some sort of rehabilitation by reflecting a rise in industrial employment. It nourishes the message that industrial development still has great potentials either in lagging performers or in moderate performers in accordance with the principle of pursuing inclusive growth.

The **highest industrial employment rate** (almost 40% within the total employment) appears to be in the Czech Republic, categorised earlier as surpassing performer in terms of innovativeness and regulatory quality (Graph 6).[24] Most DR countries are above the EU average (exceptions are Montenegro and Moldova). For most countries, there are slightly shrinking rates in a time perspective. This potentially implies automation and robotisation trends throughout the industry.

12. Graph Industrial employment (% of total employment, 2010, 2017)

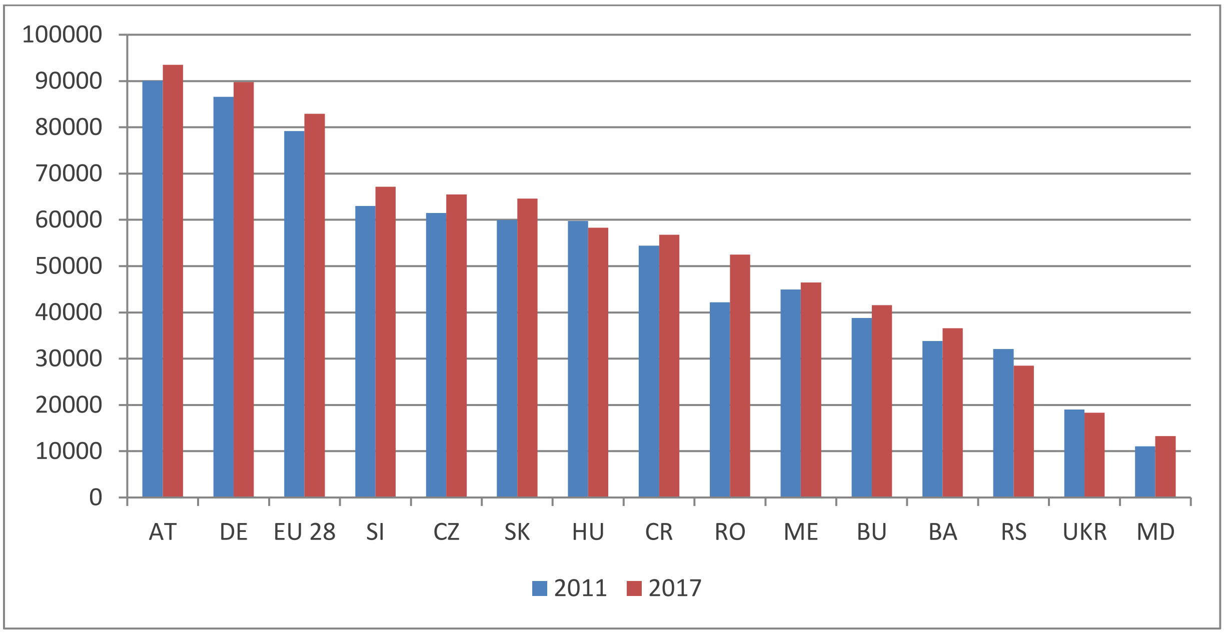


[24] According to available statistics, Croatia and the Czech Republic have the highest share of firms that are spending on research and development (22.3 and 21, respectively).

Source: World Bank, World Development Indicators.

The rate of industrial employment is not divisive among the EU and Non-EU members of the Danube Region. The **productivity performance** on the other hand, **significantly differs across the region**. Graph 13 shows the **output per worker** (for the whole economy, not only industry!) in 2011 and 2017. Austria and Germany are top performers and all other DR countries fall below the EU average. Central European countries follow and Ukraine, Moldova are the last ones.

13. Graph Output per worker, 2011 and 2017 (GDP constant 2011 international $ in PPP)



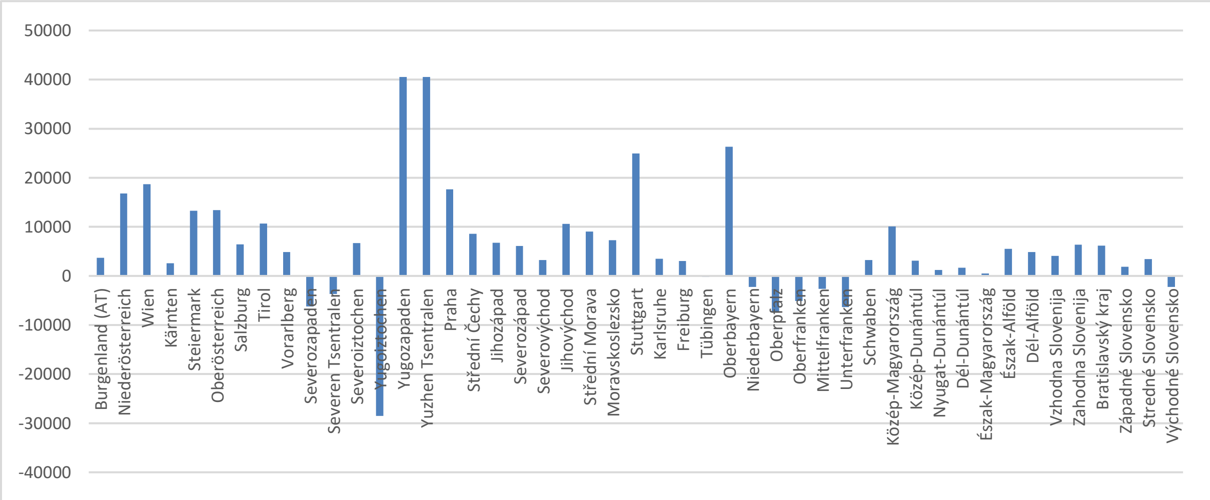
Source: ILO Labour productivity statistics -- ILO modelled estimates, November 2018 null

Parallel to **experiencing labour shortage** in several sectors (especially in manufacturing) in many of these countries, **labour wages have been on the rise**. **Raising wages and stagnating productivity** may lead to the **middle-income trap**, when cheap labour is not cheap enough anymore, while productivity and value added is not high enough to keep up the exports (so crucial for the small - and mid size open economies of Central and Eastern Europe).

Investing into human capacities and skills, as well as technology, ICTs and AI can help avoid the this trap for the countries of the Danube Region (exceptions are Austria and Germany, well above being middle-income).

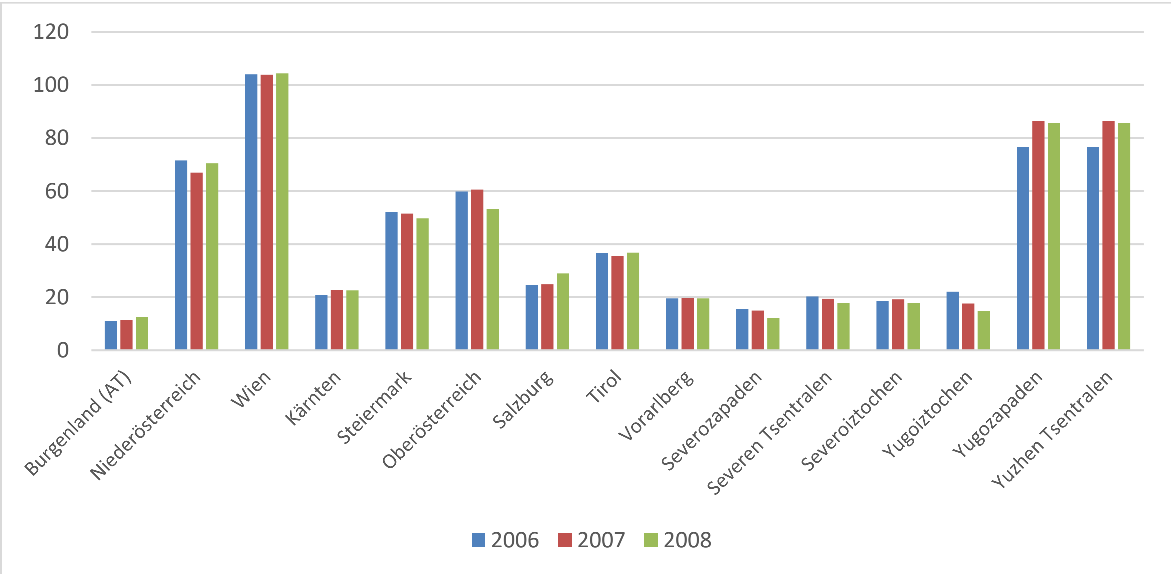
Looking at human capacities and skills, high quality of education, a stimulating business and regulatory environment (good governance) influence **the talent pool**. In an effort to reflect upon the talent-endowment, as a necessary source of SME development, we shortly look at the **absolute change in creative workers in the regions** (Graph 14). Albeit the bases are of paramount importance (Graph 15), the biggest increases were registered primarily in Bulgarian regions (coupled with the greatest decline as well) as well as in Germany and Austria.

12. Graph Absolute change in creative workforce



Note: data are not available for all regions considered in case of Danube Region.
Source: ESPON.

13. Graph Employment in creative sectors in Austrian, Bulgarian and German Danube regions (employed persons x 1000)



Source: ESPON.

Based on data from the IMD[25], several countries of the Danube Region **are net talent exporters**, except for Germany and Austria. Among others, Hungary was considered as net talent exporter in the IMD World Talent Ranking 2018 (IMD, 2018), as a corollary, the **intensifying shortage of (skilled) labour force** results in a growing dependence of households on remittances. In case of Hungary, by 2017,

[25] Institute for Management Development (Switzerland). https://www.imd.org/

personal remittances received in percentage of GDP, taken from World Bank Development Indicators, has been doubled by exceeding 3% since 2010.

Unarguably, **AI based development requires better and higher skilled people and talents** that are open and creative enough to apply various forms of AI-based solutions in their daily routines at work (and even at home).

As far as the capability of a country to raise, attract, preserve and develop talent is concerned, available evidence suggests that **only Austria (+2) and Slovenia (+9) were able to climb up a little bit in the talent ranking of 63 countries** developed by the IMD in the period 2014-2018. Declines with a differing volume are registered in the rest of the Danube Region listed in the ranking. The biggest improvement was seen in Slovenia (from its 39th position to the 30th place by 2018), while Slovakia (from 43rd position to 59th) and Ukraine (from 33rd place to 48th) suffered from the greatest declines. One can conclude that Central and Eastern European EU member Danube regions have been being mainly talent exporters in the respected period.

Table 4. Talent ranking of selected Danube Region countries, 2014-2018

	Rank 2014	Rank 2018	Change
AT	6	4	↑ 2
DE	5	10	↓ 5
SI	39	30	↑ 9
CZ	35	37	↓ 2
UKR	33	48	↓ 15
HU	45	49	↓ 2
CR	50	54	↓ 4
RO	54	56	↓ 2
BU	60	57	↑ 3
SK	43	59	↓ 16

Source: IMD World Talent Ranking 2018

4.3. The role of SMEs in innovation in the Danube Region

The SME-development potential of a Danube Region can be approached by exploring whether the enterprises can become embedded into the competitiveness landscape, i.e. what does **the 3-years survival rate** tell us about their vitality (Graph 16.)[26].

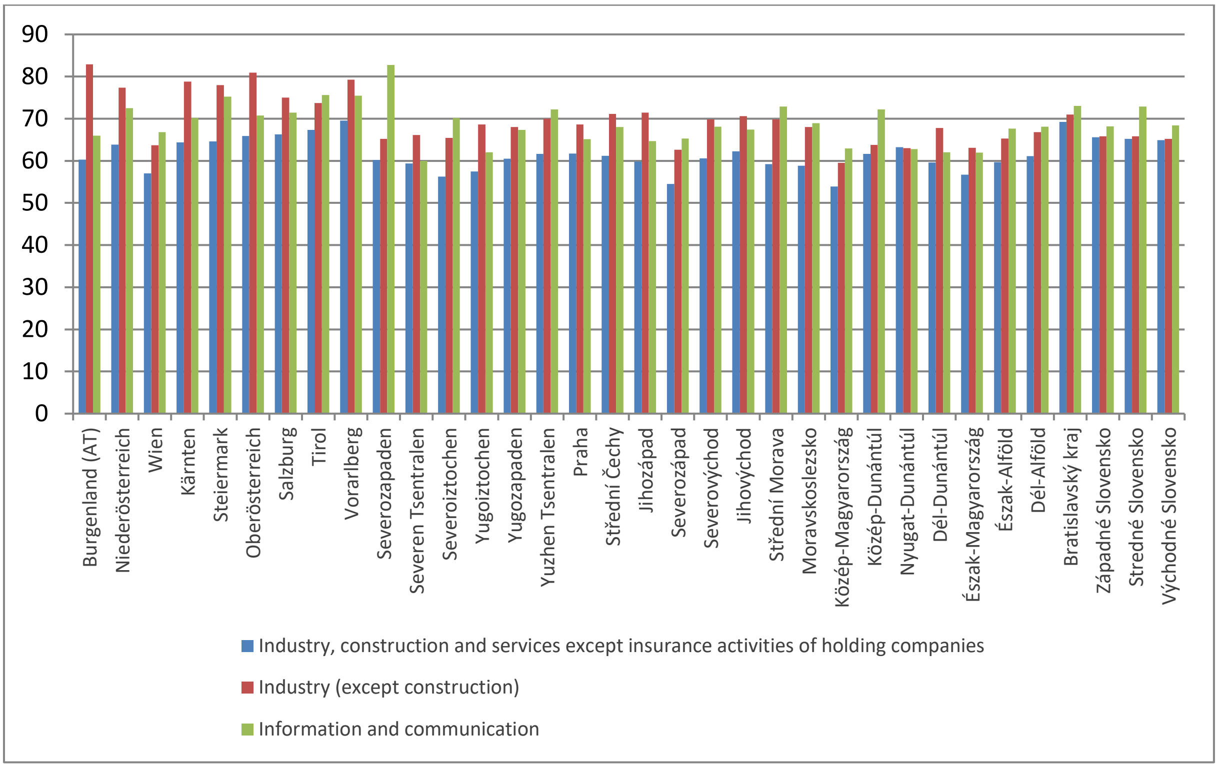
A **lower level of survival rate** can mean at least two things. First, it may reflect **fiercer competition** leading to a more conspicuous erosion of enterprises, this might be the case typically in well-known growth poles of the regions considered (e.g. Közép-Magyarország in Hungary because of Budapest; Wien in Austria). Second, it may represent **a less effective innovation ecosystem** being not so conducive to enterprise development (e.g. regional disparities are high, low level of talented

[26] Although this includes not only SMEs, the survival rate focuses at the first 3 years of a firm's lifetime therefore catches in this picture mostly the SMEs

workforce, high bureaucratic costs, less developed financial sector etc.). This latter is the case in falling regions like Severozápad in the Czech Republic.[27]

In terms of sectoral differences, **firms in industry, or specifically in the ICT sector are more likely to survive than firms in general** (industry, construction and services) in most regions. In addition, a common pattern emerges when one takes a look into the inclusive growth of the firms in the Danube region: **those firms that are surviving the first 3 years are more likely to employ 20-30 persons on average** (except the region Střední Čechy as well as Bratislavský kraj where that number is above 80 and 100, respectfully).[28]

14. Graph Survival rate of enterprises in Danube regions, % (2016)



Note: Survival rate 3: number of enterprises in the reference period (t) newly born in t-3 having survived to *t* divided by the number of enterprise births in t-3. The availability of data is rather limited.
Source: Eurostat.

Regarding **the innovativeness of SMEs**, we look at **three main factors: i) access to financing innovation, ii) availability (or shortage) of human resources, iii) location and cluster effects.**

First, **financing innovation** is often cumbersome for SMEs, and the financial instruments available differ basically in **relative to the SMEs' level of innovativeness** (i.e. presumably, short or longer term financial resources are not necessarily available at the same volume for surpassing performers of Germany or the moderate performers of Hungary).[29]

---

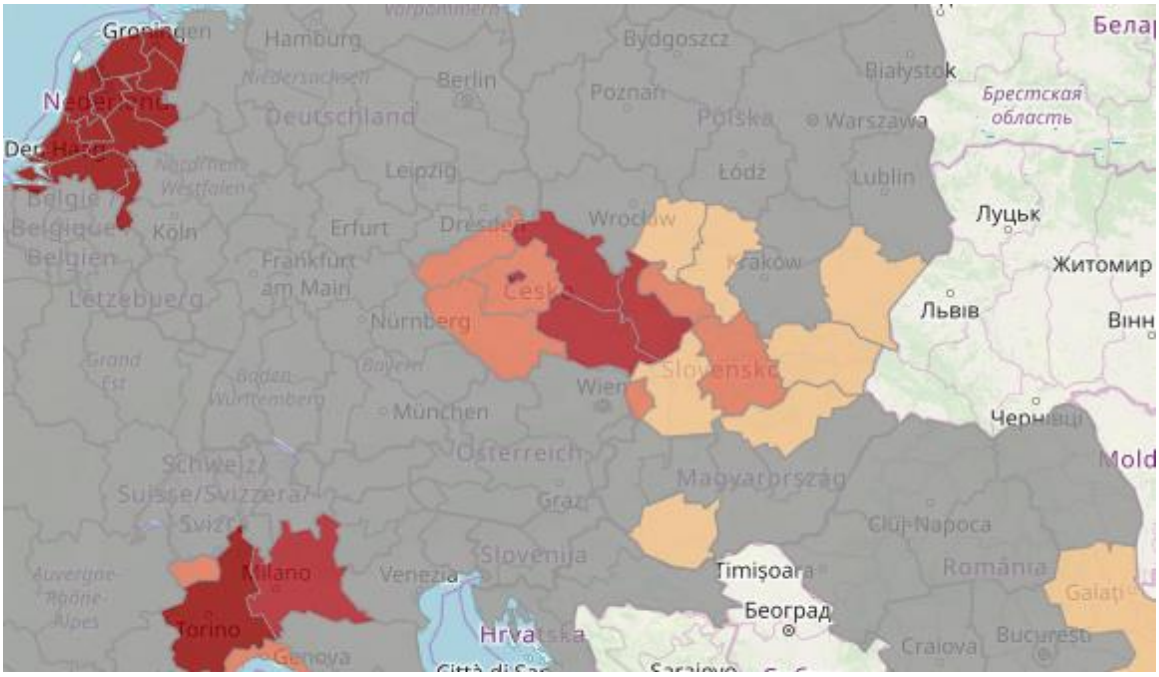
[27] See more on this: Tvrdon and Skokan (2011).
[28] Data stem from Eurostat databases for the average size of three-year old enterprises in case of Industry, construction and services except insurance activities of holding companies: number of persons employed in the reference period (t) among enterprises newly born in t-3 having survived to t.
[29] This was documented in case of German SMEs by Hummel et al. (2013).

Second, while SMEs are more likely to suffer from restricted personnel capacities and less time as well as willingness to initiate and realise higher-risk innovation ideas;[30] **optimising new product management (or the service provision) by applying new technologies** (e.g. AI, machine learning, or more cheaper technologies making the production process smarter like Micro-Electro-Mechanical Systems etc.) together with **practices mitigating the shortage of labour** (e.g. Telepresence robotics,[31]investing in knowledge management[32]) has started to gain traction.[33]

Third, location effect can be corpulent in the sense that **SMEs can perform better by being closer to large innovative companies** often concentrating spatially. It implies at least two things, (i) large companies are more likely to have the necessary resources to take more risky innovations and SMEs can collaborate with them in various ways by boasting the diffusion of ICT and Industry 4.0 technologies as well; and (ii) large companies are concentrating in areas showing relatively higher regulatory quality (i.e. where the performance of the public administration system proved to be better compared to other regions).[34]

Unfortunately, available data are rather limited, what one can observe is that **SMEs' activity in terms of pursuing and realising product or process innovations is differing across the board** (Graph 17).

15. Graph SMEs introducing product or process innovations within the technology field of industrial manufacturing (2014)

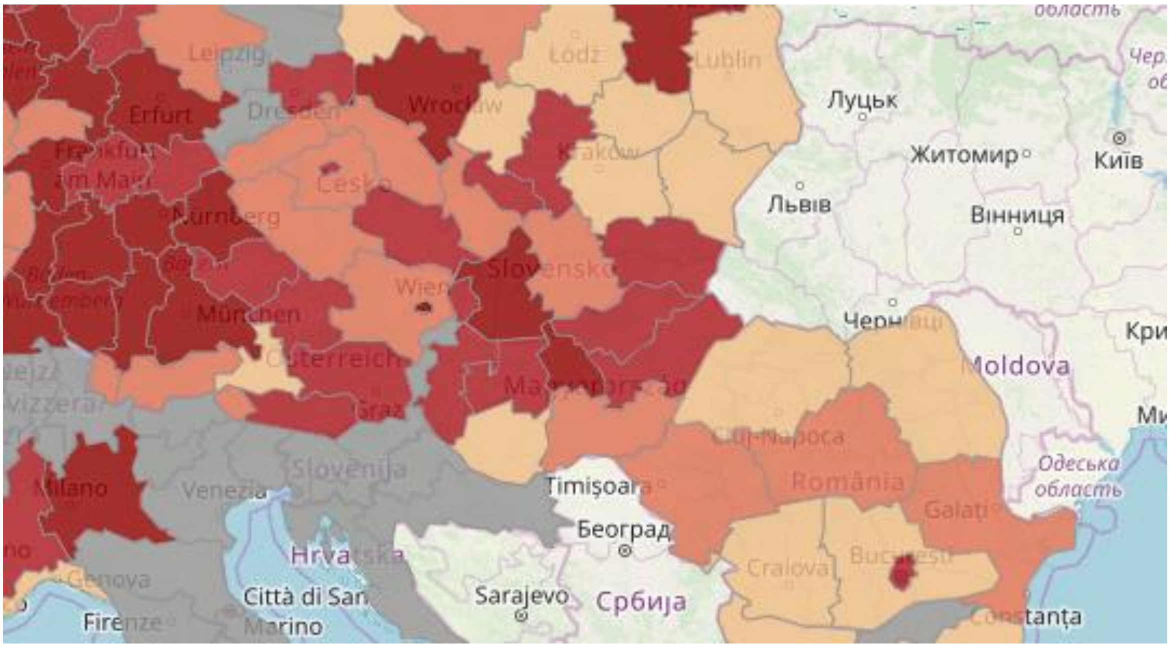


[30] See: Laforet and Tann (2006).
[31] Shortage of labour can be to a large extent eliminated by applying new technologies making the firm (SMEs) capable of reaching out talented high-skilled workers remotely (e.g. even in case of expatriated workers). Telepresence robotics helps the remote worker by providing a virtual presence, or telepresence, in the office, see the Austrian case by Beno (2018).
[32] This seems to be the case in more and more Danube macroregions. For instance, Uzelac et al. (2018) presented it in case of Serbia, Biloslavo et al. (2018) documented it in Bosnian SMEs.
[33] The adaptation of the German State-Gate systems proved to be a great helper in improving production processes in SMEs, see: Leithold et al. (2015).
[34] In case of the Czech Republic, see: Sucháček et al. (2017).

Note: the darker the colour of the region, the higher is the rate of SMEs initiating product or process innovations. The lowest rate is between 0.13 and 0.31, while the highest one is in the range of 0.59 and 0.90.
Source: European Cluster Collaboration Platform.

Another equally important aspect is whether there are companies becoming ‘stars’ with respect to **adaptation and utilisation of emerging industries** (Graph 18). In this respect, there is a great divide between EU-member Danube regions and non-EU Danube regions.

16. Graph Hotspots - Cross-Sectoral Clusters / Emerging Industries



Note: It captures the total number of stars in a region where stars are defined for the ten Cross-Sectoral Clusters / Emerging Industries all being relevant for AI development (Advanced packaging, Biopharmaceuticals, Blue Growth Industries, Creative Industries, Digital-based Industries, Environmental Industries, Experience Industries, Logistical Services, and Medical devices).
Source: European Cluster Collaboration Platform.

The lesson from our analysis on SME development is that **survival rate of SMEs are in case of most regions between 50 and 70% on a 3-year time period**, which can suggest a healthy business environment. Survival rates are typically **higher for industry and ICT sector firms than on average**.

Among the factors behind SME innovativeness, we looked at **access to finance, access to human resources and location - proximity to industry/clusters.**

4.4. Maturity for AI in the Danube Region

Danube regions can be to a certain degree evaluated with a view to their **maturity for AI**. We look at three aspects of that maturity:

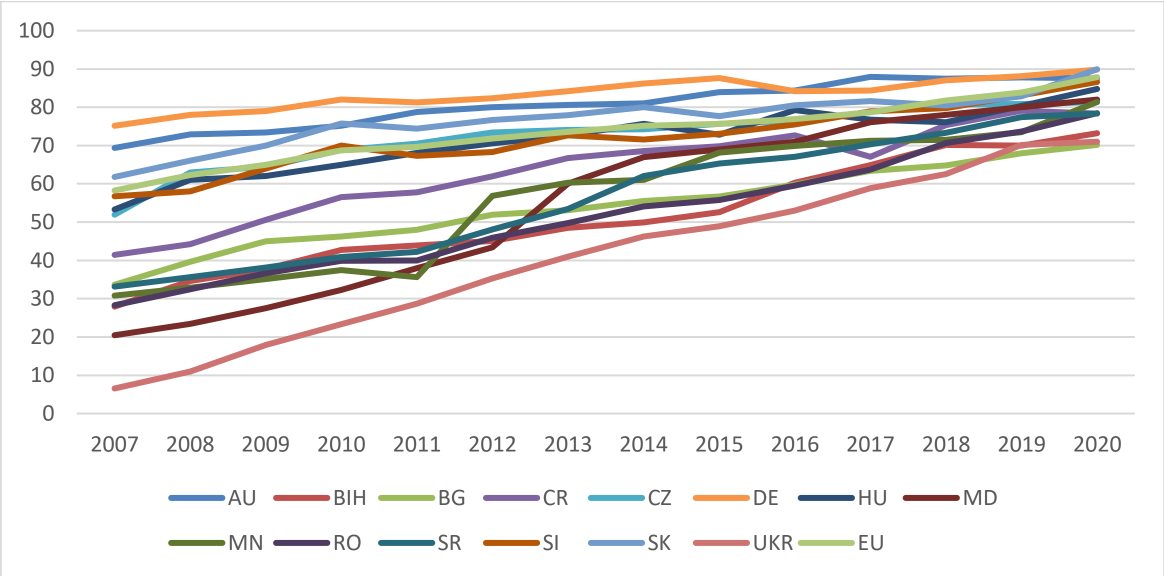
a.) **Internet access penetration in the Danube Region**,

b.) the total **Digital Economy and Society Index** (DESI) values for the DR, and c.) the **integration of technologies pillar of the DESI** in specific, together with AI technology adoption level in the Digital Transformation Scoreboard.

As far as the **access to Internet** is concerned (see Graph 19), Austria and Germany have the broadest access to Internet, the Czech Republic, Slovenia, Slovakia and Hungary still have a salient but moderated level of access, while the rest of the Danube regions are lagging behind despite the growing tendency. Of course, Internet access per se is not a panacea (i.e. **digital literacy** of the workforce does also matter together with the function the Internet is used for[35]).

It is expected that data for 2021 will show the significant increase in Internet access and use, due to the effects of the COVID pandemic and the general spread of online technologies in these countries.

17. Graph Individuals using the Internet (% of population)



Source: World Bank, World Development Indicators.
Note: Data for MD for 2018-20 and data for UKR for 2020 are estimates.

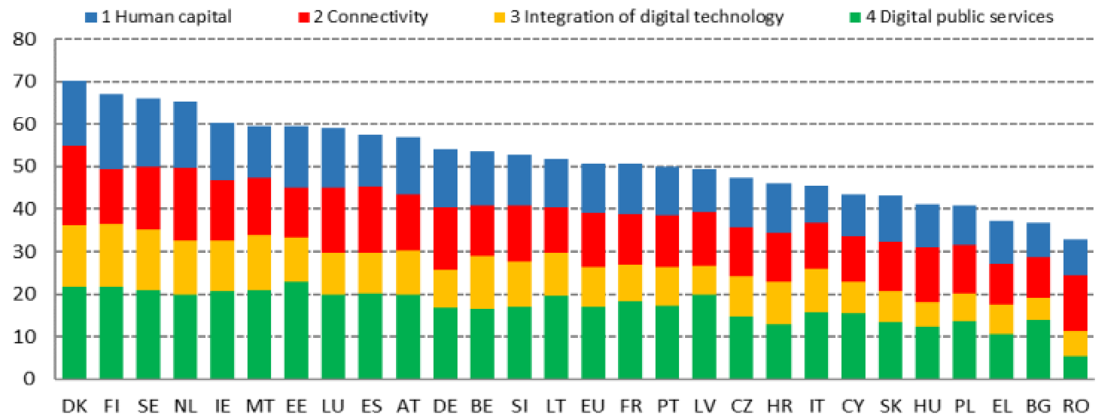
In the next step, we look at the **Digital Economy and Society Index** (DESI) developed by the European Commission. DESI is a composite index designed to measure the digital development of the EU.[36] **DESI has 5 pillars**:

a) connectivity,
b) human capital/digital skills,
c) use of internet services by citizens,
d) integration of digital technology by businesses,
e) digital public services.

[35] In case of Moldova, Internet has been more and more used to get contact with expatriated workers/relatives and not to support business development toward e-businesses. See: ICEG EC (2015).
[36] For more details see: https://ec.europa.eu/digital-single-market/en/desi

Graph 20 shows that in **the DESI composite index Austria, Slovenia and Germany** (no regional data available) **are above the EU average**, but other EU-member Danube Region countries are below.[37] [38]

18. Graph The Digital Economy and Society Index (DESI) 2021



Source: DESI 2021, European Commission.

The **integration of digital technologies pillar** (Graph 21) of DESI can be regarded as a proxy for getting a picture about machine to machine communication, Internet of things as well (IoT). In this respect, Slovenia outperformed even that of Germany and Austria. Awareness over the ever-increasing importance of Internet of Things has been rising even in poorly performing regions. For example, Ukraine launched its first IoT laboratory in mid 2017[39]. Nevertheless, certain studies pointed out that the demand pulled development of IoT faces challenges such as economic, financial, security and privacy concerns (Tick – Vinnai, 2016), especially in less developed regions.[40]

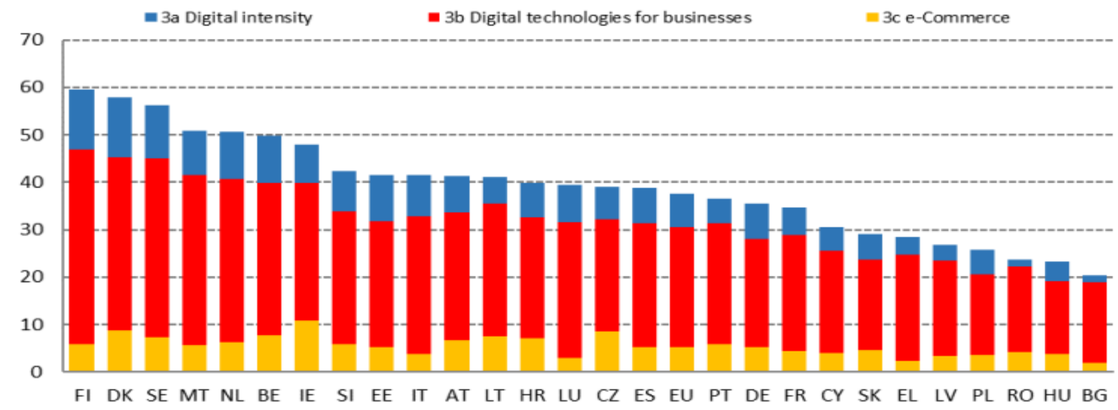
[37] Only EU member states are surveyed in DESI and there are no good proxy for such aspects in case of non-EU member state Danube regions.

[38] Source of the graph: Digital Economy and Society Index (DESI) 2021 Thematic chapters https://digital-strategy.ec.europa.eu/en/policies/desi Accessed on: 16.12.2021.

[39] See: https://kpi.ua/en/node/14676 Accessed on: 27.01.2019.

[40] Source of the graph: Digital Economy and Society Index (DESI) 2021 Thematic chapters https://digital-strategy.ec.europa.eu/en/policies/desi Accessed on: 16.12.2021.

19. Graph The integration of digital technologies pillar of DESI, 2018



Source: DESI 2021, European Commission.

The Digital Transformation Scoreboard[41] focuses at specific technologies and their uptake in policies and selected sectors. In 2018, construction and the food industry were in focus and 9 technologies were surveyed: social media, mobile services, cloud technologies, internet of things, cybersecurity solutions, robotics and automated machinery, big data and analytics, 3D printing and **artificial intelligence**. The **European-wide survey found that adoption of AI technologies are most characteristic of large firms,** above 250 employees (**20% of them introduced AI technologies**). For firms between 10 and 250 employees, the rate is up to 9%, and only 4% for companies with less than 10 employees. Furthermore, it was found that AI is more likely to be adopted by younger firms (22% for firms aged 3-5 years). Although this data is not specific to the Danube Region, based on its development level we can presume that the Danube Region falls somewhat below the European average in this aspect as well.

This also means that there is a room for growth in the SME sector in terms of AI adoption. 90% of those firms that had already introduced AI stated that **digital technologies have clearly generated positive outcomes**.

The **reason for AI adoption** for those firms that ventured with it were mainly: **deploying new products, being more competitive and engaging with customers**. The business functions most affected by AI introduction were **project management, technology prototyping and customer relations**.[42]

Regarding the maturity for AI adoption we can conclude that in terms of basic infrastructure, **the less developed countries of the Danube region are catching up fast with the class leaders.** But when it comes to **adoption of technologies**, use of internet services, digital public services, integration of digital technologies, most countries of the **DR - except for Austria and Germany - lag behind the EU average.**

[41] See: https://ec.europa.eu/growth/tools-databases/dem/monitor/scoreboard
[42] See: Digital Transformation Scoreboard 2018. Available: https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Digital%20Transformation%20Scoreboard%202018_0.pdf p. 50-51 Accessed on: 27.01.2019.

There also seems to be a difference in adoption of digital technologies, especially AI in terms of firms size. Larger firms have already made the move on integrating this technology, while **less than 10% of SMEs have introduced any AI solutions** in their production.

5. AI- related R&D&I in the Danube Region

5.1. AI -related public R&D

The European Union invests heavily into research, development and innovation. One of the key mechanisms for that are the **Research Framework Programs (FPs)**, the current one named **Horizon2020**, running from 2014 to 2020.[43] The Community Research and Development Information Service - **CORDIS database**[44] contains the research projects financed from the of the EU. In this section we look at the AI-related projects funded under Horizon2020. Although it is possible to analyse AI-related projects from earlier FPs as well, due to the fast changing nature of the topic, we focus on H2020.

From 2021, the European Union has launched its Horizon Europe program that will support ICT and AI research, innovation and development for the 2021-2027 period, but sufficient data is not yet available from the new program.

Information Communication Technologies are covered mostly under an **explicit branch, titled 'ICT'** (ICT-01,...-41) **Besides that, other branches also include ICT-related**, or more specifically, AI-related calls. These are:

- FETFLAG-02,-03 FET Flagship on Quantum Technologies
- FETHPC-01,-02,-03 Flagship on High Performance Computing
- FETOPEN-01,-02,-03 -04 Open research and innovation actions (not only ICT-specific!)
- FETPROACT-01,-02,-03 Boosting innovative technologies (not only ICT-specific!)
- FoF-01,-14 Factory of the Future (not only ICT-specific!)
- IoT-01,-02,-03 Internet of Things

According to the CORDIS database, the following number of projects have been awarded until now:

Table 5. Number of ICT- related projects in H2020 by Jan 2019

Call type	Number of projects
ICT	1000
FET	278
FOF	117
IoT	15
Total:	1408

CORDIS, own calculation

Although not all partners are known to all projects, but the name and the host country of the coordinator is available for all 1408 projects. From the coordinator's location we can extrapolate the scientific weight of each country within the ICT-related topics of the H2020 arena[45]. Examining the

[43] For more details, see: https://ec.europa.eu/programmes/horizon2020/en
[44] https://cordis.europa.eu/projects/en
[45] This does not necessarily mean that these countries take home most of the European research budget. The projects have very different budgets (with EC contributions from EUR 50 000 to 10 million), not all the project budget goes to the coordinator, and we do not have details on the specific consortia agreements among the partners. Yet, the coordination the H2020 projects shows the capacity to navigate in the European Research Area and the capacity to draw public funding to the research activities.

1408 projects, Spain (237), Germany (174), Italy (155) the United Kingdom (154) and France (111) are the countries with the most coordinated projects.

Separating the countries of the Danube Region (as regional data is not available), we can see that **only 262 projects are coordinated by Danube Region countries**, and of that, 174 belongs to Germany, which is only partially a DR-country. Out of the Non-EU DR countries, Serbian research actors were able to take 2 projects as coordinators. [46][47]

Table 6. DR-coordinated ICT- related projects in H2020 by Jan 2019

Country	ICT-related H2020 project coordinated
DE	174
AT	53
HU	11
SI	11
CZ	7
SK	3
RS	2
RO	1
DR	**262**

CORDIS, own calculation

The population size of EU is almost 445 million people after the Brexit. The population of the EU countries in the Danube Region is just above 150 million,[48] roughly 30% of EU. Yet, out of all the 1408 H2020 projects related to ICT R&D, only 262 were coordinated by a DR country, representing 18%.[49] **Therefore the representation of DR countries as ICT-related H2020 coordinators is clearly below their share in EU population.** (Graph 22)

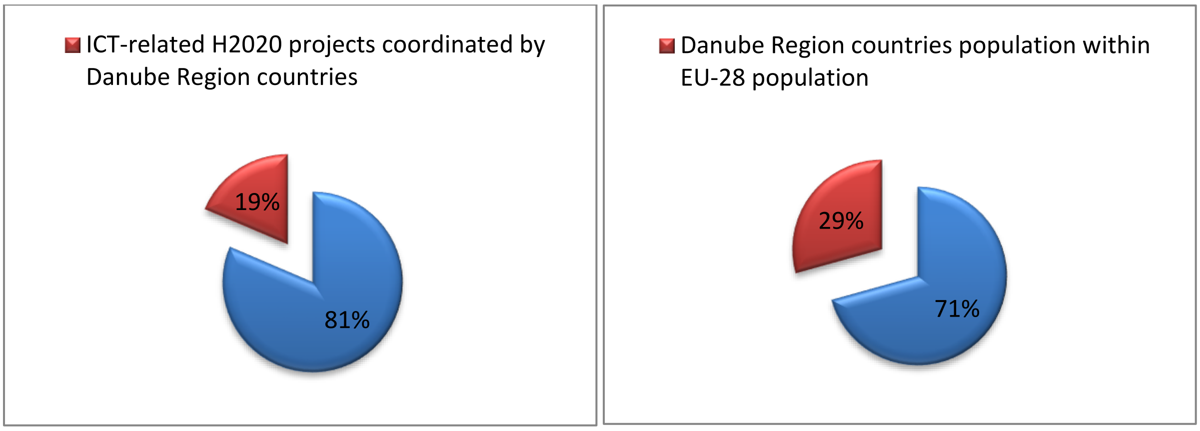
[46] The non-EU countries of the Danube Region are all associated countries to the Horizon2020 programme, eligible for funding. "As of 01 January 2017, the following countries are associated to Horizon 2020: Iceland, Norway, Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Montenegro, Serbia, Turkey, Israel, Moldova, Switzerland, Faroe Islands, Ukraine, Tunisia, Georgia, Armenia

[47] http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/3cpart/h2020-hi-list-ac_en.pdf

[48] Data from Eurostat as of 1 January 2018.

[49] For technical reasons we do not calculate with the population size of all the associated countries. If we did, the ratio would be even lower. ". Of the associated countries, Switzerland and Norway are key actors, taking 27 and 31 projects coordinated, respectively. The DR-associated countries are not large players in H2020, neither are the other non-Danube countries apart from CH and NO.

20. Graph Share of the DR in coordination of ICT-related H2020 projects and in population



CORDIS, own calculation

We can also search the CORDIS database according to specific keywords and themes. We searched the total database of projects for the **keyword 'artificial intelligence' and found 271 entries**. These are all projects related to AI[50], although many of them coming from a different domain - health, pharmaceutical, environmental research, etc.

The biggest players in a coordinator's role are the same 5 countries, as in case of the ICT-related topics: Spain (53), Italy (29) United Kingdom (28), Germany (25), France (15). Out of the 271 projects, only 40 are coordinated by a DR-country, and 25 of those are from Germany. (Note: in H2020 the United Kingdom was still a regular member with its EU membership.)

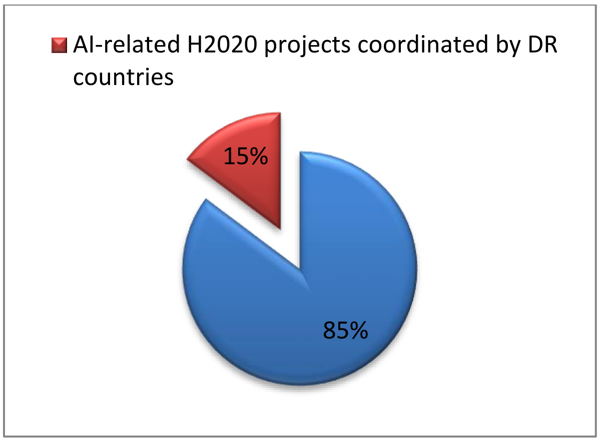
Table 7. DR-coordinated AI- related projects in H2020 by Jan 2019

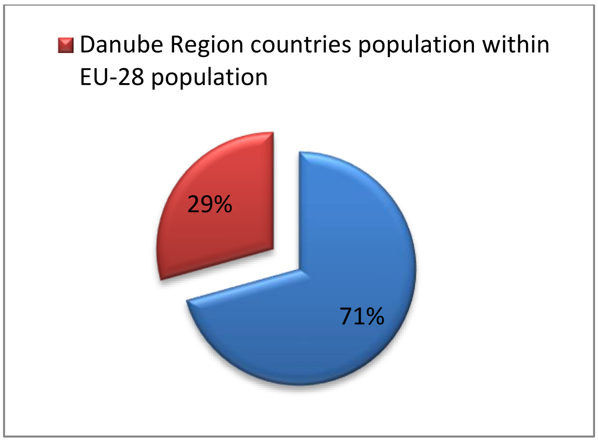
Country	AI-related H2020 projects coordinated
DE	25
AT	4
CZ	4
SI	3
RO	2
BG	1
RS	1
Total	**40**

CORDIS, own calculation

[50] Many proposals use 'AI' only as a buzzword, but the successful projects, where the EC granted financial support, went through a serious evaluation process and we are not questioning their AI-focus.

21. Graph Share of the DR in coordination of ICT-related H2020 projects and in population





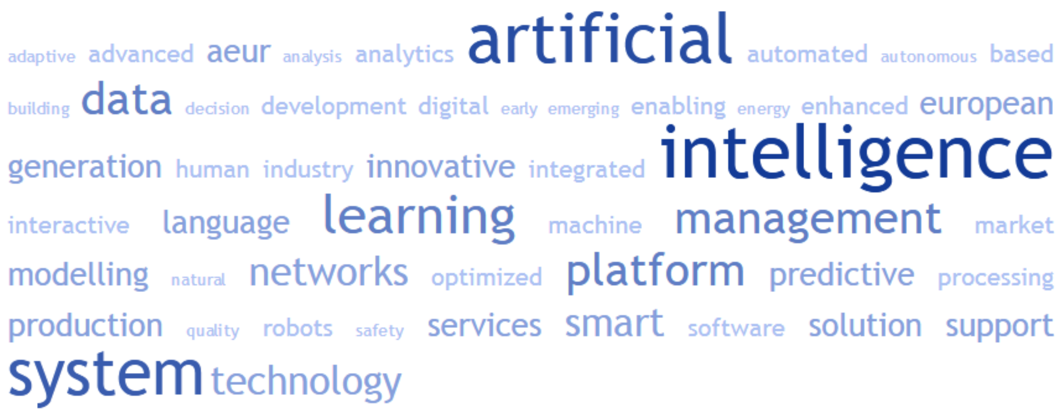
CORDIS, own calculation

As Graph 23 demonstrates**, the share of Danube Region countries is even smaller in case of AI-related H2020 projects, than in case of ICT-related ones, if we take into account their population ration compared to EU**. These trends are not unique to ICTs or AI. The Eastern member states of the EU have a trend in general to underperform in the Framework Programmes, [51]and the Danube Region is composed of several Eastern member states joining the EU only in 2004, 2007 or in 2013.

Of the 271 AI-related H2020 projects, 62 were under the "SME instrument" category. SME instrument projects support the **market innovation process of SMEs**, supporting the R&D&I costs relatively high for SMEs. These project are not grouped according to topics, the research themes range from genetics research tools to robotic scanners, from animal feeding equipment to a baby monitoring system. The rest of the projects were evenly distributed among ICT, FET, FoF categories, as well as MCSA (Marie Skłodowska-Curie actions, targeting academic research) and some other, smaller categories.

Looking at the titles of the projects (Graph 24) the following key words can be identified as the most common topics within the titles:

22. Graph Share of the DR in coordination of ICT-related H2020 projects and in population



CORDIS, own calculation, TagCrowd visualisation

[51] For example the In-depth Interim Evaluation on Horizon2020, https://publications.europa.eu/en/publication-detail/-/publication/33dc9472-d8c9-11e8-afb3-01aa75ed71a1/language-en p 64-65.

In conclusion, it is clear that the **Danube Region is under-represented in AI-related research coordination within the H2020 program**. If the calculations were further refined and the AI-related coordination were divided within the area of Germany according to regions, it would be even more striking to see how much lower the share of DR-coordinated AI-related projects are compared to population statistics. Further analysis can determine more specific areas to develop but suffice to say, **targeted measures for supporting AI-related R&D&I within the Danube Region should start with appropriate initiatives to stimulate the participation in, and coordination of AI-related framework projects.**

5.2. AI-related case stories from Europe /Danube Region

In this section, we present some of the already **existing AI-related projects in the Danube Region**. The selection is not comprehensive, only a showcase of the potential of AI originating from the Danube Region area.[52] It is important to note, that with the impact and spread of angel investments and European /global venture capital investments, not all of these companies are 'local' anymore. In fact, the most successful startups consider themselves as "born-global", meaning that from a very early stage of development they involve both talent as well as capital from the global scene and they offer their products/services on the global market. Nevertheless, they are still an important indicator of both the talent and capacities encompassed in the region and reflect the interest fields of business and experts from the Danube Region area.

AIMOTIVE is a company that originated as a Hungarian start-up operating as an independent automotive technology powerhouse, working on level-agnostic automated driving solutions. The team is still mostly composed of Hungary-based researchers but with the involvement of global knowledge and expertise. The Company has been listed as 3rd in the Top 100 Artificial Companies in the World by analyticsinside.net.

Robart is based in Linz, Austria, and targets a niche with its products and development: it creates intelligent home robots with laser navigation, with emphasis on robot vacuum cleaners. Today, Robart collaborates with major household appliances players such as Rowenta and others, offering full robotics solutions with applications and services.

DICEUS was founded in 2012 in Kiev, by Ukrainian experts, starting out in various e-commerce solutions. Since then, they cooperated with global companies and have clients from the USA, Asia and the European Union. Their focus today is at intelligent commerce, financial and banking products.

5Analytics: a start-up in Köngen, Baden-Württemberg, working with AI-enhanced Industry 4.0 solutions. Their specialty is to deploy AI solutions in a very fast timeframe, seamlessly communicating with the already existing software and technological background of companies.

BioSense Institute Digital Farm: Smart agriculture has been gaining momentum in Serbia. One of the prime examples of such development is the establishment of digital farms with the help of the

[52] Links to the websites of the companies are provided in the References.

BioSense Institute. Digital Farms in Serbia have become equipped with a wide spectrum of digital technologies (sensors etc.) coupled with AI-support (platform Weaver, a smart chat bot that eliminates language barriers among business partners and customers by making communication smoother and reliable and by putting Serbia on the international map)[53] in the interest of a shift toward modern organic production, fruit growing, viticulture etc. These technologies enable us to monitor, and thus to learn constantly to advance and rapidly adapt to changed circumstances by leading to increased efficiency and profitability.

BrightAdvise is an Odessa-based group of experts offering legal advice covering 17 countries combining real lawyers' work with artificial intelligence. There are 539 lawyers worldwide, who participate in their network, but parallel to their personal expertise, almost 5000 specific cases serve as a basis for the AI component's work. Evidently serving a large diaspora of Ukrainians, the service is available globally, on-line, to people who otherwise may not would or could turn to a legal representative.

Connecto.ai: The conversational marketing start-up Connecto.ai was founded in 2016 by Bulgarian engineers, programmers and entrepreneurs. Their work started by creating chatbots for Facebook Messenger and Viber, after those opened up their platforms for developers. The chatbots are AI-powered conversational interfaces to connect businesses with customers. Today, they have specialised solutions for various industries: FMCG, Taxi, Banking, Telecom and ECommerce. In 2018, the start-up was bought up by Leanplum, a global mobile marketing platform company.

Daktilograf is a voice-recognition system with algorithms specialising in South-Slavic languages (Serbian, Croatian, Montenegrin, Bosnian). With a special methodology that does not only follow traditional AI solutions, their service allows for clear understanding of various dialects and speaking areas. The application for Russian, Polish, Bulgarian, Slovenian, Macedonian, Czech languages is under development currently. The targeted users are media and news agencies, courts, assemblies, other public administration bodies and all other institutions or companies that have a daily need for text writing based on speech. The company comes from Bosnia-Herzegovina.

Decissio is a fintech solution, supporting investment decisions, backed by blockchain-based audit systems. The Prague-based company offers consolidated data, streamlined decision-making process, artificial intelligence insights, blockchain powered audit trails and reporting.

EVA: EVA is a voice-controlled eyewear for visually impaired. The AI identifies objects, texts, signs and verbally describes those to the user. EVA can read out loudly text, recognise objects, offer GPS-based navigation, receive and send text messages, emails, manage phone calls, surf the web. The products look like trendy glasses/sunglasses, with built-in camera, microphone and can be fitted with prescription lenses. The team behind EVA is Budapest-based, composed of Hungarian experts is various fields.

EventRegistry, a successful Slovenian AI application co-funded with European research grants, provides media monitoring and media intelligence services. They collect and analyse more than 30 thousand news sources worldwide, in over 30 languages. The content can be filtered by keywords,

[53] Keep in mind that the Serbian (being a Slavic language) show significant linguistic and cultural differences from English. See: https://www.effectivelanguagelearning.com/language-guide/language-difficulty Accessed on: 12.02.2019.

entities, sources, categories and locations. The AI algorithm helps to find out what happened, when, where and with whom involved. EventRegistry's clients include global companies and organisations such as the IMF and the London Stock Exchange.

Gideon Brothers: Gideon Brothers, based in Croatia and founded by Croatian AI and robotics experts, worked on AI-enhanced robotics that are in line with pursuing a more inclusive growth for bettering the life of people. According to their philosophy, robots do not trigger huge displacements, they expand what people are able to accomplish. Gideon develops a robot autonomy that layers deep learning on top of camera-based perception which creates a new type of robot vision that is as reliable but 10x cheaper than LIDAR and (unlike LIDAR) data-rich. The combination of hardware and software carries the capacity to convert a wide variety of industrial machines and vehicles into autonomous mobile robots that are safe in dynamic, people-filled spaces. See more: https://www.gideonbros.ai/

Mon Style: this Austrian algorithm targets the fashion industry and sales: it offers automated and scalable personalization solutions by introducing a virtual shopping assistant that is not only communicates automatically with the customers, as chatbots do, but also suggests style choices tailored for the individual, based on product detection and classification image recognition algorithms, advanced multi-modal search and deep learning technologies.

Neuron Soundware: it is a Czech-founded company now with London headquarters, using AI algorithms for sound identification, more specifically, for identifying broken engines and detecting a diagnosis. The technology can be used in cars, other transport vehicles but also in Industry 4.0 technologies.

Onlim developes AI-based, state-of-the-art chatbots and voice assistants for customer service, marketing and sales. They operate in various industries, from education to tourism, from the energy sector to the sports industry. The voice-based chatbots are supported by various social media management services. The Austrian company is a spin-off of the University of Innsbruck.

Sinetiq: the company founded by a team of Hungarian experts from the fields of economics, sociology, marketing, IT and AI developed a tool to analyse the emotional content of marketing messages, mainly online and TV ads. Sinetiq helps to optimise the ads from the viewers' and the impact's point of view. There are more than 3000 ads they have already analysed and based upon that, they can offer valuable advice on marketing challenges such as what type of character will sell better a painkiller or a car, and which version of the ad draws in the most customers.

Smartan AI is the product of Romanian, Moldovan and Russian experts, offering media analytics different to those of the global players. Smartan AI offers real time dashboards customized for digital publishers, segments article performance by authors, sections, tags, and referrers. Furthermore, with AI algorithms, it provides strong suggestions on how to use the unique metrics.

Terraloupe is a Munich-based company working in the fields of aerial imagery and recognition. They develop algorithms and deep learning solutions for roads, buildings, vegetation and infrastructure monitoring. Their inputs can be used in the real estate, insurance, energy, automotive, agriculture, tourism and security sectors.

Transmetrics: it is an AI-based solution to stop shipping air instead of cargo, in other words: to find the optimal shipping and transport solutions with the help of AI. First, they take and clean a large data set of previous cargo shipments, then prepare future forecasts and finally, optimise that with AI support. The company, founded in 2013 in Bulgaria, already received significant appreciations: Business Insider listed Transmetrics among the top 5 startups to watch in “AI for Supply Chain Management".

TREVOR AI: The time-management solution was developed by a Bulgarian expert. TREVOR offers complex time-management tools from tasks lists, priorisation matrix, progress tracking but all with the support of an AI system. Taking one step forward from the usual, well-known time management apps, the AI in TREVOR analyses the energy level of the user throughout the day, helps to schedule the most important tasks to the best time slots, and offers tools to build a good work-life balance. TREVOR is supported by the Founder Institute.

Turbine: Turbine is a spin-off company set-up by specialists working at Semmelweis University, Budapest and academics in the fields of bioinformatics, network medicine, cloud technologies and artificial intelligence. Turbine is a precious tool in cancer research. Using laboratory trial and error data as input, the AI of Turbine models how cancer works on the molecular level and tests millions of potential drugs on a daily level. Turbine aims to support the quest for cancer drugs in a new way compared to the traditional pharmaceutical solutions.

TypingDNA focuses at identification - but not based on classical biometrics, rather on the typing technique of individuals. Based in Oradea, Romania, the company offers AI-based typing authentication to be used in various sectors from financial services to education. It is a useful identification option in circumstances where no specific tools for reading biometrics are available or the users may not have their phones with them. Typing habits are very specific and hard to change, and can serve as one of the two compulsory identification methods that the new European regulation Payment Services Directive (PSD2) intends to command.

Uponsmart is a smart surveillance company based in Transylvania, Romania, developing its own AI-based solutions. They offer services for industrial cold froze and refrigerators, including monitoring HACCP regulations and other parameters. For other industrial areas they monitor and suggest climatisation options, in order to save energy and offer the best environment for the given work tasks and work force. Their AI-enhanced technology is supplemented by "traditional" Industry 4.0 solutions.

WorkHeld is an Austrian company offering communication for production, assembly and service within the factories based on voice assistants rather than typing. The idea behind is that mechanics, technicians can communicate more efficiently and more timely via voice than typing, because this allows for multitasking (e.g. to document the actions while doing them, retrieve documents while solving a problem, etc.)

6. Perspectives for AI-supported economic development in the Danube Region

The Danube Region countries have long passed the state when cheap labour force ensured international competitiveness. To avoid the middle-income trap, the DR countries have to build resilient, robust and innovation-based economies. Moving forward to higher value added, innovation-based economies is not only the only way forward from the pitfall of the middle income trap, but also the way to build more diverse economies, with enhanced cooperation among the Danube Region industries.

ICTs in general, and AI is specifically a pervasive technology, applied to almost all sectors and industries already. AI helps to identify cancer on CT scans and searches for a cure as well a vaccine for COVID-19, it washes our clothes cleaner with less washing powder, answers our questions as a chat bot in online stores and decides on the suggestions we receive on Facebook.

Innovation in the ICTs and AI is a good candidate to support and invest in for the Danube Region because of the pervasiveness - finding the main sectors that are a part of the DR's smart specialisation profile and infuse those with research and innovation capacities in ICTs and AI is a sound strategy for competitiveness. Smart specialisation areas can be derived from existing R&D and academic centres, key industries present (agriculture and food, machinery, automotive, etc.) and local needs and demand (e.g. health and life sciences, energy) draw the map of target areas. There are also good examples of AI applications in the wood and furniture industries as well as in intelligent textiles in the DR.

It is still paramount to have excellent talent pool of ICT and AI experts, keeping them in the DR instead of being brain-drained, but collaboration platforms with the selected smart specialisation industries, within the countries and among the V4 can create a good basis for innovation in the selected areas. **Furthermore, the companies and start-ups, originating in the Danube Region, shall be helped to keep their local ties even if they get European/global funding and investments**.

Our rudimentary overview of the Danube Region pinpoints at least three things:

1.) Danube **regions are rather heterogeneous** and the **socio-economic innovation ecosystem's performance must be analysed holistically** by taking into account the demand side as well; still,

2.) based on the status of the innovation ecosystems, there is a **perceptible potential for a (uniformly not strength) AI development** in the regions; and

3.) that kind of **development path is not without challenges**.

AI seems to be unavoidable in the life of SMEs in the Danube Region. A more serious application of AI can be considered as a curse and as a blessing at the same time from the point of view of SMEs' data. One the one hand, AI allows hackers/attackers to identify computer vulnerabilities in a substantially more effective way, furthermore, it might offer a wider range of opportunities in launching automated attacks. One the other hand, for legal and law-abiding actors in the innovation ecosystem, AI serves as an effective tool for managing automated defence, more accurate detection of unknown computer vulnerabilities, and can also reduce human labour shortages by replacing many workers who would otherwise be responsible for cyber security at the given company.

With the more vital use of AI, Danube regions can also profit from its usage particularly in increasing the effectiveness of the general fight against cyber-attacks / cyber-terrorism and in achieving a higher level of data security; and, through these, to achieve a higher level of confidence in the diffusion of Industry 4.0 technologies.

The development of Industry 4.0 technologies (including AI) depends a lot on governmental policies designed to initiate sustainable changes that are politically feasible and socially acceptable (inclusive-featured enough).

The areas to give special attention to when formulating development measures:

1.) The **detailed AI-strategy** of the Danube Region has to be formulated, starting with defining its standpoint on legal and ethical issues (mostly following the common EU principles) and on some specific aspects such as cyber security and environment protection.

2.) **In terms of AI-related R&D&I, special assistance programmes** are to be designed, in order to support the higher participation and higher level of coordination within the **European research framework programmes**. Such assistive programs have been conducted before, a proper policy analysis shall help identifying the practices to follow and learn and the mistakes not to repeat.

3.) The innovative **AI applications originating from the region** show that there is significant potential in innovators, SMEs and spin-offs to create AI solutions that are viable on the European/global scale. These innovation can be supported by **a proper innovation hub ecosystem and sufficient business angel /venture capital activities**.

4.) Technology-intensive sectors can receive special support to introduce new AI-based solutions and carry out product- or process innovation within their boundaries. Those sectors within the manufacturing industry are:

- **food and beverages industry,**
- **fabricated metal products,**
- **machinery,**
- **motor vehicles,**
- **rubber and plastics,**
- **textile and leather,**
- **pharmaceuticals,**
- **computer,**
- **electronic and optical products,**
- **wood and cork industry.**

5.) AI -uptake should be supported in general among the SMEs of the region, at the appropriate levels. The potential of AI technologies is to transform any existing technology, means and method of production and consumption of goods and services. Companies and citizens of the Danube Region can only win with the AI-enhanced economy that builds on its innovativeness and specific location.

In addition to other sectors, special attention can be given to the followings, based on the need to overcome labour shortages and other problems challenging the development of the Danube Region:

- **education,**
- **health services,**
- **public sector,**
- **creative and media industries,**
- **information technologies,**
- **tourism**

6.) In order to achieve the real results, the development programme to support the spread and use of AI technologies in the Danube Region must be accompanied by a proper methodological tool system, with statistical, monitoring and evaluating solutions.

In the next table we summarise these actions:

Table 8. A summary of potential actions

Actions, interventions	Rationale and details
1. Formulate a joint ICT and AI policy for the Danube Region, reviewing relevant and existing EU-wide legislation and policies and determine the specificities for the Danube Region	For most legal and ethical issues, the European principles can easily apply to the Danube Region as well (although it is up to individual agreements with the Non-EU member countries).
Agree on main legal and ethical aspects	Review European standpoint
Create an action plan for specific cybersecurity issues	Review critical infrastructure of the region, particular security threats (e.g. geopolitical conflicts and their cybersecurity hazards).
Create an action plan for reducing the environmental footprint of ICT and AI	The climate of the Danube Region requires energy efficient solutions for data centres and large computing facilities
2. Specific R&D&I support actions in order to enhance the participation and coordination activities of local AI R&D&I actors	There will be significant research and innovation funds for ICTs and AI in the H2020 as well as in the forthcoming EU research framework programme (FP), there is no need to dedicate special funding for that alone.
FP coordination and management trainings targeting AI R&D&I actors in the Danube Region	But DR actors lag behind leading AI research and support programmes for joining FPs and taking lead of research projects will be helpful

Networking and matchmaking support Other support measures	
3. Innovation hub and cluster network for AI development	In order to support the local innovators, AI-focused innovation hubs and clusters shall be set up
Offering access to new R&D&I results, Offering test and lab opportunities Networking with other disciplines and industries, in order to create new and innovative products and services Offering legal support, patenting, intellectual property rights Connecting actors to public funds and venture capital	Studies show that complex support and development programmes can reach much better results than single-profiled aid mechanism.
4. AI-application support for areas of strength in the DR	In order to reap the benefits of AI, wide economic and societal use have to be achieved, starting at the areas of strengths of the Danube Region ecosystem.
Focusing at the manufacturing industry, within that: food and beverages industry, fabricated metal products, machinery, motor vehicles, rubber and plastics, textile and leather, pharmaceuticals, computer, electronic and optical products, wood and cork industry.	These industries are of key importance in the countries of the Danube Region, a region with a specific profile of high industrial activities and employment.
5. AI- application support for areas of need in the DR	The Danube Region faces several challenges, especially critical ones in demography and labour shortages among others. AI tools should be used to help to overcome those problems.
Focusing at education, health services, public sector, creative and media industries, information technologies, tourism	These services are important for the development of the region and AI tools can boost their effectiveness
6. Proper monitoring and statistical support to measure interventions	In order to ensure the eurocents well-spent, continuous monitoring and evaluation is needed
Solutions to overcome lack of data and information in the current statistical systems	Lack of comparable data creates significant challenges for the evaluations

Tools to measure efficiency of investment into support programmes, to offer and opportunity to mid-term fine-tune actions	The methodology for programming and evaluating exists but it needs to be applied

7. Project ideas – suggestions

7.1. AI-related agrifood cooperation projects for the Danube Region

The **Danube Region is in a unique position regarding climate change** and the future of agriculture: while the change will affect and may radically alter the whole of the globe. The relative importance of the DR agriculture, being located in the temperate belt, with a still strong water supply and arable land is high and will long hold its key position as the **agricultural treasure chamber of Europe**. Furthermore, the **food industry is rather developed** and is to be further improved in order to bring local jobs and growth. As discussed in our paper, the economic and political will to produce our own food will increase in the future due to lessons learnt from the COVID pandemic. The region is also **rich in natural wonders** and wildlife to be preserved. The project ideas are elaborated along these conditions and preferences.

Production and process of alternative grains, resistant to climate change effects

The Danube Region produces … m tons of wheat every year, this represents the …% within the whole of Europe. But with a growing share of people suffering from various food allergies, intestinal diseases, **the demand for alternative grains (oats, amaranth, quinoa, etc) is rapidly growing**, though quite a lot of those grains are imported into the region. A complex agrifood project could be launched, with the application of AI solutions in order to localise this production and prepare for the climate change effects while also better serving the special needs of people with special diets.

The project would involve a **diverse stakeholder group** from the R&D sector, the production chain (both in agriculture and the food industry), diet and health experts and agencies but also client representatives.

The project can be built on a complex set of **different modules (not all compulsory)**:

- A solid overview of the state of the art of main and alternative grain production and process techniques in the DR
- Collection of big data for cultivation conditions of alternative grains from the global scene
- AI-supported analysis (research, simulation) of alternative grains and their behaviour in various climate change scenarios
- Identifying the optimal conditions localisations within the DR for such production
- Building an agro-alliance of producers willing to take part in a modern production procedure (possibly with the support of agro-chambers and/or associations)
- AI-based support in the production in terms of identifying the optimal level and mixture of fertilizers and pesticides (if the project succeeds, a special brand mark can be created that places products between bio and traditionally processed food. A mark/label such as “Minimal chemical” or “Natural-grown” can be very successful in the market where currently only the very expensive bio and the very industrial, chemical-infected traditional products are available).
- AI/Industry 4.0-based support in the processing procedure: many alternative grains are not working for people with food sensitivities because they are cross-contaminated with wheat (gluten) during harvest /processing
- AI-based support for the farmers in terms of weather and climate monitoring, with suggestions for production steps within the year and across years.
- AI/Industry 4.0 -based support in the full production chain until packaging

- Involvement of health experts and dieticians (institutionally, in the form of an association or similar) in providing qualified health and diet recommendations. Many people switch off from gluten but switch to alternatives that are not helping in their cases (e.g. corn has a high oxalate level, etc.) A specific health-spinoff can be built on this aspect, with big data collected globally on health effects of alternative grains. Also, a feedback loop can be inserted into the project, finding new, innovative techniques in the production chain to solve these issues (e.g. reducing oxalate content, etc.)
- In order to ensure the success of the project, a wide awareness-raising should be done among all types of professionals involved plus institutional actors (including agro and health state and public institutes) with proper marketing campaign towards the potential users. If there is a common mark/label developed that connects the different producers in the group, joint marketing is possible and reduces individual costs for the participating producers.
- If a common mark/label is developed, there has to be a regular checking and controlling to see if the conditions are met. This can also be supported by AI.
- The products are expected to be successful not only in the DR but on the export markets as well, especially in Europe and Asia. As modern, non-GM but climate-aware, chemically not overloaded products satisfying special diets but at a slightly lower price than bio – success is guaranteed. (The slightly lower price than bio can be achieved by the simple fact that this AI-supported production can still be less labour-intensive and done in larger quantities than traditional bio production.)

The costs and timeframe of the project depends on the exact modules chosen. It is advisable to start with a moderate project, with approximately 8-10 partners, within the 1.5 M – 8 M EUR range, with a timeframe of 3-5 years, and build the rest of the modules on top of the running ones once the core results are delivered.

AI-supported collaboration of farmers and wildlife

A great advantage of the Danube Region, **the diverse wildlife often also creates a problem for agricultural production**. There are local efforts to manage the co-existence of the two (a good example is the protection of Charadrius alexandrines nesting places in the Hungarian Great Plains) but coherent, larger scale exercises would be needed in order to ensure long-term co-existence of the natural wildlife and modern agriculture in the DR. With a better understanding of wildlife behaviour and a support from AI can help farmers not only to reduce wildlife loss but also to better protect their crops.

In traditional agriculture, the small- parcel labour intensive method allowed for a relatively peaceful co-existence but modern, often large-parcel industrial agriculture does not afford individual deliberation of specific cases. **The proposed project would build on a large amount of information, big data, Industry 4.0 and AI use in agriculture to accommodate protected wildlife to co-exist.**

The project needs **at least two different types of stakeholders** involved, mostly from the agricultural production and natural preservation scene.

The following modules can be used to set up the project:

- Collection of information and big data on current wildlife and habitat distribution in the DR, with details on protection level and key behavioural aspects (such as migration patterns of birds, etc). The research also needs to include data from outside of Europe in case of migrating species.
- Collection of clashing points both from agricultural and nature protection aspects (loss of crops, loss of wildlife, etc.).
- With the use of big data and AI, with the involvement of experts identifying the starting points for change and potential remedies. The research must consider the food chain of the key protected animals as well. Remedies suggested may involve small but manageable changes in the agricultural production (such as plowing or sowing or harvesting 1-2 weeks earlier or later or using alternatives in fertilizers and pesticides).
- Building a coherent monitoring system with the use of meteorological data, crops information, data from either the farmers or agricultural associations, chambers, natural protection experts
- Use of AI to forecast potential clashing points and intervention recommendations
- AI and Industry 4.0 support for the agricultural producers to carry out those recommendations (such as GPS-based localisation of exact nesting places or sensor-based adaptation of chemical use, etc.).
- Wide-range information campaign is necessary to ensure both the cooperation of agricultural producers and natural preservationists.
- Besides the agricultural producers and wildlife protection specialists, the more diverse stakeholders are involved, the better for the project's success. This may include hunting organisations (already involved in keeping certain wildlife populations at a manageable level), institutional and public organisations, state funds.
- The project has a high educational potential for various colleges and universities, allowing for proper scientific background to be used.
- The project is very marketable, with potential funds for innovation in AI use, for modernisation of agriculture and for wildlife protection as well.

The project can be scaled to a pilot (e.g. 2-4 species to be taken into account or selected geographical locations) but can be enlarged to whole ecosystems. The ideal focus would be at wild birds, due to their relevance to the region with many different habitat locations. Mammals are slightly better managed by existing hunting organisations, and aquatic wildlife is important though, but even more complex to protect as the connection between agriculture and wildlife involves more indirect effects to manage.

A smaller project with a specific focus can be realised from the budget of 1.5-8 M EUR, with a timeframe of 3-5 years. Ideally, the project can be enlarged with various funding options involved. Furthermore, EU/state funds intervention is very welcomed, as in certain cases financial compensation can also be utilized for the farmers when no other intervention is sufficient.

7.2. AI-related health projects for the Danube Region

AI-supported exoskeleton R&D projects for the aging society

The Danube Region population, just as any developed region, faces **aging society challenges** and this will only increase further in the upcoming decades.

Exoskeleton research projects started out at very high excellence research departments, mostly financed by the military for supporting military personnel. Health-related applications very often consider their subjects to be young, "otherwise healthy" apart from certain limb losses, spine injuries.

An important area for research, innovation and development is the **application of AI-supported exoskeletons in helping elderly people to relatively keep up their mobility**. Elderly people have different health and mental conditions that needs to be taken into account. This requires a **different developer mindset**, building on existing technological achievements but innovating in terms of application, user-friendliness, maintenance necessities and monitoring.

Furthermore, exoskeletons are still considered as unique equipment, only available for a selected few. This project also needs a **different attitude in terms of designing the production**, maintenance and monitoring, to allow for a larger scale use at a lower price.

The following project depends on a very complex set of experts – technological researchers, health experts, gerontologists, psychologists, etc – and a user group of elderly people needing assistance in their mobility.

The following modules are to be considered:

- A complex overview of existing exoskeleton research with special marks of applicability to the elderly group.
- A detailed review of the main physical challenges of elderly in terms of potential technological applications. The aim is to increase the mobility, and in certain cases this allows for re-entering society at large, re-entering worklife as being part of the silver economy, in other cases this mobility allows for more independence in the elderly home, partly relieving the support staff.
- A very elaborate analysis of the user-friendliness and psychological aspects of utilizing new tools in this age group. Some already have problems adapting to their new hearing aid, it cannot be expected that they will take up use of new technology seamlessly.
- Using AI and big data to re-design the application of existing exoskeleton technologies to the special needs of this target group. This includes desk research, data collection from other global trials.
- With initial demonstrator items developed, pilot tests in use, supported by sensors and AI to identify key characteristics of use
- Designing new products based on the results from the pilot tests
- Detailed analysis of the user-friendliness of the tools and adaptability to this age group
- Developing a proper online monitoring system for the products
- Designing a communication campaign and to launch a wider application test period with more participants
- Full scale launch of product(s)

The success of the project strongly depends on the non-technological factors, therefore the involvement of health and psychology experts, gerontologists and communicators. Furthermore, if the products are to be used large-scale, developers must make sure to comply with any necessary requirements and legislation in terms of safety as the health regulation of the different countries describe.

Finally, health financiers' cooperation should also be ensured if large scale launch is considered, as public social security and private health insurances' coverage can significantly ease the introduction of the products to the market.

The project can be scaled to a smaller pilot, focusing on certain health problems and dedicated solutions. Such a project can be realised from the budget of 1.5-8 M EUR, with a timeframe of 3-5 years.

References

Beno, M. (2018): Work Flexibility, Telepresence in the Office for Remote Workers: A Case Study from Austria. In: Kaenampornpan, M. – Malaka, R. – Nguyen, D. D. – Schwind, N. (eds.) (2018): Lecture Notes in Computer Science. Multi-disciplinary Trends in Artificial Intelligence Volume 11248 (12th International Conference, MIWAI 2018, Hanoi, Vietnam, November 18–20, 2018, Proceedings. Chapter 2, pp. 19-31.

Bertoldi, P. - Avgerinou, M. - Castellazzi, L. (2017): Trends in data centre energy consumption under the European Code of Conduct for Data Centre Energy Efficiency, EUR 28874 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-76445-5, doi:10.2760/358256, JRC108354

Biloslavo, R. – Kljajic-Dervic, M. – Dervic, S. (2018): Factors Affecting Effectiveness of Knowledge Management: A Case of Bosnia and Herzegovina Trade Enterprises. Knowledge and Process Management, Wiley Blackwell (John Wiley & Sons). https://doi.org/10.1002/kpm.1570

Cabrilo, S. – Kianto, A. – Milic, B. (2018): The Effect of IC Components on Innovation Performance in Serbian Companies. *VINE Journal of Information and Knowledge Management Systems*, Vol. 48, No. 3, pp.448-466, https://doi.org/10.1108/VJIKMS-06-2016-0033

Calvano, E. - Calzolari, G. – Denicolò, V. – Pastorello, S. (2018): Artificial intelligence, Algorithmic Pricing and Collusion. CEPR Discussion Paper No. 13405.

COM(2010) 715 final: European Union: European Commission, Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: European Union Strategy for Danube Region, 8 December 2010, COM(2010) 715 final, available at: https://www.danube-region.eu/images/Communication_from_the_Commission_2010.pdf [accessed 30 January 2019]

COM(2015) 192 final: European Union: European Commission, Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: A Digital Single Market Strategy for Europe, 5 June 2015, COM(2015)192 final, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0192&from=EN [accessed 30 January 2019]

COM(2018) 237 final: European Union: European Commission, Communication from the Commission to the European Parliament, the European Council, The Council, The European Economic and Social Committee and the Committee of the Regions: Artificial Intelligence for Europe, 25 April 2018, COM(2018) 237 final, available at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=51625 [accessed 30 January 2019]

Craglia M. (Ed.), Annoni A., Benczur P., Bertoldi P., Delipetrev P., De Prato G., Feijoo C., Fernandez Macias E., Gomez E., Iglesias M., Junklewitz H, López Cobo M., Martens B., Nascimento S., Nativi S., Polvora A., Sanchez I., Tolan S., Tuomi I., Vesnic Alujevic L., Artificial Intelligence - A European Perspective, EUR 29425 EN, Publications Office, Luxembourg, 2018, ISBN 978-92-79-97217-1, doi:10.2760/11251, JRC113826.

Cvetanović, D. – Despotović, L. – Jovanović-Kranjec, M. (2018): Global Competitiveness of the Republic of Serbia in Terms of Innovation Performance. *Ekonomika*, Vol. 64., No. 1. pp. 25-35.

Czakó, K. – Fekete, D. – Poreisz, V. (2014): Economic Differences of Countries by the River Danube. *Procedia Economics and Finance*, Vol. 9, No. 1. pp. 163-175.

Digital Economy and Society Index (DESI) 2021 Thematic chapters, https://digital-strategy.ec.europa.eu/en/policies/desi

Directive 2003/98/EC of the European Parliament and of the Council of 17 November 2003 on the re-use of public sector information, amended by the Directive 2013/37/EU of the European Parliament and of the Council of 26 June 2013. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02003L0098-20130717&from=EN. Accessed: 11 February 2019

ESPON (2018): Small and Medium-SizedEnterprises in European Regions and Cities. Applied Research, FinalReport, Version 31/01/2018

Ezrachi, A. – Stucke, M. E. (2015): ArtificialIntelligence and Collusion: WhenComputersInhibitCompetition. University of Tennessee Legal Studies Research Paper No. 267.

Fuster, A. -Goldsmith-Pinkham, P. - Ramadorai, T. - Walther, A. (2017): PredictablyUnequal? The Effects of MachineLearningon Credit Markets.CEPR DiscussionPapersNo. 12448

Gopinath, G. - Kalemli-Özcan, Ş. – Karabarbounis, L. - Villegas-Sanchez, C. (2017): Capital Allocation and Productivityin South Europe. *The Quarterly Journal of Economics*, Vol. 132, No. 4, 1 November 2017, pp. 1915–1967, https://doi.org/10.1093/qje/qjx024

Hummel, D. – Karcher, B. – Schultz, C. (2013): The Financial Structure of Innovative SMEs in Germany. *Journal of Business Economics*, Vo. 83, No. 5, pp. 471-503.

Ianioglo, A. – Polajeva, T. (2017): Innovative Component of Economic Security of Enterprises: A Case of the Republic of Moldova. *Journal of Business Economics and Management*, Vol. 18, N. 6, pp. 1228-1242, DOI: 10.3846/16111699.2017.1405365

ICEG EC (2015): National Study on Research-to-Innovation Bottlenecks in Promotion of Energy Efficiency in Moldova. INNOVER-EAST, WP1, Deliverable 1.3. Project co-funded by the European Commission within the 7th Framework Programme (2007-2013). Prepared by Oliver Kovacs.

IMD (2018): IMD World TalentRanking 2018. IMD, Switzerland. Available: https://www.imd.org/wcc/world-competitiveness-center-rankings/talent-rankings-2018/ Accessed on: 20.02.2019

Kovács, O. (2016): The Hungarian Agony over Eurozone Accession. In: Magone, J. M. – Laffan, B. – Schweiger, C. (eds.) (2016): Core-periphery Relations in the European Union – Power and Conflict in a Dualist Political Economy. Routledge, Taylor and Francis Group, Chapter 16. pp. 231-250.

Kovacs, O. (2018): The Dark Corners of Industry 4.0 – Grounding Economic governance 2.0. *Technology in Society*, Vol. 55., No. 3, pp. 140-145. https://doi.org/10.1016/j.techsoc.2018.07.009

Kovács, O. (2019 - forthcoming): Big IFs in Productivity-enhancing Industry 4.0. *Social Sciences*, Vol. No. 2019.

Leithold, N. – Haase, H. – Lautenschläger, A. (2015): Stage-Gate® for SMEs: a Qualitative Study in Germany. *European Journal of Innovation Management*, Vol. 18, No. 2, pp. 130-149.

McKinsey Global Institute (2018): Notesfromthe AI frontier: Modelling theimpact of AI ontheworldeconomy, September.

Ministry of the Interior, Digitisation and Migration on behalf of the State Government of Baden-Württemberg (2018): Becoming the Key Region for Digital Change. Baden Württemberg Leads the Way in Artificial Intelligence. Position Paper. https://www.digitorial.digital-bw.de/download/20181220_Positionspapier_KI_BW_Kurz_EN.pdf. Accessed: 1 February 2019.

OECD (2016): Summary of the OECD Technology Foresight Forum Economic and Social Implications of Artificial Intelligence OECD Conference Centre, Paris, 17 November 2016. DSTI/CDEP(2016)17. http://www.oecd.org/sti/ieconomy/DSTI-CDEP(2016)17-ENG.pdf Accessed: 21 January 2019.

OECD (2018), "AI: Intelligent machines, smart policies: Conference summary", OECD Digital Economy Papers, No. 270, OECD Publishing, Paris, https://doi.org/10.1787/f1a650d9-en.

Polanyi, K. (1944): *The Great Transformation. The Political and Economic Origins of Our Time.* Beacon Press, Boston.

Probst, L. et al (2018) Digital Transformation Scoreboard 2018. EU businesses go digital: Opportunities, outcomes and uptake. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Digital%20Transformation%20Scoreboard%202018_0.pdf. Accessed: 27.01.2019.

Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL LAYING DOWN HARMONISED RULES ON ARTIFICIAL INTELLIGENCE (ARTIFICIAL INTELLIGENCE ACT) AND AMENDING CERTAIN UNION LEGISLATIVE ACTS COM/2021/206 final https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1623335154975&uri=CELEX%3A52021PC0206

Sucháček, J. – Seďa, P. – Václav, F. – Jaroslav, K. (2017): Regional Aspects of the Development of Largest Enterprises in the Czech Republic. *Technological and Economic Development of Economy*, Vol. 23, No. 4, pp. 649-666, DOI: 10.3846/20294913.2017.1318314

SWD (2017) 220 final: Commission Staff Working Document. In-depth Interim Evaluation of Horizon2020. 29 May 2017, SWD (2017) 220 final, available at: https://publications.europa.eu/en/publication-detail/-/publication/33dc9472-d8c9-11e8-afb3-01aa75ed71a1/language-en.

SWD(2019) 6 final: European Commission Working Document Accompanying the Document Report from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Region on the implementation of EU macro-regional strategies: 29 January 2019, SWD(2019) 6 final, available at: https://www.danube-region.eu/images/EC_Report_to_EP_ECouncil_EESC_CoR_Jan2019.pdf

Tick, A. – Vinnai, D. (2016): Internet of Things - Monitoring the Hungarian Business Sector and Consumers. *Hadmérnök*, Vol. 11, No. 2, pp. 192-203.

Uzelac, Z. – Ćelić, D. – Petrov, V. – Drašković, Z. – Berić, D. (2018): Comparative Analysis of Knowledge Management Activities in SMEs: Empirical Study from a Developing Country. *Procedia Manufacturing*, Vol. 17, No. 1, pp. 523-530.

Vidal J (2017) '"Tsunami of data" could consume one fifth of global electricity by 2025', Climate Home News, 11 December 2017. http://www.climatechangenews.com/2017/12/11/ tsunami-data-consume-one-fifth-global-electricity-2025. Accessed 15 February 2019

Links to the case studies:

https://aimotive.com/

https://robart.ai/

https://diceus.com/

https://5analytics.com/

https://biosens.rs

https://brightadvise.com

http://connecto.ai

https://daktilograf.me/

https://decissio.com

https://www.eva.vision/

http://eventregistry.org/

https://www.gideonbros.ai

https://monstyle.io/

https://www.neuronsw.com/

https://onlim.com/en/

https://synetiq.net/

https://www.smartan.ai/

http://www.terraloupe.com/

http://transmetrics.eu/

https://www.trevorai.com/

https://turbine.ai/

https://www.typingdna.com/

https://uponsmart.eu/

https://www.workheld.com/

http://centraleuropeanstartupawards.com