Contribution of Artificial Intelligence to solutions for enterprises

Study regarding the state of the art in the Danube region at the time of the Ukraine crisis and the post-Corona period

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MINISTRY OF ECONOMIC AFFAIRS, LABOUR AND TOURISM
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Preface

This report has been prepared in the framework of the "Development of flagship projects for the PA8 of the EUSDR". The Ministry of Economic Affairs, Labour and Tourism Baden-Württemberg, who is also one of the coordinators of Priority Area 8 (PA 8) of the EU Strategy for the Danube Region (EUSDR), contracted the leader of the awarded consortium (Pannon Business Network) to prepare a comprehensive study regarding the state of the art in the Danube region at the time of the Ukraine crisis and the post-Corona period.

The study has been prepared in line with the required content listed in the public procurement documents of the tender, namely, 1) the analysis of the current economic situation of the EUSDR region; 2) Identification of common problems of SMEs in the EUSDR region as well as 3) Identification of funding opportunities for a possible proposal submission through one or more stakeholders of the PA8 EUSDR in 2022 or latest in 2023.

The current study has been preceded by recently publicised relevant materials which had been written either by the external expert of Pannon Business Network or the author's own previously finalised compilation. The main data, information, results and conclusions of these thematic studies and materials have been utilised in the current study as well, supplementing with new information.

The following main expert materials have been utilised and supported the content finalisation of the current study:

- Interreg Europe Programme: FOUNDATION project; *Building Regional Resilience to Industrial Structural Change; Report on the Resilience of Hungarian Manufacturing Companies*; finalised by Renata Anna Jaksa from ICEG European Center in August 2022

- Artificial Intelligence Working Group of Priority Area 8 of the EU Strategy for the Danube Region: Policy paper on future development areas: *Technology Trends, Artificial Intelligence and Economic Development in the Danube Region;* finalised by Renata Anna Jaksa and Olivér Kovács from ICEG European Center in December 2021

- Interreg V-A Austria-Hungary Cooperation Programme 2014-2020: IMPROVE! project: „Industry 5.0 still digital production" Univ.Prof DI Dr.techn . habil . F. Bleicher and Dr. Thomas Trautner from Vienna University of Technology in September 2022

- Interreg Central Europe Programme: 4STEPS project: *Pilot report of PBN;* finalised by Pannon Business Network in February 2022

- European Commission: Horizon Europe - Work Programme 2023-2024 Digital, Industry and Space_ Annex 7_ Draft version

- European Commission: Horizon Europe- Work Programme 2021-2022_ 13. General Annexes_ European Commission Decision C(2022)2975 of 10 May 2022)

- European Commission: Digital Europe Programme (DIGITAL) Call for proposals Cloud Data and TEF (DIGITAL-2022-CLOUD-AI-03)_ 15 September 2022

- European Commission: Horizon Europe: Preliminary list of ideas for discussion regarding potential topics for the Work Programme 2023-24, v 31/01/22

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Abbreviations

AI: Artificial Intelligence
COVID-19: the Coronavirus disease of 2019
DR: Danube Region
DTP: Danube Transnational Programme
EC: European Commission
EU: European Union
EUR: Euro
EUSDR: European Union Strategy for the Danube Region
EU27: The countries being members of the European Union since 2020 (post-Brexit)
EU28: The countries being members of the European Union between 2013-2020 (pre-Brexit)
GDP: Gross domestic product
GERD: Gross domestic expenditure on R&D
I.4.0: Industry 4.0
I.5.0: Industry 5.0
ML: Machine learning
NACE: Statistical classification of economic activities in the European Community used for identifying various industrial branches (among others)
NUTS2: Level 2 of the Nomenclature of Territorial Units for Statistics
PA8: Priority Area 8 (of the EUSDR)
PBN: Pannon Business Network
R&D: Research and development
R&D&I: Research, development and innovation
RRF: Recovery and Resilience Facility for mitigation the impact of COVID-19
RRP: Recovery and Resilience Plan for mitigation the impact of COVID-19
S3: Smart specialisation strategies
SO: Specific Objectives
SME: Small and medium-sized enterprise(s)
WG: Working group (within each Priority Area of the EUSDR)

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Executive Summary

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. 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. Besides, 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. 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.

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.

Apart from the COVID-19 pandemic, Danube region is heavily impacted by the digitalization that caused paradigm shift in manufacturing. Then this structural change has furthered been deepened by the Ukrainian war, damaging the international supply chains, drastically impacting the raw material and energy costs and the unpredictability of the entire ecosystem.

During this uncertain and turbulent background, it is inevitable for the ecosystem players, including the enterprises as well, to and keep abreast of the latest requirements and tackle the new recently occurred challenges in order to become competitive or maintain their competitiveness. One of the main challenges of the new era is to increase the level of resilience. According to the new paradigm shift, called Industry 5.0. the industries have to be resilient, sustainable and human-centric, and it is important to bring human creativity back into work processes.

The current study shall present a quantitative approach of measuring resilience with summarising an advanced analysis carried out by PBN among Hungarian companies. The used method and the results of this analysis might be transferred to other countries and regions as well. Apart from the quantitative approach, the study shall also propose a method to conduct the qualitative research among companies in order to receive a more comprehensible picture about their resilience level.

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The study is also going to reveal the different type of shocks, that the entire ecosystem, including the companies might undergo, and some recommendations will be also shown how to become resilient, nevertheless, we must clearly state that there are no specific characteristics neither of a company nor the ecosystem that would make them resilient.

One of the elements of becoming resilient might be that enterprises utilise Artificial Intelligence solutions which have different application areas, which will be also described in the study.

Artificial Intelligence will be playing an important role in the next 10-15 years in the development of the Danube Region, so the proper policy support and adequate financial measures need to be advocated.

Most of the EUSDR countries/regions have their own AI platforms, which would benefit from enhanced collaboration and interoperability. Individually the players cannot achieve the necessary critical mass with respect to know-how and competencies. The synergies can only be identified through collaboration among the players.

In the last part of the study, policy recommendations shall be scrutinised firstly on company level on regional, national, Danube Region as well as EU level.

Finally, funding opportunities in different programmes will be also described which might be also beneficial for enterprises.

1. General background

1.1 Danube Region and its SMEs

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

Map 1 Graph Territorial coverage of the Danube Region

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

The Danube Region is a complex and heterogeneous macro-region, encompassing EU-members, candidate countries and member countries of the European Neighbourhood Policy. Countries in the Danube Region vary according to size, population, development level and innovativeness and many other factors. (Jaksa and Kovács,2021). Due to this diverse character, the macro-regional entities face very different development potential and challenges. Despite of the previous phenomena such convergent factors are also crucial like the high importance of manufacturing industry and the overwhelming demand of applying novel technologies for competitiveness improvement.

It is essential to be highlighted that, industry still plays a significant role in the economies of the Danube Region countries. 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. Nevertheless, rising wages may lead to middle income trap, unless innovation and increasing productivity can counterweigh. (Jaksa and Kovács, 2021)

Looking at the SME (small and medium-sized enterprises) demography of the Danube Region, it is rather vivid and complex. According to Jaksa and Kovács, 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.
Jaksa and Kovács highlight that 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. (Jaksa and Kovács, 2021)

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. 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. (Jaksa and Kovács,2021)

Apart from the significant labour shortage, the deficiency of raw materials should be also solved with the best optimalization of the value chain**. Because of the Ukrainian war from February 2022,** the global energy shortage has been playing a crucial role, which also needs to be optimised in order to reduce energy supply dependencies, and also enhance more sustainable and environmentally friendly energy modes in the near future.

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

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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. (Jaksa and Kovács,2021)

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.

1.2 Main objectives of Priority Area 8 of the EUSDR

1.2.1. EU Strategy for the Danube Region (EUSDR)

The EUSDR is a macro-regional strategy adopted by the European Commission in 2010 and endorsed by the European Council in 2011. By implementing the strategy, the aim is to create synergies and coordination between existing policies and initiatives taking place across the Danube Region and to tackle challenges of this region:

- Environmental threats
- Uneven socio-economic development
- Untapped shipping potential and lack of modern road and rail transport connections
- Uncoordinated education
- Shortcomings in safety and security
- Insufficient energy connections
- Uneven research and innovation systems

The EUSDR provides an integrated framework for strengthening this cooperation between nations. Bringing together 115 million people from nine EU member states, three EU candidate countries and two EU neighbour countries, it has an important integrative and cohesive function. Reports of the European Commission acknowledge that, since its creation in 2010, the strategy has successfully generated structures, projects, and networks to tackle common challenges. However, large dissimilarities between countries and within countries persist, highlighting the need for a continued and even re-enforced joint endeavour. In addition, some challenges, as climate change or demographic change and migration, are becoming more urgent and need to be addressed in a coordinated way beyond borders. Digitalisation brings both challenges and new opportunities; again, cooperation and exchange among the Danube countries will be crucial to avoid increasing disparities[1].

The EUSDR intends to develop coordinated policies and actions in the area of the river basin, reinforcing the commitments of Europe 2020 strategy towards the smart, sustainable and inclusive growth based on four pillars and twelve priority areas. These shall tackle key issues as mobility, energy, biodiversity, socio-economic development or safety.
In line with the goals of territorial cooperation objective, the Strategy is not focusing on funding, but rather on enhancing closer cooperation within the concerned territory. A key element of the strategy is

[1] EU Strategy for the Danube Region Action Plan_ version 2020 April

coordination, by encouraging the increase in the level and quality of network activities, strengthening the existing regional and interregional cooperation but also fostering new cooperation.[2]

1.2.2. Priority Area 8 within the EUSDR

A core objective of the EUSDR is to enhance the economic connection and integration within the entire European Union. It leads directly also to companies' integration, that is the ultimate goal of the PA 8 of the EUSDR.
For each Priority Area (PA) the Action Plan will present the issue and indicate main problems. For example, the PA 8 aims to support the competitiveness of enterprises in the Danube Region[3].

The main actions of the PA 8 are:

- to foster cooperation and exchange of knowledge between SMEs, academia and the public sector in areas of competence in the Danube Region
- to improve business support to strengthen the capacities of SMEs for cooperation and trade
- to support enterprises through high performing training and qualification schemes
- to prioritize the effective implementation of measures provided for under the Small Business Act for Europe
- to improve the competitiveness of rural areas and in particular of the agricultural sector
- to eliminate cross border barriers and bottlenecks to people and business -Seamless Europe for a liveable Danube Region
- to improve framework conditions for SMEs in areas where competitive infrastructure is missing

Priority Area 8 is divided into five thematic working groups, (WG) and all of the WGs are led by a competent and experienced partner.

WG – Innovation and Technology Transfer

WG Leader: Steinbeis-Europa-Zentrum from Germany

Main Objectives:

- to identify the main challenges and to improve the framework conditions in innovation and technology transfer in the Danube region
- to foster the cooperation in the field of innovation and technology transfer to generate concrete transnational projects
- to support and improve the competitiveness of the Danube region by generating concrete technology offers, technology requests and expression of interest in the field of innovation and technology transfer
- to support cross-fertilisation collaboration in innovation and technology transfer by organising specific thematic workshops
- to improve policy dialog and public governance in innovation and technology transfer by promoting adequate policies and policy papers

[2] Interreg Danube Transnational Programme website: https://www.interreg-danube.eu/about-dtp/eu-strategy-for-the-danube-region
[3] Danube Region Strategy website: https://competitiveness.danube-region.eu/

- to support and improve the innovation technology transfer framework conditions at the local and regional level through the flagship project "Danube Transfer Center network" as HUBs for SMEs
- to support and increase the participation of the Danube actors in EU innovation and technology transfer financed project

WG- Digital Danube

WG Leader: Reutlingen-University, Herman-Hollerith Centre, Germany

Main objectives:

- to combine the major regional and transnational stakeholder and their complementary resources, systems and skills – supported by instruments like e.g. digital innovation hubs / digital service platforms / value chains – with the clear goal to generate, new digital business models, products, processes or services

WG – Female Entrepreneurship

WG Leader: Regional Agency for Entrepreneurship and Innovations – Varna (RAPIV), Bulgaria

Main objectives:

- to improve business support to strengthen the innovative and digital capacities of female-led-SMEs

WG- Artificial Intelligence

WG Leader: Pannon Business Network, Hungary

Main Objectives:

- to foster the application of AI in the Danube Region in the key application areas using different kind of technologies.
- to address different types of representatives (such as experts, BSOs R&D associations) throughout the Danube Region who might collaborate and learn/experience good practices from each other in the field of Artificial Intelligence

WG – Clusters and Regional Development

WG Leader: Croatian Wood Cluster

Main Objectives

- to support cluster managers in providing the effective support to their SMEs
- to support clusters of the Danube region to strengthen their role in the regional development

As the main objectives of the WGs reveal, the horizontal goal of the Priority Area 8, as supporting the competitiveness of the SMEs in the Danube Region is incorporated into the specific objectives of each WG. Working Group Members have also contributed to the most updated version (2020 April) of the EU Strategy for the Danube Region Action Plan (EUSDR Action Plan).

The unequal level of economic development is one of the most visible challenges within the Danube Region. The economies of the region are strongly relying on SMEs, but due to various difficulties, they are not able to exploit their existing potential completely. However, their support in overcoming the economic disparities is indispensable.

As the April 2020 version of the Action Plan is highlighting, SMEs are facing extremely heterogeneous challenges during their daily operation, but the effects of the digital transformation processes will concern them all. Unfortunately, due to the different economic development, digitalisation as a topic may seem relevant in one country but does not yet exist in another. However, digitalisation is rightly referred to as the third Industrial Revolution. Single technologies like Cloud Computing, Mobile Computing, Internet of Things, Block Chain or Artificial Intelligence and their combined application, are changing the way we do business today. Digitalisation affects all economic sectors and areas of life. Against this background, digitalisation and its challenges should be addressed when talking about competitiveness. The same is valid for the Artificial Intelligence, which is a complex domain on a hype, with enormous resources put behind. It is an organic consequence of earlier decades of ICT, data storage, processing capacity and data transmission developments. The applications of artificial intelligence will determine the operation.

The greatest added value for the Danube Region will be achieved if priority is given to sectors where the region has existing strengths, or in priority activities identified in the corresponding regional smart specialisation strategies.

Due to the successful involvement and valuable contribution of the WG leaders and the WG Members, the following five actions have been defined and have been incorporated into the latest version of the Action Plan. These proposed actions certainly correspond with the main aim of PA8 and the specific objectives of each WG:

Action 1:
To foster cooperation and exchange of knowledge between SMEs, creative industry, academia, the public sector and civil society in areas of competence in the Danube Region

Action 2:
Establishment of an Innovative Digital Ecosystem in the Danube Region in order to support SMEs when tackling the challenges of a digitalised world

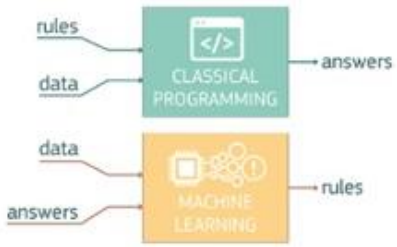
Action 3:
Improvement of framework conditions, support programs and capacity building of stakeholders, to enhance the collaboration between cluster initiatives and regional innovation strategies, with an accent on rural areas

Action 4:
To improve business support to strengthen the innovative and digital capacities of female-led-SMEs

Action 5:
Enhance the application of Artificial Intelligence (AI) technologies in the Danube Region SMEs

1.3. The uptake of Artificial Intelligence solutions in the Danube Region

An explanation on the nature of AI is provided by the experts of IPTS JRC, EC[4]: 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 1). 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)



Graph 1: The difference between classical programming and machine learning

In Table 1 the most frequently used, AI related terms and definitions are explained and summarised, whereas in Table 2 the key application areas of Artificial Intelligence and the possible technologies are shown in a matrix format. This matrix can be considered a starting point, which enterprises in the Danube Region should take into consideration.

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.

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

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.

Table 1: Key AI definitions (Source: Jaksa and Kovács, 2021)

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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

Table 2: Key application areas of AI (Source: Jaksa and Kovács, 2021)

As it was emphasised by Jaksa and Kovács, 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, also in socio-economic fields, from finance to politics**.

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.**

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1.4. A new industrial revolution: Industry 5.0

In the last decade, Industry 4.0, and the advanced application of I4.0 technologies were playing an important role in the lives of enterprises not only in the Danube Region, but in the entire EU as well. Companies were endeavouring to adapt to the technology areas of I4.0 in order to maintain or become more competitive on the market. The name Industry 4.0 refers to the fourth industrial revolution, by which we mean the automated, optimized and fully integrated production process.

Industry 4.0 was considering the digitization of production almost exclusively as a technological issue, whereas the importance of human resources appeared only in the background. Nevertheless, Industry 5.0, which term has been being used approximately from 2020, requires manufacturers to highly focus on human expertise in many cases in order efficient production run sustainably and smoothly. (Dalnoki, 2022)

Similarly to Industry 4.0 about 15 years ago, several definitions and concepts were already raised in connection with Industry 5.0 in the last few years. In this sub-chapter, the main message, and common agreements of I5.0 shall be briefly described.

As Oláh et. al. argue in their article, compared to Industry 4.0 - which enabled the digitization of production - Industry 5.0 emphasizes the cooperation between human and machine. This cooperation should be interpreted broadly, as it also has a social, ecological, and economic dimension. Industry 5.0 includes today's modern production processes with the aim of enabling robots and humans to work and collaborate together, as it is important to bring human creativity back into work processes. Consumer expectations and market requirements are increasingly moving away from mass production, and customers are requiring and preferring unique products. (Oláh et. al., 2019)

According to Bleicher and Trautner, Industry 5.0 cannot be considered a chronological continuation of I4.0, they are highlighting that a paradigm shift is required to be carried out between I4.0 to I5.0. (Bleicher and Trautner, 2022)

The EU's recovery requires the acceleration of the twin green and digital transitions, so a more sustainable and resilient society and economy is required to be built. Industry is among the key drivers of this dual transition.
Based on the definition of the European Commission, "Industry 5.0 recognises the power of industry to achieve societal goals beyond jobs and growth to become a resilient provider of prosperity, by making production respect the boundaries of our planet and placing the wellbeing of the industry worker at the centre of the production process.

One of the main findings of the Commission's report is that digitalisation provides industry unprecedented opportunities. Digital technologies such as AI or robotics allow radical workplace innovation, optimising human-machine interactions will capitalise on the added value human workers bring to the factory floor. By developing innovative technologies in a human-centric way, Industry 5.0. can support and empower, rather than replace, workers; we increase industries' resilience and make it more sustainable.[5]

[5] European Commission: Industry 5.0 : towards a sustainable, human-centric and resilient European industry, Publications Office, 2021

If we rephrased the Commission's definition, we would highlight that industry has to be resilient, sustainable and human-centric as also emphasised by Bleicher and Trautner. As a result, based on technological progress a "win-win" situation will appear between society and industry.

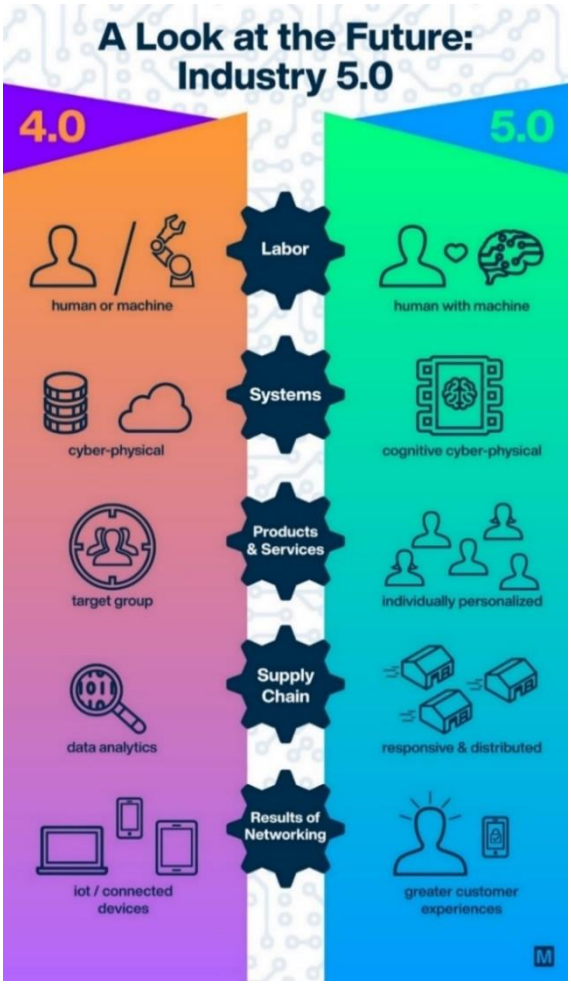

Figure 1: Infographic of Industry 4.0 and Industry 5.0
Source: Mouser Electronics (2020)

The Industry 5.0 approach to industry contributes to three of the Commission's priorities for between 2019-2024: "An economy that works for people", "European Green Deal" and "Europe fit for the digital age".

Elements related to the future of industry are already part of major Commission policy initiatives

- adopting a human-centric approach for digital technologies including artificial intelligence (Proposal for AI regulation)
- up-skilling and re-skilling European workers, particularly digital skills (Skills Agenda and Digital Education Action plan)
- modern, resource-efficient and sustainable industries and transition to a circular economy (Green Deal)
- a globally competitive and world-leading industry, speeding up investment in research and innovation (Industrial Strategy)

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These are just some examples that demonstrate the strong links between the industrial transition and other societal developments. [6]

As this sub-section has shortly revealed, a paradigm shift needs to be carried out by industry and society from Industry 4.0 to Industry 5.0, in order to become resilient, sustainable and human-centric. As also presented, the most updated strategic documents on European level have been also advocating this shift, therefore, this concept has to be understood and applied by the ecosystem together with the enterprises in the whole EU and obviously by the Danube Region companies as well.

This sub-chapter has also emphasized that resilience and being resilient is a crucial element in Industry 5.0. Consequently, in the following sub-chapter, the definition and concept of resilience shall be scrutinised, presenting the literature background, methodological use case and their conclusions.

2. Understanding the concept of resilience

2.1. Resilience in parallels of ecology and economy

The modern reuse of the concept dates back to Holling's article from 1973[7], on resilience and stability of ecological systems.

Gallopin[8] transferred the ecological concept into economy, defining the resilience or resistance of enterprises as "the ability of an enterprise to cope with changes, adapt to and recover from negative impacts coming from the business environment" (Gallopin, 2006).

The paradigm was shifted again by[9] Sanderson, Capon and Hertzler in 2017 claiming that economic resilience in fact is nothing like ecological resilience. In their understanding resilience is defined from the perspective of a decision-maker and the most crucial difference between socio-economic resilience and ecological resilience is that people as decision makers are conscious of the future (therefore are capable of planning, weighting options) in a way that the natural ecosystem (actors) are not.

[6] European Commission: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/industry-50_en

[7] C.S. Holling: Resilience and stability of ecological systems, IIASA . 1973 Sept
[8] Gilberto C. Gallopin – UN ECLAC 2006 Global Environmental Change 16 (2006) 293-303
[9] Sanderson,T – Capon, T - Hertzler, G. (2017) (N.d.). Monash.edu. Retrieved June 30, 2022, from https://www.monash.edu/__data/assets/pdf_file/0010/1168381/Capon.pdf

2.2. Shocks and crises

Resilience definitions also differ in their subject(s) as well – whose resilience are we looking at? Answers differ from micro-level actors (decision-makers, households, enterprises, etc.) to mid-level players (industries, regions) to macro-economies – nations, continents, planets. In the literature, researchers representing evolutionary economic geography are the ones who are most interested in the concept of regional economic resilience.[10]

Jaksa in her 2022 report highlighted that it is important to note, crises are not **per se negative.** A certain crisis might be advantageous for a company whereas impedimental for other firms.

Jaksa (2022) revealed that the term of resilience is not a single issue, but apart from the definition of resilience, the crises themselves must be also better understood. Jaksa (2022) distinguished different types of crises: First, the **temporality of the crisis:** most resilience-related research targets reaction to shocks, namely sudden, rather fast hitting crises that come, hit, go – they have a "lifespan" of maximum 1-2 years - and then economy and society have to deal with the consequences. A significant number of these shocks are so-called "**black swans",** i.e. events that were not foreseeable and prognosed.

However, enduring crises like war, recession, inflation pressure, unsolved labour shortages can all create persistent stress factors and only the resilient ones shall survive. It is still a question how this type of resilience relates to the resilience to sudden shocks, whether these are the **same qualities needed or a completely different skillset**, approach and characteristics describe resilience in endured crises.

There are several so-called **"megatrends"** that create a clear and compelling stress for a significant share of the economic actors, yet they are Ianus-faced: for some actors they represent a crisis, for others, an opportunity. Typical such megatrends are digitalisation and climate change, which creates opportunities for green energy, non-traditional agriculture and all those actors that will gain from others forced to leave the market.

There are comprehensive economic crises, such as the global financial and economic crisis of 2008-09, which affected all aspects of life and business. There are crises that do not affect **all sectors equally** (such as COVID-19: although it has an impact on tourism and the food industry, the effects are not comparable). Radical sectoral regulation, product fee changes or an increase in the minimum wage for skilled workers may also pose a crisis situation for certain sectors.

Yet, crises can be completely unique and **company-specific.** The withdrawal of the largest customer, the termination of the most important supplier, or the loss of important key people from the organization can also lead to an unexpected shock situation for a company when it comes to creatively solving the problem and finding a way out, moving forward. Identifying, measuring resilience at this individual level is rather subjective and can be approached with a more qualitative methodological toolbox than quantitative.

[10] Boschma, R., Balland, P.A. and Kogler, D. (2015) Relatedness and Technological Change in Cities: The rise and fall of technological knowledge in U.S. metropolitan areas from 1981 to 2010, Industrial and Corporate Change, 24 (1): 223-250

2.3. Resilience in enterprises

Supardi et al. conducted a comprehensive analysis of the concept of resilience in SMEs and arrived at the conclusion that three main concepts can be defined in terms of company resilience. When researchers characterise resilience as "alertness", "preparedness", they are describing an a-priori resilient organisation, one that is not hit (seriously) by the crisis – this is ***proactive*** resilience. In other cases, resilience is seen as the capacity to "bounce back" suggesting a ***reactive*** relationship to the crisis. The authors also coined the term ***absorptive/adaptive***, for those companies that – though they are not insusceptible – can learn, transform, adapt during the crisis and absorb at least part of the shock.[11]

Various analyses identify **different skills** and capacities for enterprises as tools of resilience, most revolving around notions of having a portfolio of business finance tools, a diversity in buyers and suppliers, spendings for R&D&I, allocation of investments into IT and modern, efficient technologies, devoting efforts for trainings and education, getting involved in professional and social networks. Nevertheless, it cannot be defined unequivocally whether these options are available for a set of companies, **what makes some of them more resilient than the others?**
The managerial skills have to be also highlighted together with the entrepreneurial spirit that makes the decisions on strategy, investments and portfolio building, but they are **the hardest to be grasped**, yet the most crucial bits for resilient companies.

Recent global developments have re-rooted many preconceptions about the global labour distribution and optimal structure of production and value chains. The COVID-19 pandemic demonstrated very clearly what happens when either production or transport/logistic[12] disruption hit economies, originating next door or from the other side of the globe.

3. Measuring resilience - quantitative approach

Measuring resilience is a rather complex methodological issue where – before answering any questions – one must revisit the same old challenges of definition: resilience of *whom* and to *what type of crisis*? Scientific literature offers many different approaches to measuring resilience, varying depending on whom we consider to be the subject of resilience (company, region, regime, nation, sector, ecosystem, etc.) and what types of crises we define.

An interesting approach to resilience measurement is offered by Kahsai et al.[13] as they evaluate and measure county-level resilience in West Virginia, US. This approach can be modified and adapted to the Danube Region as well. Their dimensions are as follows:

- Human Capital
- Physical Capital

[11] Supardi, Supardi & Hadi, Syamsul. (2020). New Perspective on the Resilience of SMEs Proactive, Adaptive, Reactive from Business Turbulence: A Systematic Review. Xi'an Jianzhu Keji Daxue Xuebao/Journal of Xi'an University of Architecture & Technology. Volume XII. 4068-4076.

[12] The Evergreen container ship's case was also cardinal in proving the point

[13] Kahsai, Mulugeta; Yu, Junbo; Middleton, Mark; Schaeffer, Peter V.; and Jackson, Randall, "A Framework for Measuring County Economic Resilience" (2015). Regional Research Institute Publications and Working Papers. 22. https://researchrepository.wvu.edu/rri_pubs/2

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- Industrial Diversity
- Income Diversity
- Scale and Proximity (as in economic geography)
- *Entrepreneurial Activity and Business Dynamics*

3.1 Use case of quantitative resilience analysis among Hungarian companies

A research group from Pannon Business Network (Nemény, Molnár and Barta[14]) built a framework for the quantitative analysis of resilience based on the typology presented by Supardi et al.[15] operating with the three main enterprise behaviour in times of crisis: proactive, adaptive/absorptive and reactive.

In the Hungarian context, the research team had made an effort to delve into the last dimension coined by Kahsai et al.: *entrepreneurial activity and business dynamics*. The research aimed at pinpointing which Hungarian companies in the manufacturing industry can be considered as resilient so they can be identified and the reasons behind their resilience can be further analysed in order to learn the lessons and transfer that knowledge to a wider range of economic actors and among other regions.

The database used for the research exercise included the key data of Hungarian enterprises from their yearly accounting reports. The balance sheets, profit and loss report are due for each calendar year and are publicly available. The database runs from year 2002- 2019. Unfortunately, data from 2020/2021 were not yet available – would be advisable in the future to include in the analysis since they describe the impact of the most recent crisis, the COVID-19 pandemic. There are – except for 2002 – more than 10.000, less than 18.000 individual companies' data for each year from more than 80 NACE sub-sectors in the database.

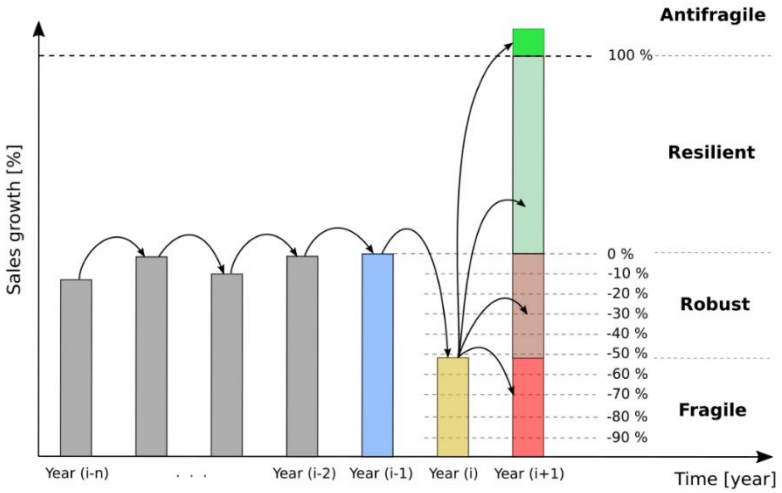
The database was – regardless of shortcomings – extremely valuable due to the fact that no other data collection than the legally compulsory yearly financial accounts would offer such a systematic, corresponding, methodologically and temporally harmonised dataset in so many different indicators.

Experts of Pannon Business Network have conducted a detailed statistical analysis that was not using sectoral averages as baselines. The motivation behind was the attempt to measure not only the resilience against global/national/sectoral crises but to be able to draw conclusions on any crisis, regardless of its coverage – a crystal clear understanding of what "resilience" may mean, even if the shocks are not otherwise identified by the researcher. This approach also allows for taking a look at resilience in individual-level crises (e.g. major changes in the life of the given company, key HR changes, dropout of the most significant buyer or supplier, etc.)

The analysis concluded to four main categories of companies identified and tested for their resilience performance. (Graph 2) A control group was also identified in the framework of the above analysis. As the report defines, the categories are:

[14] Nemény, D., Molnár, M., Barta, B.: Measuring Business Resilience: An analysis of Financial Indicators for Quantifying Resilience on the Micro Level. Under publication.
[15] Supardi, Supardi & Hadi, Syamsul. (2020). New Perspective on the Resilience of SMEs Proactive, Adaptive, Reactive from Business Turbulence: A Systematic Review. Xi'an Jianzhu Keji Daxue Xuebao/Journal of Xi'an University of Architecture & Technology. Volume XII. 4068-4076.

- Fragile: Annual revenue(year i+1) < Annual revenue(year i) or
  (Shock level[16])% > Sales Growth(year i-1 -> year i+1) > -100%
- Robust: Annual revenue(year i) < Annual revenue(year i+1) < Annual revenue(year i-1) or
  0% > Sales Growth(year i-1 -> year i+1) > (Shock level)%
- Resilient: Annual revenue(year i-1) < Annual revenue(year i+1) < 2*Annual revenue(year i-1) or 100% > Sales Growth(year i-1 -> year i+1) > 0%
- Antifragile: 2*Annual revenue(year i) < Annual revenue(year i+1) or
  Sales Growth(year i-1 -> year i+1) > 100%[17]



Graph 2: Basic concept for the classification of companies that were exposed to economic shocks. (Source: D.T3.7.1. 4STEPS Project)

The results from the analysis can be used as a background for identifying next steps for the qualitative research phase as well as drawing up further methods to quantitatively analyse the existing dataset.

The second analysis – Notre Dame team

The economic resilience of Hungarian companies was also analysed by the Notre Dame Capstone Project Team[18] based on the same data described earlier in this chapter. They approached the data with a regression and a clustering analysis. The logical framework rests on the thesis that the sectoral average performance provides a baseline in the given year, compared to which individual companies over- or

[16] The shock level of a company is depicted based on its annual sales growth indicator that represents the relative change in its annual net revenue compared to the level measured in the previous year. In case the sales growth is 0% the revenue stagnates, while at -100% the company loses the complete amount of revenues and earns literally no money in the sequential year. A positive sales growth is advantageous and expected, however in case of an economic turbulence negative values can appear in the time series. If the annual sales growth is less than 0% we define an annual economic "shock" of the company and the level of this fall-back characterizes the depth of the crisis.

[17] the year of economic disturbance as year i, while the previous one with year i-1 and the year of comeback with yeari+1

[18] Arden Cohen, Gabriel Wu, JD Damarillo, Skye Liu, Notre Dame Research Team, 2022. Under publication.

underperform. This can help pinpointing those companies that show resilient behaviour and even provides a scaling of that resilience.

The research team identified two behavioural patterns of companies: resisting and recovering therefore defined resilience "as a company's ability to resist or recover from difficult events.".

The "crisis influence matrix" was set up by the team included the sectoral influences (identified as increasing, stagnating or decreasing sectoral -level influence/performance) compared to the individual company level financial performance index (again, increasing, stagnating or decreasing).

Based on this evaluation within the crisis influence matrix, all companies were assigned a number between 1 and 5, number 5 representing top performers, the most resilient ones.

Results of the analysis in case of the manufacturing sector were (excerpt from the Report)[19]:

- Cluster 1 characterized by having the highest resiliency score and total assets and the second lowest shareholders' equity and ROA. It can also be described by its companies typically being located in the Pest region while being 19 years old
- Cluster 2 had the second highest total assets, shareholders' equity, ROA, and resiliency score metrics. These companies are typically located in the Western Transdanubia region and are 19 years old
- Cluster 3 characterized by having the highest shareholders' equity and ROA but the lowest total assets and extraordinary income -- It is tied for second regarding its resiliency score. These companies are typically located in the Central Transdanubia region and are 19 years old.
- Cluster 4 described as having the lowest ROA, resiliency score, and shareholders' equity. These companies are typically 18 years old and are located within the Budapest region

The authors of this analysis state that further analysis should lead to a better identification of success and resilience characteristics and a more focused profiling of those companies that are worth to be taken into an even deeper – qualitative – investigation.

3.2. Understanding and interpreting the results

During the above-described analysis, it turned out, that there are also many factors outside the financial analysis that pose questions for the interpretation of results. One key example is the socio-economic embeddedness of companies: Certain companies may not show a downslide in economic performance even during a crisis because a.) they are not operating fully in market conditions (e.g. companies with special licences, concessions) b.) the decrease in profit from markets would be counterbalanced by state or EU-funded grants that can mask in the shorter term (couple of years) the otherwise more negative performance.

Some of the indicators that are worth looking into at a deeper level are:

- fixed assets
- intangible assets / or capitalized value of R&D

[19] Arden Cohen, Gabriel Wu, JD Damarillo, Skye Liu, Notre Dame Research Team, 2022. Under publication.

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- shareholders equity
- revenue from other performances / other income

The **value of this quantitative exercise** can be considered as twofold:

- First, it provides an overview of the economic state of resilience of Hungarian companies, even if all the methodological challenges are taken into account.
- Second, this is the only tool to filter out those companies that are worth to be looked at in a deeper way, during a qualitative research phase. All those numbers do not answer our underlying question: *What makes these companies resilient*? To answer that, we will have to use **qualitative methods to question them**.

The main goal of the above-described quantitative research was to better understand the resilience and business performance of the Hungarian companies, or rather – to be specific – of the manufacturing industry. The conclusions of the study can be considered as an appropriate starting point, and therefore, might be exploited, and it is recommended that **a similar analysis might be carried out in a future project among other European and/or Danube region companies**, in order to examine and better comprehend the resilient companies and their characteristics, making Danube Region and its enterprises more competitive and as resilient as possible, **as required also by the paradigm of Industry 5.0.**

4. Measuring the resilience; Recommendation for a qualitative approach

4.1. Conceptual framework for the interviews

Apart from the quantitative research (described above), the qualitative approach is also playing a significant role in order to receive an overall picture of the companies and their resilience level. The various social science and economic analyses can be approached with numerous qualitative research methods, techniques and procedures.

The questionnaire and interview process of this exercise is advised to build on several previous attempts to understand and analyse resilience at company level. Most importantly a future project might provide an opportunity to overview the topics, issues and to set the questions that are relevant in this effort.

In the qualitative phase, the secrets, causes and tools of perseverance and resilience in businesses are recommended to be interviewed. We would like to know how a company recovers from a crisis, what external and internal resources it relies on in this process, and what solutions can serve as an example for other businesses.

For conducting the qualitative analysis, a preliminary interview scheme and a proposed invitation letter have been prepared which can be found in the ANNEX 1-2 of this report. This scheme is intended to shed light on different aspects of being resilient of a company including relevant topics among others, Managerial; Labour force and organizational structure; Products/Services Technological:
This interview- of course following a customisation of a certain project- might be utilised in the qualitative approach in the future.

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4.2. Preliminary results and interpretation

An exercise based on similar prepositions but at a much smaller scale has already been conducted in the framework of an Interreg Central Europe project. (4STEPS project, 2022) The most important findings were that robust (very resilient) companies were characterized by the following features:

Robust

- Serves a rather conservative but stable demand
- The company also aims to keep its customer pool diverse.
- Invests into product development
- Introducing Industry 4.0 technologies
- To standardise and monitor all company functions and processes, to lessen their dependence on individuals and to reduce the chances for human error.
- Having the market advantage is still being relatively low-cost in production but producing a quality that meets the "Western" requirements.
- Successful generational change on behalf of the leadership
- The enterprise runs internal trainings and offers development opportunities for the staff.
- Initiate trainings and mentoring in change management, to be better adapted to continuously changing environments.
- To keep building by smaller steps.
- Standing on more than one foot allows them to create stable growth for the company and its employees.
- Having diverse clients, having a portfolio that is less sensitive to individual shocks.
- Having the market advantage of being broad-scaled
- Happy customers yield a lot of word-of-mouth marketing,
- Operating in a specialised niche market
- The system is built on a standardised but modular principle,
- Investing into their very own R&D team, applying Industry 4.0 technologies

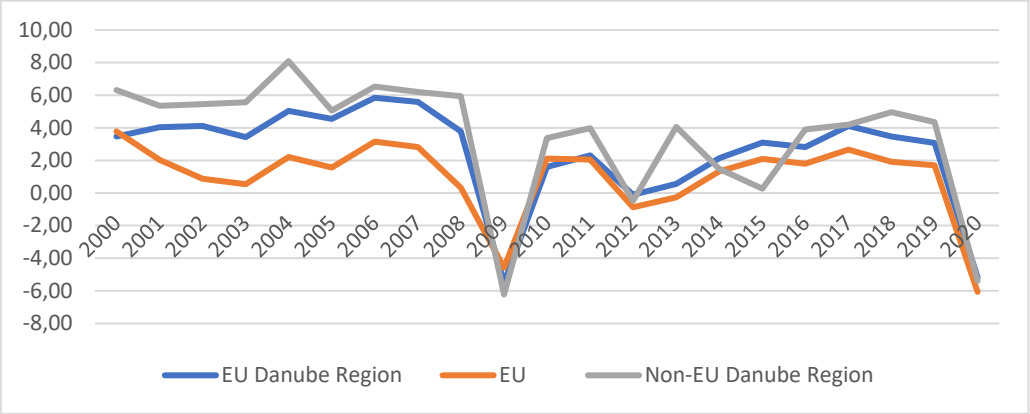
Based on these results, the hypotheses and potential tool/characteristics definitions of this research were revisited and refined. Once the analysis is conducted and the new research report is available based on the interview series, the relevant policy recommendations can be elaborated for future use.

5. Analysis of the current economic situation of the EUSDR region

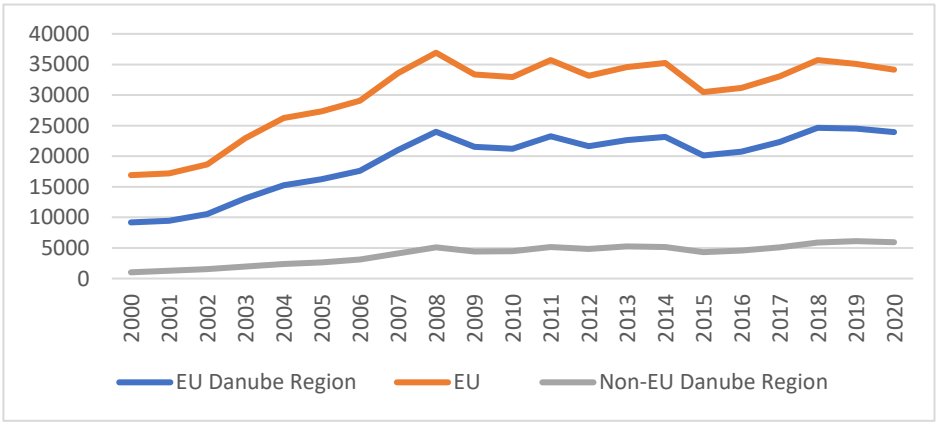
5.1. Identification of common problems of SMEs in the EUSDR region

As it was stated in Jaksa's and Kovács's report in 2021, 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 3). 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.



Graph 3: GDP per capita growth in EU and non-EU Danube regions (annual %) (Source: Jaksa and Kovács, 2021)



Graph 4: GDP per capita, PPP (current international $) (Source: Jaksa and Kovács, 2021)

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 5 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.)

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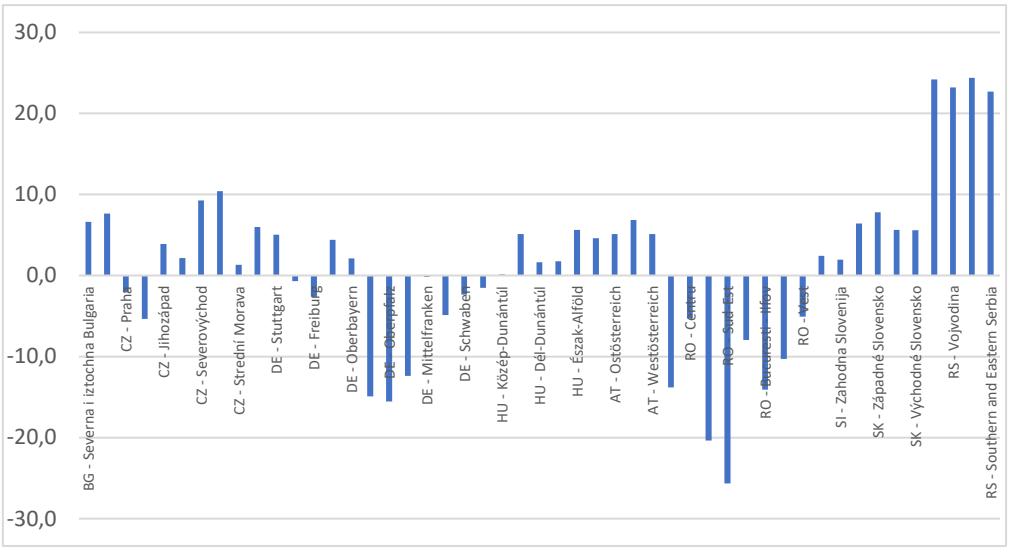
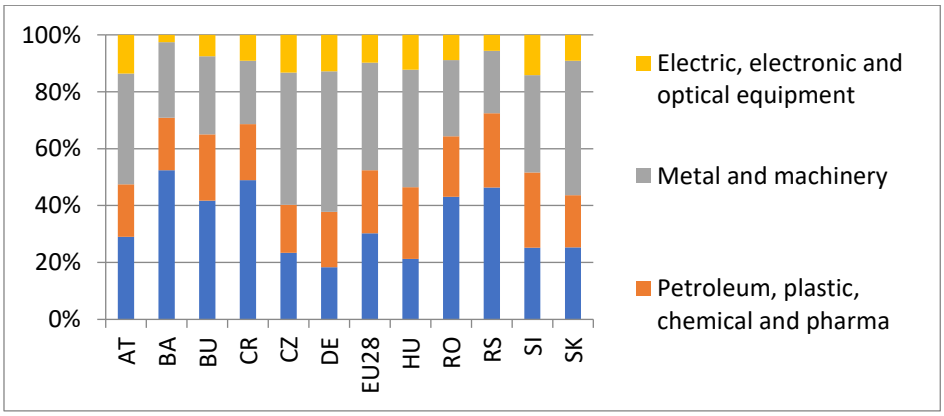


Graph 5: The development of innovativeness of the Danube regions (relative to the EU, changes between 2009 and 2017) (Source: Jaksa and Kovács, 2021)

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.

Looking at the **composition of the manufacturing sector**[20] itself (Graph 6), 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 equipment** vary between 3 and 14%, the EU average being 10%.



Graph 6: Share of sub-sector groups within the manufacturing sector, % (2016)(Source: Jaksa and Kovács, 2021)

[20] 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.

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 3 allows for identifying the commonalities even though each country has a specific manufacturing profile.[21]

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)*

[21] 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

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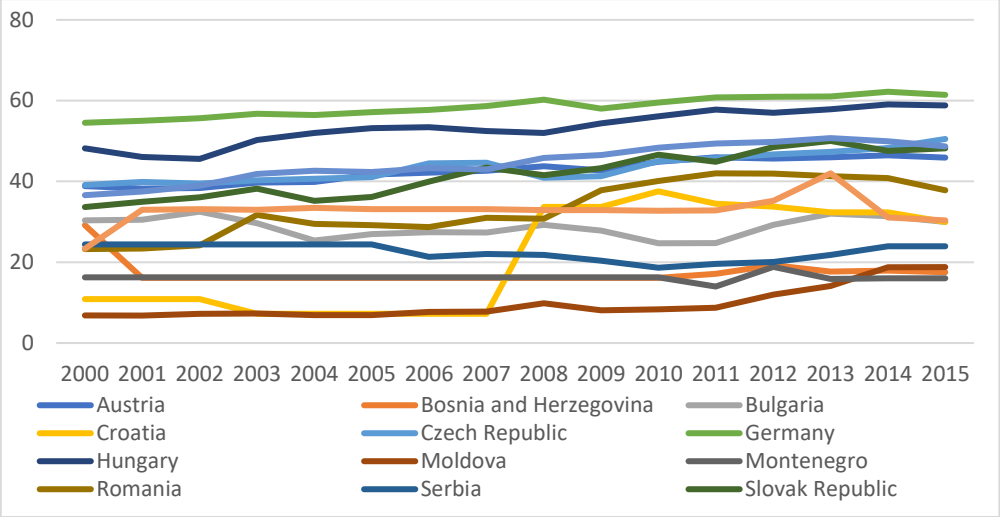
What is more, there has been a real progress in **medium and high-tech industrial activity** in most of the Danube regions as Graph 7. shows.



Graph 7: Medium and high-tech industry (including construction) (% manufacturing VA, 2015)

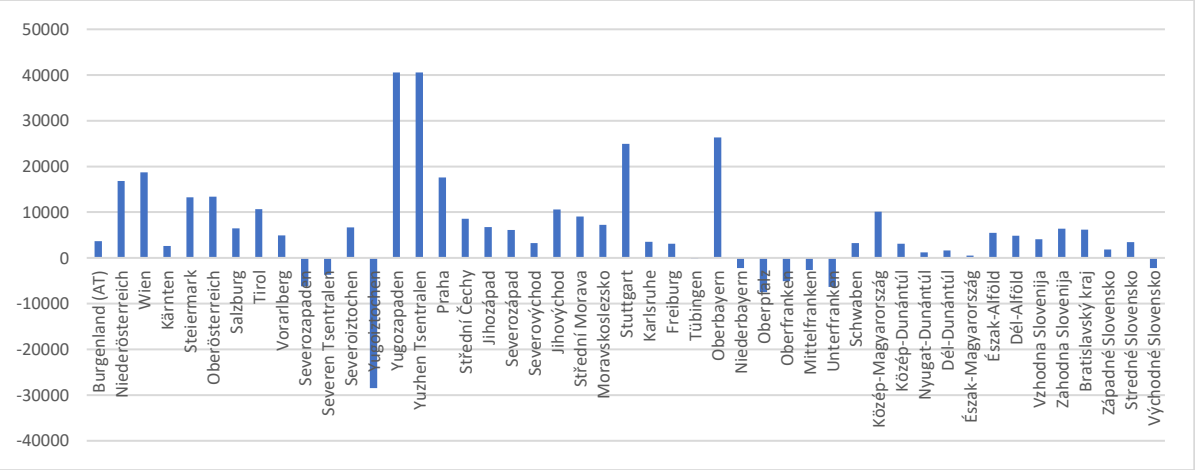
Source: World Bank, World Development Indicators.

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.**

It can be undoubtedly stated **that 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). Therefore, the **longer trend in industrial employment** is of paramount importance.

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-sized open economies of Central and Eastern Europe). To **avoid the middle-income trap**, the DR countries have to build resilient, robust and innovation-based economies.

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.
Therefore, investing into human capacities and skills, as well as technology, ICTs and AI can help avoid 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 8).



Graph 8. Absolute change in creative workforce

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

Innovation in the ICTs and AI is a good candidate to support and invest in 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.

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 indicated above, investing into human capacities are playing an important role, which is also requested by Industry 5.0 to make industry and companies human-centric.

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.

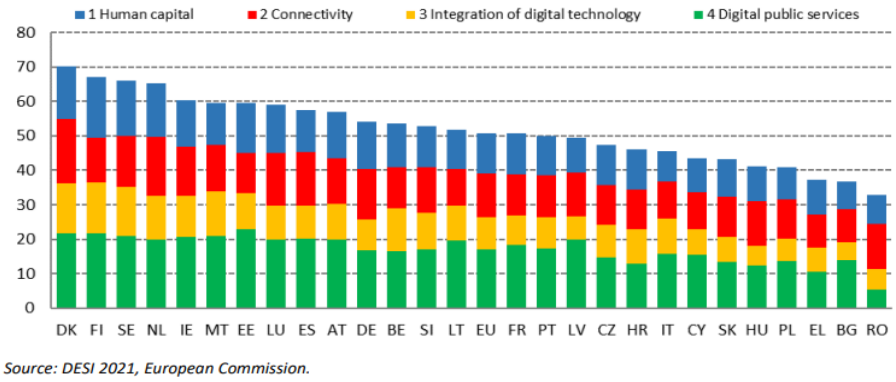
First, financing innovation is often cumbersome for SMEs, and the financial instruments available differ basically in relative to the SMEs' level of innovativeness

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;[22] optimising new product management

[22] See: Laforet and Tann (2006).

(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,[23]investing in knowledge management[24]) has started to gain traction.
Third, location effect can be corpulent in the sense that **SMEs can perform better by being closer to large innovative companies** often concentrating spatially.

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.[25] **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.
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.



Graph 9: The Digital Economy and Society Index (DESI) 2021

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**.[26]
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.**

[23] 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).
[24] 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.
[25] For more details see: https://ec.europa.eu/digital-single-market/en/desi
[26] 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.

5.2. The industrial-technological framework

Different industries and subindustries have distinctive characteristics relevant from the point of view of **resilience.** The size and nature of the (sub)industry, the level of globalisation, the availability of a flexible supplier pool at different levels of the production and value chain, all make the given sector somewhat vulnerable to various types of crises.

The EU-28 level comparative data is not yet available for the COVID-19 impact to be measured, but other datasets show that most of the manufacturing sector – automotive industry, machinery, electric and household appliances, IT – were hit hard more by raw material and supply shortages than the pandemic itself. The pandemic highlighted a special aspect of resilience: the resilience of supply chains. **After the COVID-19** pandemic hit, there was a public call – and economic necessity - for **a higher level of autarky**, at least to some level of **self-sufficiency** in certain key sectors. Fast development of the globalization process for several decades indicates that priority has consistently been given to economic efficiency rather than security.

Economies and societies with a good immune system – general resilience, stable economies and solid institutions – have a better chance to react well to the actual challenges, but even the most stable and resilient ones have to develop new tools and measures to handle this crisis.

The supply chain disruptions due to COVID were seemingly relatively fast overcome in several industries. In several sectors though, where shortages were already existing, the problems only enlarged in the upcoming period. In the time of global supply chains, different events in different locations can all add up to a master butterfly effect.

Even before the pandemic, **industrial relocation** had been in the political focus because of several aspects, most importantly due to the shifts in the global geopolitical power plays. The United States – both under Obama and Trump administration – aimed at (instead of relying on imports) reviving certain segments of the American manufacturing industry, most importantly the automotive industry. Europe has found itself more and more vulnerable to Asian – most importantly, Chinese – manufacturing, but contrary to the previous decades, this vulnerability is doubled by a weakened position in global R&D and innovation. This leads not only to a weakening position in the global production and **value chains but also to an explicit security concern for the European Union**. In several **R&D and innovation intensive areas China clearly has taken over Europe's position**, owning the knowledge on which the products and services are based.

2022 has further deepened the geopolitical divides and the national/continental call for a higher level of self-sufficiency and autarky by the **Ukrainian war** and the international hail to embargo goods from Russia, which leads to the **current energy crisis.** The proposition **to cut out as much Russian oil and gas** from the European energy mix as possible leads to a bizarre double-deal of a parallel boost of the development in renewable, green and sustainable energies (which coincides with the European Green Deal targets) and re-starting the traditional power plants and taking a U-turn in decreasing CO2 emissions. Thus both the COVID-19 lessons and the political power plays push nations and continents to work towards more **self-sufficient industries** (and energy supplies).

A further incentive to "bring home" some of the industries is the changing landscape of pollution and environmental protection. While on the one hand, China is also becoming more and more conscious about environment-threatening industries, therefore the earlier European strategy of exporting the polluting phases of industrial production is not functioning well anymore, on the other hand new technologies available now are also greener and allow European locations as well to be used for plant sites.

The **European Green Deal policies** will further fuel this trend by providing financial support for these technologies, also supporting the potential of relocation. The green transition is also a relocation incentive for several outsourced industries, and this anti-globalisation trend in industry (at least the manufacturing industry) is expected to keep up in the next decade.

6. Policy conclusion and recommendations

Based on the literature review and the existing analysis, we aim to summarise the main policy challenges and recommendations at the different levels of actors involved in building resilience. We refer back to the beginning of this paper to state that **resilience is a.) understood as a consequence of a series of managerial decisions, resilient actors are responsible for influencing their resilient behaviour, b.) resilience may be proactive, adaptive and reactive.**

Furthermore, we point out that policy recommendations at all levels – let that be company level policy, regional or sectoral, national or Europe-wide – are building on the same policy cycle, though at different size and scope. There are several iterations of the policy cycle, we refer here to a graphic representation by the Policy NL as a good example.

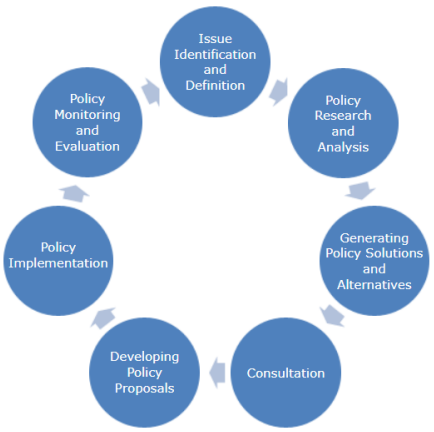


Figure 2. The policy cycle

Source: Policy NL

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6.1. At company level

In this chapter we shall define and categorize the scope of actions available for companies in becoming resilient. Looking into the scientific literature on entrepreneurial resilience, both quantitative and qualitative research lack sufficient evidence to come up with a clear checklist for resilient behaviour. Partly, because resilience is always reflective – it mirrors the given crisis that needs to be tackled.

We must clearly state that there are no specific characteristics of a company that would make it resilient. The only symptom we can identify **as potentially leading to resilience is adaptability**. Therefore, the most important recommendations of a resilient company are:

- flexibility, capacity for change management, rapid reaction time, and
- the knowledge, experience and skillset of the management team to properly assess the given situation, come up with options and make the right decisions
- the overall readiness for adaption, the openness of the management and the organization for change.

Referring to the policy cycle presented in the introduction of this chapter (though originally designed for public policy process), **the company management must be equipped with the capacity and information necessary to:**

- identify the crisis
- gather information on potential solutions and set up alternatives
- run consultations with the relevant stakeholders involved (main suppliers, employee representatives, etc.)
- formulate the action (often a "policy mix" – a composition of protective/remedial actions)
- run the steps necessary for the action(s)
- monitor and evaluate the outcomes

Recognising the reaction cycle of enterprises may also help to better understand the distinctions among the three types of resilience identified earlier: proactive, adaptive and reactive. A key difference among these is the timeframe, the "response time" for assessment and action, while proactive companies are built with an intrinsic capacity to operate the reaction cycle almost automatically and are well-equipped with "sensors" for assessment of monitoring. Adaptive organisations are reacting in a slower pace, while reactive resilient actors need sufficient time to put this reaction cycle into use.

The **internal factors of entrepreneurial resilience** is built on three pillars. First, relevant knowledge and information shall be available for these actors. Second, the actors must be capable of acting based on the information received. Third, the management and the organization **must be in general open and flexible for changes.**

- Collecting, systematically organising and presenting data, information, knowledge that supports the enterprises.
- Aiding the enterprises with the skills necessary for timely assessment and reaction to crises.
- Helping the organisations understand and interpret flexibility and change, introducing change management concepts, flexibility screenings.

Trainings, education, information and development support shall emphasize the transfer of knowledge and the need for assessment, monitoring and adaptation in the following domains.

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- General entrepreneurial skills and knowledge in a post-COVID era
- Tacit knowledge must become formulated, ad-hoc processes need to be standardized, job positions defined, otherwise appropriate assessment of situations and proper monitoring of actions are not possible.
- Business intervention, policy and strategy cycle at the enterprise level: understanding the motifs and mechanisms for timely identification of issues and the means to set up adequate measures for intervention, means of monitoring. Change management.
- Industrial production and value chain management, export promotion in the 2020s: understanding the factors influencing supply chains in this new era (post-COVID, global industrial relocation trends, rising transport costs, international embargos, the effects of the Ukrainian war etc;) and internationalisation
- Technologies in business and organisational management – the proper tools of ERP, CRM, with the use of the up-to-date technologies including machine learning and AI.
- Technologies in production: Industry 4.0 technologies available for the manufacturing industry, reflective of the latest trends, post-COVID applications.
- Understanding the green economy
- Innovation management: identifying the needs and opportunities for firm-level innovation, different types of innovation managing innovation projects and identifying co-funding options, valorisation of innovation and R&D.
- General state and EU fund support options and availability for manufacturing companies in various domains

6.2. Regional and national level

Resilience of a region does not only incorporate the resilience of its companies, it relies on a wider resilience-set of actors, such as resilience of educational institutions and very importantly their capacity to retain crucial knowledge and key personnel, their adaptive skills in terms of curricula changes resilience of citizens and employees and most importantly, resilience of regional policy making.

According to Linkov et al. [27], in order to have a useful policymaking process for resilience, we have to **identify the domains of resilience and the potential sources of system collapse**. The regional policy setting must be aware and must utilize **the existing Smart Specialisation Strategies which** are built on local advantages, strengths and opportunities, making it more likely for the strategy to succeed.

The important task of national resilience policy is to find the appropriate balance in the centuries-old challenge of competition versus cohesion – that is finding the equilibrium between supporting those actors that already have a good shot at success, have the close potential to achieve significant results while not forgetting about the actors, regions, citizens that are lagging behind, the ones that need to take the longest road in order to catch up with the rest of the regions, economy and society.

6.3. European level

Resilience is crucially important for European policy making, so in this sub-chapter we shall summarise the main elements to connect within the European policy framework.

[27] Linkov, I., Trump, B. and Hynes, W., 2019. Resilience-based Strategies and Policies to Address Systemic Risks. [online] Oecd.org. Available at: <https://www.oecd.org/naec/averting-systemic-collapse/SG-NAEC(2019)5_Resilience_strategies.pdf>

The new European **industrial policy is a policy of re-industralisation and industrial relocation.**[28] It finetunes the preferences of the 2020 Industrial Strategy in light of the pandemic and in realization of the disruptions in the industrial production chains, as proven by the COVID-19 impacts.
First, the European Commission through its Joint Research Centre offers a resilience dashboard in order to facilitate monitoring and assessment of the state of the art. The aim is to succeed in the green, digital and fair transitions in economy and society, on the European level as a whole. [29]

Regarding actual policy measures, the pandemic pressured the European Commission to launch a rather significant recovery package available for all EU members to mitigate the effects and lessen the negative impacts. It is important to understand that the aim is not to return to where the economy stood at in 2019 – since resilience is about adaptation and transformation to the modified circumstances, the European recovery package aids to find a new equilibrium (even though that is also just temporary).

The **RRF - Recovery and Resilience Facility**[30] - mobilises almost 724 billion EUR financial support, of which 338 billion are in forms of grants and 386 billion in forms of loans. The key target areas of development are digital and green projects, in line with previous goals of the EU strategical planning. The RRF is conducted and realised through the respective Recovery and Resilience Plans (RRPs).

The RRF has incorporated – just as in real life the COVID-19 pandemic slipped into the Ukrainian war confrontation and energy crisis – the **REPower EU Plan**[31], that aims to:

- save energy;
- diversify supplies (imports);
- quickly substitute fossil fuels by accelerating Europe's clean energy transition;
- smartly combine investments and reforms.

As far as AI is concerned, 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.

[28] 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 Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery , 5 May 2021, COM (2021) 350 final available at: https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf
[29] Caperna G., de Pedraza P., JRC Statistical Audit of the Resilience Dashboards, EUR 30895 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-43728-4, doi:10.2760/401349, JRC127139. https://publications.jrc.ec.europa.eu › repository › bitstream › JRC127139 › JRC127139_01.pdf
[30] European Parliament and Council Regulation (EC) 2021/241 of 12 February 2021 establishing the Recovery and Resilience Facility, [2021] OJ L 57/17. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0241
[31] 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 REPowerEU Plan, 18 May 2022, COM(2022) 230 final available at: EUR-Lex - 52022DC0230 - EN - EUR-Lex (europa.eu)

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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 **European Commission** set up a **High-Level Expert Group on Artificial Intelligence (AI HLEG)** [32], 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**[33] 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.

Furthermore, the **Structural Funds, the Horizon R&D and Innovation framework program**, the international collaboration schemes and various European investment programmes are all newly aligned with post-COVID recovery and prepare the economy and society for the new challenges currently arising – the Ukrainian war conflict with its geopolitical embeddedness and the subsequent energy crisis.

Another key policy elementary for European level resilience is the already cited **Green Deal**[34]. It aims to cut completely net emissions of greenhouse gases by 2050 (reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels), while ensuring economic growth decoupled from resource use and societal fairness, inclusion of all actors. Several financial means are set in favour of backing the policy, including about 6 trillion EUR investments from the NextGeneration EU Recovery Plan, and various other EU funds (including Structural Funds, Horizon Europe and other international collaboration schemes)

T**he policy has enormous impacts for the European and also to Danube Region economy and society,** for several reasons: first, by promoting **environmentally friendly technological solutions**, it contributes to the slowdown of climate change. Second, it stimulates businesses and leads them on the way of innovation, hopefully valued on the international/global scale as well. Third, by supporting businesses it also supports jobs and employees, income generation for European citizens. Fourth, as the current energy crisis so harshly puts it into focus, new technologies are needed in order to feed the energy demand of future use. Fifth but not last, building the European green economy offers a chance to gain some independence from global political actors otherwise not favoured and adds to European self-sustainability.

We also emphasize the European importance **of European industrial policies in the 2020s.** Another set of crucially important factors that will re-structure global production chains in the upcoming decade are **the geopolitical shifts and the threat of China's technological dominance**.

[32] See: https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence
[33] See: http://www.oecd.org/going-digital/ai/oecd-initiatives-on-ai.htm#expert-group
[34] 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 The European Green Deal, 11 December 2019, COM(2019) 640 final available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN

5.4. Danube Region level

As already highlighted by Jaksa and Kovács in 2021, 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 **on 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.

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.

As already described earlier (Chapter 1.2) **in this study, Priority Area 8 aims to support the competitiveness of enterprises in the Danube Region as well as the latest version of Action Plan** and within the strategy, PA8 in particular, is also advocating the support of SMEs in the Danube Region from different aspects (e.g.: the involvement of academia and society; cluster establishment; capacity building; female-led SMEs; and the enhancement of application of AI technologies)

On a final note, as closing this report, we would like to emphasize one more crucial aspect of resilience: let it be entrepreneurial, regional, industrial, national or Europe-wide, economic resilience is not intrinsically important, it is not a goal per se. **Economic resilience itself is a key element to societal resilience.**

7. Identification of funding opportunities for a possible proposal submission through one or more stakeholders of the PA8 EUSDR in 2022 or latest in 2023

Since resilience and being resilient are currently and in the future shall be playing an important role in the most recent European strategies and initiatives, as well as it is also a recommendation of utilising Industry 5.0., therefore, this “hot” topic should be addressed into the upcoming European transnational project proposals.

In line with resilience, in project proposal to be submitted in late 2022 or early 2023, the following goals and issues are recommended to be discussed and reached:

- to contribute to the increase of the competitiveness of Danube regional SMEs
- to familiarize the Danube Region´s SMEs with the relevance and potential application opportunities of artificial intelligence in the defined application areas

    - training, testing and applying novel solutions of artificial intelligence at companies of the region
- to support developing AI-driven applications to overcome international value chain challenges
- to reduce the negative impact of the value chain challenges:
    - shortage of raw material → optimalization of the value chain
    - global energy shortage → energy usage optimalization
    - labour shortage → AI solutions for labour support

- to identify the proper solution that is applicable for the region and contributes to a more balanced, convergent territorial development
- to be in line with the wider EU level strategies (e.g: EUSDR- PA8-; Green Deal, Territorial Agenda 2030)
- Pilot projects based on cross-sectoral and cross-border cooperation
- Exploitation of Industry 5.0 opportunities

7.1. Possible funding opportunities

Within this sub-chapter different financial instruments shall be listed in the topic of AI. The basic info of these calls will be described. Some of these calls are closing soon, some of them will close in the beginning of next year, whereas some of them have not opened yet, but preliminary info is available. Not only the submission dates of the calls differ, but also their funding rate as well, these will be summarised in the end of the current sub-chapter.

7.1.1. Danube Region Programme

In the 2021-27 Programming Period the Danube Region Programme has launched the first call for proposals which is open from 29 September 2022 till 21 November 2022, 14:00 hours Central European Time. [35] The call is targeted to proposals for projects focused on the programme priorities 1, 2, 3 and specific objective 4.2:

- Priority 1: A smarter Danube Region
- Priority 2: A greener, low-carbon Danube Region
- Priority 3: A more social Danube Region
- A better cooperation governance: 4.2 Increased institutional capacities for territorial and macroregional governance

Each priority is broken down into specific objectives (SOs). Projects to be funded in the framework of the programme have to address one of them.

From the application of AI solutions together with an advanced resilience analysis, mainly Priority 1 and/or Priority 3 might be targeted.

[35] Information derived from the Interreg Danube Transnational Programme: https://www.interreg-danube.eu/about-dtp/new-funding-2021-2027/how-to-apply/first-call

Within Priority 1, two specific objectives (SOs) have been defined, namely SO1 is the *Enhancing innovation and technology transfer in Danube region* which focuses on the below mentioned areas:

- RDI related transnational policies and processes
- Uptake of innovation and advanced technologies
- Capacity building among thematic value chains
- Technology transfer and uptake from and towards SMEs
- Circular economy policies and processes
- Smart, sustainable and green transport technologies and networks
- E-mobility solutions
- Integration of smart cities' and regions' solutions

SO2 in the same Priority is the *Development of skills for advancing smart specialisation strategies, industrial transformation and transition towards industry 4.0, including cross-sectorial collaborations,* and its focus areas have defined as follows:

- Skills development for and of joint advancement of smart specialisation strategies and policies – less advanced regions
- Skills development and cross sectoral collaborations of smart and traditional type of industries – industrial transformation and transition
- Skills development for delivering products and services with transnational impact

In the framework of Priority 3, three Specific Objectives are distinguished, but from our topics point of view two of them can be considered relevant, which are:

SO3.1: Accessible, inclusive and effective labour markets, which focusing on:

- The integration of vulnerable groups into the labour market, with special attention on regions that display high proportions of disadvantaged
- Retaining skilled labour and developing a more sustainable migration of educated people
- Capacity building for employment support bodies (information and data systems; coordination; training e.g. in social economy

SO3.2 Accessible and inclusive quality services in education, training and lifelong learning, where these focus points have been targeted:

- Developing innovative educational models, programs, practical tools and materials for disadvantaged learners, including early school leavers
- Maximising the use of existing knowledge and experience to develop best practices in inclusive education policy and advancing education and policy reform
- Innovative approaches to encourage and improve inclusive vocational education and training and life-long learning

The following major novelties have to be highlighted in DRP 2021-2027:

- EU contribution to projects is 80%
- Use of Interreg funds (ERDF, IPA and NDICI funds are pooled together in a single pot)

- Lead Partners can be both from EU and non-EU countries (exception: Ukrainian organisations can participate in the 1st call for proposals only as project partners)

Further information of the priorities, specific objectives, as well as project proposal application procedure including guiding webinars and deadlines are found on the official website of the Danube Transnational Programme

Apart from the current call of the Danube Region Programme, further numerous AI-related financing instruments are available at the moment.

Below some of these instruments shall be described and summarised.

7.1.2. *European Network of AI Excellence Centres: Expanding the European AI lighthouse (RIA)*

- Call: A HUMAN-CENTRED AND ETHICAL DEVELOPMENT OF DIGITAL AND INDUSTRIAL TECHNOLOGIES 2022 (HORIZON-CL4-2022-HUMAN-02)[36]
- Programme: Horizon Europe Framework Programme (HORIZON)
- Opening date: 16 June 2022
- Submission date: 16 November 2022 17:00:00 Brussels time

Expected outcome:

- Scientific progress in AI, addressing major challenges hampering its deployment, including systems engineering.
- Build-up the European AI lighthouse, initiated by earlier Networks of excellence centres
- Unify and reinforce the world-class European AI community.

Main scope:

To ensure European open strategic autonomy in critical technology such as AI, with huge potential socio-economic impact, it is essential to reinforce and build on Europe's assets in such technologies, including its world-class researcher community, in order to stay at the forefront of technological developments. Europe has to scale up existing research capacities and reach a critical mass through cross-community networks of European excellence centres in AI. Proposals should develop mechanisms to reinforce and strengthen the networks of excellence centres in AI. They are expected to bring the best scientists from academia and industry together to join forces in addressing the major AI challenges hampering its

[36] Information derive from the Funding & tender opportunities from the Euopean Commission: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl4-2022-human-02-02

deployment, and to reinforce excellence in AI throughout Europe via a tightly coupled network of collaboration.

7.1.3. AI for human empowerment (AI, Data and Robotics Partnership) (RIA)

- Call: A HUMAN-CENTRED AND ETHICAL DEVELOPMENT OF DIGITAL AND INDUSTRIAL TECHNOLOGIES 2022 (HORIZON-CL4-2022-HUMAN-02)[37]
- Programme: Horizon Europe Framework Programme (HORIZON)
- Opening date: 16 June 2022
- Submission date: 16 November 2022 17:00:00 Brussels time

Expected outcomes:

Proposal results are expected to contribute to at least one of the following expected outcomes:

- Truly mixed human-AI initiatives for human empowerment
- Trustworthy hybrid decision-support systems

Main scope:

Build the next level of **perception, visualisation, interaction and collaboration** between humans and AI systems working together as partners to achieve common goals, sharing mutual understanding and learning of each other's abilities and respective roles.

Innovative and promising approaches are encouraged, including human-in the loop approaches for **truly mixed human-AI initiatives** combining the best of human and machine knowledge and capabilities, tacit knowledge extraction (to design the next generation AI-driven co-creation and collaboration tools embodied e.g. in industrial/working spaces environments)

All proposals should adopt a human-centred development of trustworthy AI and investigate and optimise ways of human-AI interaction, key for acceptance and democratisation of AI, to allow any user to take full advantage of the huge benefits such technology can offer, regardless of their age, race, gender or capabilities. This includes development of methods to improve transparency, in particular for human users, in terms of explainability, expected levels of performance which are guaranteed/verifiable and corresponding confidence levels, accountability and responsibility, as well as perceived trust and fairness. AI could also be used to empower humans in supporting them to improve responsible behaviours, where appropriate, but this should be done in full respect of the requirements ensuring trustworthy AI, including human autonomy.

[37] Information derive from the Funding and tender opportunities from the European Commission

7.1.4. Increased robotics capabilities demonstrated in key sectors (AI, Data and Robotics Partnership) (IA)

- Programme: Horizon Europe Framework Programme (HORIZON)[38]
- Call: Digital and emerging technologies for competitiveness and fit for the green deal (HORIZON-CL4-2022-DIGITAL-EMERGING-02)
- Type of Action: HORIZON-IA HORIZON Innovation Actions
- Opening date: 16 June 2022
- Submission date: 16 November 2022 17:00:00 Brussels time

Expected outcome:

- Demonstrators able to show the added value of robotics and their performances in addressing challenges in major application sectors, or in dangerous, dull, dirty tasks or those strenuous for humans or in extreme environments.
    - Systems able to demonstrate beyond human performance in complex tasks, with high impact in key sectors, that show extended levels of adaptation and flexibility.
    - Systems able to show high levels of reactivity and responsiveness and intelligibility when performing human-robot and robot-robot interactions in major application sectors.

Main scope:

- Proposals are expected to focus on application-oriented use cases that enhance specific sectors in achieving significant improvements in functional and application performance.
- Proposals will integrate novel robotics technologies into solutions that are capable of autonomously taking over dangerous, dull and dirty jobs, or that are capable of achieving tasks beyond human capabilities, in a range of innovative applications in key sectors or that are capable of reaching the level of reactivity, flexibility and adaptivity and natural intelligibility required for smooth and beneficial human-robot, as well as robot-robot collaboration and interaction.
- Considering that human factors and socio-economic aspects can limit or lessen efficient use of robots, human-centred and socio-economic approaches in combination with multi-stakeholder co-design activities can contribute to sustainable development of new enabling technologies.

[38] Information derive from the Funding and tender opportunities from the European Commission

7.1.5. Deployment of the AI-on-demand platform

- Call name: Cloud Data and TEF (DIGITAL-2022-CLOUD-AI-03)[39]
- Programme: Digital Europe Programme
- TOPIC ID: DIGITAL-2022-CLOUD-AI-03-AI-ON-DEMAND
- Opening date: 29 September 2022
- Submission date: 24 January 2023

Objective:

The objective of this action is to develop and deploy the AI-on-demand platform, building on the results from the project implementing the AI-on-demand preparatory action, providing the requirements and underlying mechanisms for such platform.

Scope:

The awarded project will develop and deploy the AI-on-demand platform in close cooperation with the project implementing the preparatory action, taking into account the proposed requirements and mechanisms to optimise the impact of the AI-on demand platform. The platform will gather all the AI resources (algorithms and tools), and make them available to the potential users, businesses and public administration, with the necessary services to facilitate their integration.

The platform will play the role of a central marketplace for AI tools, and a service layer providing support to users (incl. public administrations) for integration of AI solutions.

The platform will build a solid support layer of integration services, enabling industries and public administrations to incorporate AI solutions to their IT and business processes. This support layer can eventually rely on a business partner network covering the totality of the EU and EEA countries.

Outcomes

- Increased visibility to trustworthy innovations, in particular those made in Europe.
- Easy access to AI

7.1.6. Data space for manufacturing (deployment)

- Call name: Cloud Data and TEF (DIGITAL-2022-CLOUD-AI-03)
- Topic: DIGITAL-2022-CLOUD-AI-03-DS-MANUF - Data space for manufacturing (deployment)
- Programme: Digital Europe Programme

[39] 7.1.5-7.1.6: Digital Europe Programme (DIGITAL) Call for proposals

- Opening date: 29 September 2022
- Submission date: 24 January 2023

Objective:

Data sharing among manufacturing companies and with (service) providers will be increased by the deployment of two data spaces of the manufacturing industry, which will demonstrate how sharing industrial data improves company operations.

Manufacturing data spaces and their AI-based analytics and optimisation applications can influence company-internal processes as well as processes across organisations.

Scope:

The action calls for the deployment of two operational data spaces of the manufacturing industry, building on the work and results of the preparatory actions. Both discrete manufacturing and process industry are envisaged. The projects should have sufficient activities to lead to sustainability at the end of the action, in line with the business plans and blueprints proposed in the preparatory actions mentioned above. Such data spaces will offer a secure and trustworthy way of making data usable between supplier and user companies on the basis of voluntary agreements. 'Embryonic' data spaces that are used by a significant amount of manufacturing companies should be scaled up to a European level.

Outcomes:

The two selected actions will each deploy a data space for the manufacturing industry at scale, continuing to be available after the end of the project, that will build on and be integrated with the data space technical infrastructure, delivering industrial data sharing among manufacturing companies and with (service) providers, thanks to agreements on common rules for access to data and fair compensation. The solutions must be characterized by a high degree of user-orientation in terms of trustworthiness, data sovereignty of the companies and manageability. Particularly SMEs will benefit from larger sets of industrial data to broaden their offers in terms of products and services, with the support of the European Digital Innovation Hubs.

The following proposals are just draft versions since they have not been adopted or endorsed by the European Commission. However, these can be considered a guideline and consist the main focus areas and the draft calls for proposals which will open in the upcoming months.

7.1.7. HORIZON-CL4-2023-DIGITAL-EMERGING-01-01: Industrial leadership in AI, Data and Robotics – advanced human robot interaction (AI Data and Robotics Partnership) (RIA)

Opening: 01 Dec 2022 - Deadline(s): 29 Mar 2023[40]

Expected Outcome:

Projects are expected to contribute to the following outcome(s):

• Step change in autonomy of robots including Human-Robot interaction and robots acting in isolation demonstrated in key high impact sectors (e.g. healthcare, agrifood/agriculture, etc) under realistic settings.

• Step change in enabling conditions essential for the diffusion of robots in various industries, sectors and services which can either 1) handle tasks (semi-)autonomously, and safely, for a sufficiently long period of time and 2) interact safely and smoothly to support humans in their daily activities, based on strong multidisciplinary approach, including the relevant SSH dimension.

• Major advances in science and technology, to maintain Europe's scientific excellence and ensure sovereignty of these key technologies expected to affect the society in contributing to addressing major societal challenges.

Scope:

Addressing major societal challenges accelerate the need for advanced robotics solutions – such as increasing lack of caregivers to take care of constantly rising numbers of elderly people, shortage of manpower in industry, environmental challenges such as waste management, circular economy, local production and more environmentally sustainable agriculture. High autonomy is required as robotic systems are expanding from traditional sectors to new applications where the environment is not as predictable, which requires robots to adapt dynamically by addressing these cognitive aspects. Recent advances in AI, Data and Robotics technologies bear promising results, especially in adopting a multidisciplinary approach, exploiting the latest results from underlying disciplines.
Substantial efforts in novel research approaches are required, exploiting latest results from sensing on the robots but also in the smart environments they evolve in, as well as advances in AI/learning approaches, including cloud robotics sharing knowledge, exploitation of all sources of data and knowledge, to improve their perception, environment awareness, anticipation of their environments and the consequences of their actions, all contributing to make robots more cognitive, improve their decisions, actions and robustness, all contributing to increase their level of autonomy.

[40] 7.1.7-7.1.8 Horizon Europe: Cluster 4 – Digital, Industry and Space
Preliminary list of ideas for discussion regarding potential topics for the Work Programme 2023-24, v 31/01/22

7.1.8. HORIZON-CL4-2023-DIGITAL-EMERGING-01-02: Industrial leadership in AI, Data and Robotics – advanced human robot interaction (AI Data and Robotics Partnership) (IA)

Opening: 19 Sep 2023 Deadline(s): 07 Feb 2024

Expected Outcome:

• Validate AI, Data and Robotics at scale by demonstrating the potential of integrating these technologies to address challenges in key industrial ecosystems and develop solutions that are environmentally friendly and contribute to the green deal

• Major advances in technology, to maintain Europe's excellence and ensure sovereignty of these key technologies expected to affect the society in contributing to addressing major societal challenges.

• Boost the innovation potential for wide uptake of AI, Data and Robotics for environmental sustainability

Scope:

Proposals should demonstrate the added value of integrating AI, Data and Robotics technologies through large-scale validation scenarios reaching critical mass and mobilising the user industry, while demonstrating high potential impact contributing to the European Green Deal objectives. Focus should be given on attracting new user industries, to boost the uptake of AI, Data and Robotics in major sectors and stimulate the involvement of end-users where appropriate. Besides major industries, these Actions should also involve SMEs and/or start-ups with big potential to foster innovation by supporting high-tech start-ups. Focus will be on the most mature and promising sectors that can contribute to the green revolution (e.g. agri-food, utilities/waste-management, production/retail).

Large scale pilots bringing major industries from key application sectors in Europe – facilitating collaboration between these major companies and innovative SMEs/Start-ups/academia/tech-transfer organisations with the goal is to exploit tools and solutions re-usable in various use-cases/sectors (showing scalability/versatility, and allowing economies of scale)

7.1.9. HORIZON-CL4-2024-DIGITAL-EMERGING-01-03: Novel paradigms and approaches, towards AI-powered robots– step change in functionality (AI, data and robotics partnership) (RIA)

Opening: 19 Sep 2023 Deadline(s): 07 Feb 2024

Expected outcome: [41]

Achieve the substantial next step in the ability of robots to perform non-repetitive functional tasks in realistic settings, based on underlying robot functions (e.g. guidance/navigation/manipulation/interaction etc.), demonstrated in key high impact sectors where robotics has the potential to deliver significant economic and/or societal benefits.

Scope:

For robots to be usefully and efficiently deployed to perform new activities in physical interaction with the real world requires an improvement in and expansion of the range of functionalities robots can deploy.

This needs to take place in sectors where the capabilities of robots can be utilised to progress productivity in critical industries, support European industries essential for sovereignty and in sectors with high impact across Europe such as manufacturing, healthcare, agri-food, construction etc.

7.1.10. HORIZON-CL4-2024-DIGITAL-EMERGING-01-04: Industrial leadership in AI, Data and Robotics boosting competitiveness and the green transition (AI Data and Robotics Partnership)

Opening: 19 Sep 2023 Deadline(s): 07 Feb 2024

Expected outcome:

The creation of systems to address large scale challenges using combined robotics data and AI solutions that have significant impact on the objectives of the green deal. For example; in improving domestic energy consumption or in the cleaning up of contaminated land and waterways or in accelerating the circular economy along the complete value chain through automated waste avoidance and waste processing or reuse of materials.

The creation of systems to address large scale resource optimisation challenges using combined AI and Data solutions, that have significant impact on the objectives of the green deal, such as optimisation of any kind of resources, from production to use along the complete value chain in order to minimise waste or foster the reuse of resources or in using AI and data solutions to maximize energy efficiency, ensuring energy security.

[41] 7.1.9-7.1.10: Annex 7; Horizon Europe; Work Programme 2023-2024 7. Digital, Industry and Space

Scope:

Proposals should demonstrate the added value of integrating either AI and Data, or AI, Data and Robotics technologies through large-scale validation scenarios reaching critical mass and mobilising the user industry, while demonstrating high potential impact contributing to the European Green Deal objectives. For example in the recycling of electric car batteries, cleaning and monitoring the oceans, decommissioning energy infrastructure, supporting the recycling of materials, the optimisation of energy usage, the minimisation of resource waste in value-chains, for example through the better adaption of production to demand, etc.

Focus should be given to attracting new user industries, and/or showing new business opportunities to boost the uptake of AI, Data and Robotics in major sectors and stimulate the involvement where appropriate of end-users to define the technological barriers to uptake and the use cases for deployment.

Proposals should address the involvement of SMEs and/or start-ups with significant potential to foster innovation through their engagement with large scale pilots. Focus will be on leveraging and nurturing emerging collaborations between stakeholder communities shaping an effective eco-system fit for the challenge of European AI, Data, Robotics, and on accelerating European R&I through structural involvement of innovative SME and deep-tech start-ups.

7.1.11. Comparison of the different calls for proposals

In Chapter 7, several calls for proposals have been listed in different programme frameworks. As the descriptions of these calls have reflected, all of them are available for companies in the Danube Region, and all of them are requesting project proposals focusing on AI solutions. They are calling innovative organisations (including SMEs as well) who might utilise AI solutions within the partnership. In most of the calls human-centric , and human-robot cooperation as well as sustainability aspects are highlighted, which are one of the main elements of Industry 5.0. Moreover, as the objectives and the scopes of the calls have described, these projects might highly contribute to the horizontal challenges (labour; raw material; and energy shortage;) which have to be tackled not only by the Danube Region, but also in whole Europe as well.

As far as the **eligibility criteria are concerned,** as for Danube Transnational Programme, all Danube Region countries as well as their regions are applicable. Regarding the calls in the Horizon Europe Programme, Any legal entity, regardless of its place of establishment, including legal entities from non-associated third countries or international organisations (including international European research organisations) is eligible to participate (whether it is eligible for funding or not), provided that the conditions laid down in the Horizon Europe Regulation have been met, along with any other conditions laid down in the specific call topic.

A 'legal entity' means any natural or legal person created and recognised as such under national law, EU law or international law, which has legal personality and which may, acting in its own name, exercise rights and be subject to obligations, or an entity without legal personality.

Beneficiaries and affiliated entities must register in the Participant Register before submitting their application, in order to get a participant identification code (PIC) and be validated by the Central

Validation Service (REA Validation) before signing the grant agreement. For the validation, they will be asked to upload the necessary documents showing their legal status and origin during the grant preparation stage. A validated PIC is not a prerequisite for submitting an application[42].

As for Digital Europe Programme, in order to be eligible, the applicants (beneficiaries and affiliated entities) must:

- be legal entities (public or private bodies)
- be established in one of the eligible countries, i.e.:
- EU Member States (including overseas countries and territories (OCTs))
- non-EU countries (except for topics with restrictions; *see below*):
    - listed EEA countries and countries associated to the Digital Europe Programme or countries which are in ongoing negotiations for an association agreement and where the agreement enters into force before grant signature

Beneficiaries and affiliated entities must register in the Participant Register — before submitting the proposal — and will have to be validated by the Central Validation Service (REA Validation). For the validation, they will be requested to upload documents showing legal status and origin.

It has to be noted that the following topics of this call are subject to restrictions due to security reasons

- DIGITAL-2022-CLOUD-AI-03-PILOTS-CLOUD-SERVICES
- DIGITAL-2022-CLOUD-AI-03-DS-MOBILITY
- DIGITAL-2022-CLOUD-AI-03-DS-MANUF
- DIGITAL-2022-CLOUD-AI-03-DS-SMART
- DIGITAL-2022-CLOUD-AI-03-AI-ON-DEMAND

Therefore, entities must not be directly or indirectly controlled from a country that is not an eligible country. All entities have to fill in and submit a declaration on ownership and control. [43]

Regarding the funding rate, in the Danube Region Programme, EU contribution to projects is 80%. In Horizon Europe Programme, the EU contribution rate differs from the type of actions accordingly:

[42] Horizon Europe Work Programme 2021-2022 13. General Annexes

[43] Digital Europe Programme (DIGITAL) Call for proposals Cloud Data and TEF (DIGITAL-2022-CLOUD-AI-03)

- Research and innovation action: 100%
- Innovation action: 70% (except for non-profit legal entities, where a rate of up to 100% applies)
- Coordination and support action: 100%
- Programme co-fund action: between 30% and 70%
- Innovation and market deployment: 70% (except for non-profit legal entities, where a rate of up to 100% applies)
- Training and mobility action: 100%
- Pre-commercial procurement action: 100%
- Public procurement of innovative solutions action: 50%

Other funding rates may be set out in the specific call conditions.
For **lump sum and unit grants**, the funding rate is already applied as part of the methodology for fixing the amounts and is therefore not shown in the grant agreement

Regarding Digital Europe Programme, the coordination and support actions (the one described in Session 7.1.5) the funding rate is 100%. Whereas, for SME Support Action (Session 7.1.6) the funding rate is lower, 50% and 75% for SMEs.

When it comes to the **submission deadlines**, some of the listed calls will close in November 2022, whereas some of them will be still open until January 2023, or event has not opened yet. Regarding the ones which will close in November 2022, the time is too short for SMEs to contribute to a proposal as a project partner, however, it is recommended to examine the winner project proposals (content, focus, project partners) since it might happen that certain SMEs from the Danube Region might contribute to project implementation either as an external expert or even a beneficiary of the pilot projects to be carried out within the implementation.

Regarding the calls which are open until the end (24th) of January, it is advised for companies to ask their networks to join to a formulating proposal, or even initiate a proposal as a Lead Partner.

As for which are not open yet, it is recommendable to examine the draft versions of the calls in order to have a better understanding about the required focus areas, the content as well as the terminology of each call. It is also advised to start formulating an indicative partnership, in order to well-prepare for the proposal elaboration even before the official opening of the call.

CONCLUSION

The current study was aiming to shed light on the economic situation of the Danube Region. The study was identifying the common problems of SMEs which can be considered the followings, taking into account the effects of the COVID-19 pandemic as well as the ongoing Ukrainian war:

- shortage of raw materials
- global energy shortage
- labour shortage

The overarching goal is attempting to provide solutions to all these challenges exploiting Industry 5.0. paradigm with the result of resilience analysis as well as the uptake of more and more AI solutions will be also playing a crucial role among companies.

In the beginning of the paper, the concept and the main objectives of Priority Area 8 were discussed and the section has revealed that the overarching goal of the priority is to support the competitiveness of enterprises in the Danube Region. In order to reach this horizontal goal, different aspects and topics were detailed and incorporated into the latest version of the EUSDR Action Plan. Shortly, the involvement of academia and society, cluster establishment, capacity building, female-led SMEs, and the enhancement of application of AI technologies can be considered the main elements of Priority Area 8 actions.

Still in Chapter 1, possible solutions of Artificial Intelligence and the concept of Industry 5.0. were shown. Regarding AI, key technologies as well as key application areas were collected which might be utilised in an upcoming project, based on the competences of a future proposal.

We have also learnt that the cooperation between human and machine will be significant in the life of Industry 5.0, therefore following Industry 4.0 a paradigm shift is required and it is important to bring human creativity back into work processes. This cooperation should be interpreted broadly, as it also has a social, ecological, and economic dimension too. According to the literature review, the most important catchwords of this new concept are resilient, sustainable, and human-centric. As a result, based on technological progress a “win-win” situation will appear between society and industry. It was also highlighted in this chapter that the current EU strategies and the priorities of the EU Commission are also corresponding with the utilisation of AI and Industry 5.0. as well.

The study was also discussing in detail the concept of resilience, as being one of the main elements of Industry 5.0. As Chapter 2 has revealed, the first modern understanding of the concept was not in business at all, rather in complex ecological systems and their resilience in various types of crises. Important to note that crises are not per se negative, therefore this chapter has scrutinised the different types of crises and shocks.

Chapter 2 was emphasising that numerous analyses identify different skills and capacities for enterprises as tools of resilience. It turned out that apart from the hard, quantitative data of the companies (e.g.: business finance tools; spendings for R&D&I, balance sheet), the qualitative aspects cannot be neglected either, so among others, the managerial skills together with the entrepreneurial spirit are also determining the resilience level of a certain company.

It is also a significant issue whose resilience we are looking at. Answers differ from micro-level actors (decision-makers, households, enterprises, etc.) to mid-level players (industries, regions) to macro-

economies – nations, continents, planets, so at this point we can conclude that the whole ecosystem, as also indicated at Industry 5.0, should be resilient in order to make the enterprises resilient.

Based on the certain characteristics, the companies can be classified as different resilience types, as proactive, reactive or adaptive. It needs to be mentioned that a company can belong to all types in their lifetime, depending on the crises they went through and the reaction they have carried out against these crises.

The resilience main chapter also summarised an advanced quantitative resilience analysis where manufacturing companies were also classified based on their resilience level, labelled them as either antifragile, robust, resilient and fragile. Some characteristics were found what might make a company more resilient. Nevertheless, it has to be highlighted that there is no a specific and exact "recipe" which enterprises can follow to become always antifragile in all cases.

Apart from the quantitative research, the qualitative approach is also playing a significant role in order to receive an overall picture of the companies and their resilience level. In order to facilitate such an analysis, an interview scheme is provided in the annex of this study.

In the 5th Chapter, the relevant economic data of the Danube Region and its SMEs have been described. The common features, as well as the common problems were also identified. According to the data, the general ameliorating trend in high-tech industry can cultivate an industrial system along the Danube Region being a potential candidate for the effective use of AI related pervasive technologies. The analysis chapter has depicted that labour shortage is one of the main challenges for the industries of the Danube Region. Besides, energy shortage and the shortage of raw materials are the most important problems which should be solved. Within the Danube Region investing into human capacities and skills, as well as technology, ICTs and AI are playing an important role and would enhance the adaptation to Industry 5.0 among the SMEs of the region.

In the last part of the study, policy recommendations have been listed on company, national, European and Danube Region level, whereas in the last chapter a possible funding opportunities have been also recommended and compared.

Taking everything into account, it is really important that national governments support their companies to enhance their competitiveness on national and EU level as well. As the study has highlighted numerous problems (shortage of raw materials; shortage and high cost of energy, and labour shortage) should be solved, but the authors of this report are convinced that the higher uptake of Artificial Intelligence solutions by companies in the different application areas as well as advocating enterprises to become as resilient as possible would contribute to the solution of the mentioned problems.

As a result, it is the responsibility of each government in Europe- of course of the Danube Region too- to support them in the AI application as well as to better adapt to Industry 5.0 which is also a recommendation and requirement of the current EU strategies.

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Annex

Annex 1. The proposed interview questionnaire including the interview guidelines

Below we provide the interview questionnaire, edited together with the notes for the interview conductor, therefore composing the interview guidelines. The notes are in brackets [..].

[We have to assume that the interviewee is not familiar with resilience scientific literature. We expect therefore that the person has a more or less clear concept of the explicit crises – in which they reacted adaptive or reactive – but a separate set of questions have to tackle those situations where they may have been proactive.

It is important that in the cover letter in which companies are invited to the interview there has to be a common-sense, easy-to understand description of the concept of resilience. This will help to bring closer the mutual understanding of the issue.

The topic of resilience relies on very quantitative data – like the main company financial data, etc – but the REASONS behind resilience are a very qualitative. Therefore, the interviews will have to depend on a lot of qualitative evaluations, which needs a qualified interviewer and sufficient time for the interview. I tried to still support the process with a lot of easy-to-answer closed questions (also to allow for a better comparison across the companies) but there is a significant chance that key information will come up in the very open questions-discussion part. We must balance between the length of the interview (and the patience of the interviewee) and the info we collect.

A further note for the interviewers is to try to keep the discussion focused at the resilience aspects. Company CEOs love telling about the company history and their achievements, but a general overview is not the goal here. In order to convince the interviewees and help them focus is to demonstrate that we are already knowing the general history, we are familiar with their public information. It is highly advised that a junior staff member prepares in advance a short company description on each company to be interviewed, with data from their website, data from the database and let the interviewee know that we are already familiar with this information.

It is highly advisable to re-evaluate the questionnaire after the first 1-3 interviews (basically, test it first) and make any changes that help this to be more effective.]

PART 0- TO BE PREPARED IN ADVANCE

[Notes for the interviewer: short description:

- of the company , mainly from their website, etc.
- of the data available from the database
- the company's economic performance in the economic-financial crisis of 2008-2010
- the company's economic performance in the suspected other crisis period
- what is the preliminary expectation: proactive/adaptive or reactive?]

PART 1

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[introduction for the interview, providing info for the interviewed person: very-very short description of the project, common-sense explanation of our resilience definition, expected timing of results etc.]

PART 2 – BASIC INFORMATION

Name of the company: ……

Name and position of the interviewed person: ……

When did he/she started working at the company and when did she/he assume her/his current position [allows reflecting on the personal experience] [ideal to be chosen so it overlaps with the "crisis" period]…

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During the history of the firm, how many major crises has the company faced? These could be external-driven, based on finances, prices, disruption in the client circle or supply chain, employment supply, etc. But also individual, internal: significant changes in ownership, management structure, etc.

Which ones of these crises have been the most influential according to your opinion? Max 1-2-3:

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[for the interviewer: you have to work with the interviewee to find a crucial max 2-3 such events, because there will be no time to talk about 10 different crises. Here, list all they mention but then focus at 1-2- max 3.]

PART 3 – THE CRISES

[Almost the same block can be asked about the 2008-10 economic-financial crisis and any other crises, with small adaptation, up to the interviewer]

Please provide a short description of the crisis (external, internal, financial, managerial, client or supplier-related, etc.):

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How did it affect the company? Production, sales, profit, etc:

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How did you manage to overcome? What do you consider as key tools?

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Who were the key actors to manage this ?

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What was the timeframe needed to overcome the crisis?

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……

How would you rate the importance and helpfulness of the factors below in overcoming the crisis? Please rate from 1 (not important at all) to 5 (tremendously important):

[for the interviewer: please take down notes on details on anything that gets 4 or 5 points]

[in the final text it can be better -edited with little boxes or scales]

Financial – Revenues, funds:

- Availability of existing company funds, equity
- Availability of short-term loans from the bank sector
- Availability of short-term loans from other F&F&F (family, friends and fools)
- Availability of state support
- Availability of long-term loans from the bank sector

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- Availability of other financial assistance

Financial - Costs:

- Reduction of general operational costs (on overhead, etc)
- Reduction of salaries of top-level management
- Reduction of middle-level management salaries
- Reduction of general salaries
- Reduction of workforce
- Reduction of costs on incoming supplies
- Reduction in costs in any other way:

Managerial:

- Special capacities or skillset of the top-level management/owners:
- Special capacities or skillset of the middle-level management
- Hiring new staff with special capacities or skillsets
- Involvement of external managerial support, consultants, etc.

Labour force and organizational structure:

- Hiring
- Any change in the structure of the labour force
- Organisational change: re-organising the company's departments, units
- Changes in the remuneration and motivation tools for the labour force
- Changes in the flexibility of the workforce (in hiring techniques, etc.)

Products/Services:

- Changing the products/services portfolio

Technological:

- Introducing a local technological innovation with the existing production technologies (machinery)
- Introduction of new production technologies (machines)
- Introduction of a new software /ERP/CRM etc solution,
- Introduction of new production methods (re-organising the production chain)

R&D:

- Launching new R&D activities
- Launching new innovation and technological development of products/services
- Finishing R&D activities (and either closing the activity or reaping its benefits)
- Finishing innovation and technological development of products/services (and either closing the activity or reaping its benefits)

Clients:

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- Contracting new clients
- Contracting new clients in a new geographical area:
- Renegotiating contracts with existing clients

Suppliers:

- Contracting new suppliers
- Contracting new suppliers in a new geographical area:
- Renegotiating contracts with existing suppliers

Packaging, marketing, sales:

- Any change in packaging
- Any change in your marketing
- Any change in your sales techniques

Trainings

- Any training at the the top-level management/owners
- Any training at the middle-level management
- Any training for the workforce

Professional assistance at the top level

- Any mentoring, coaching, human support for the top-level management/owners
- Any mentoring, coaching, human support for the middle-level management

Any other factor that you deem significant: (e.g. location, being embedded into local society, EU projects, ……

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……

PART 4 – THE AVOIDED CRISES AND THE "IMMUNE SYSTEM" OF THE COMPANY

Can you recite any events, periods when a crisis was explicitly averted because you were prepared? We are curious of crises that could have hit hard – maybe hit hard your competitors – but you did not seem to be affected by it. What was it? Why do you think made you immune to this problem?

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In general, how do you rate the preparedness, the "immune system" of your company in terms of: (please rate from 1-worst to 5- best)

- Own financial preparedness
- Availability to reach out for financial assistance
- Capacities and skillsets of top level management/owners
- Capacities and skillsets of middle level management/owners
- Capacities and skillsets of general workforce
- Flexibility of employment
- Motivation and loyalty of your workforce
- Competitiveness of your products/services
- Your technological readiness in terms of hard technology, machinery, production lines
- Your technological readiness in terms of soft technology, software, ERP, CRM, etc
- Efficiency of your production line
- Clientele set
- Supplier set
- Packaging, marketing, sales

Any other factor that you deem significant: (e.g. location, being embedded into local society, EU projects, ……

……

……

PART 5 – CROSSCHECKING THE DATA

Are there any mistakes or information needing interpretation regarding data the official databases? The data presented are correctly describing the company in terms of revenues, profits, employment, etc.?

If not, remarks:

Thank you for your support!

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Annex 2. The proposed invitation letter

Letterheaded paper
Address, subject, date

Dear Madam/Sir!

On behalf of the ……, thank you for being available for an interview! In our international project called …., we look for the secrets, reasons and tools for business resilience and resilience. We would like to know how a company recovers after a crisis, what external and internal resources it relies on in the process, and what solutions it can serve as an example to other businesses.

There are many things that can cause a crisis in the life of a business. There are comprehensive economic crises - such as the 2008-09 global financial and economic crisis, which affected all aspects of life and business. There are crises that do not affect all sectors equally (such as COVID-19: although it has an impact on tourism and the food industry, the effects are not comparable). A radical regulation of the sector, a change in product fees, and possibly an increase in the minimum wage for skilled workers could also mean a crisis situation for some sectors.

However, crises can be completely unique and company-specific. The withdrawal of the largest customer, the disappearance of the most important supplier, or the loss of important key people from the organization can also put a company in an unexpected shock situation, when it is necessary to solve the problem creatively and find a way out.

Resilience works similarly in economic life as it does in the human body. Someone may be resilient (so-called proactive resilience) without being spectacularly hit by the crisis (although their peers, industry or regional competitors may fall back), a resilient person who understands the crisis but shakes himself quickly adapts (adaptive resilience) and is also considered resilient who finds a way out of a relapse and can recover even after losses (reactive resilience).

Our interview questions try to assess the external and internal means by which a company can recover from a difficult situation after an economic downturn. Based on the data of the public balance sheets and income statements, we filtered out the companies that showed signs of resilience after a business downturn in a given year.

Please help our work by answering our questions! If you feel that we are not mentioning any important topic or aspect, please let us know!

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