Deliverable D4.2:

Positioning of the EUt+ alliance within the European Universities' ecosystem in terms of socio-economic developments

DEL. REL. NO: DX4.2

WPX: 4

DESCRIPTION:

PRESENTATION OF THE CAPACITY, CAPABILITIES, MISSIONS, AND GOALS WITH REGIONAL ECONOMIC AND SOCIAL DEVELOPMENT OBJECTIVES WITHIN EACH OF THE ALLIANCE MEMBERS OF EUT-EXTRAS. EXAMINATION OF EU POLICIES AND PRIORITIES. UNDERSTANDING OF SOCIO-ECONOMIC STAKEHOLDER'S RESEARCH PRIORITIES.

COMMENTS:

Dissemination level:	Public
Due date:	30st November 2022
Languages:	English
Deliverable objectives	+ Conduct an in-depth review of EU-wide policies + Analyse the priorities of EU research policy via automatic content analysis tools + Conduct a series of focus groups

EUROPEAN UNIVERSITY OF TECHNOLOGY

EUt Extras

WORK PACKAGE 4

Deliverable 4.2

Positioning of the EUt+ alliance within the European Universities' ecosystem in terms of socio-economic developments

FOREWORD TO DELIVERABLE 4.2

The purpose of this document is to present, in an aligned way, the existing capacity, capabilities, missions, and goals with regional economic and social development objectives of each of our alliance members of EUt EXTRAS, by undertaking an **in-depth examination of EU-wide policies** aimed at addressing various major strategic challenges.

Since one of the objectives of EUt EXTRAS is to create a **joint roadmap for research and innovation**, it is required to examine the common practices, procedures, and frameworks that exist within these eight countries and that construct and define R&I areas and actions.

Two specific action lines are envisaged in this framework. The EU research policy priorities are examined using automatic content analysis tools on pertinent papers (strategic aims, policies, call for proposals, etc.). Moreover, across the EUt+ partner states, a series of focus groups involving researchers, industry partners, and local research policymakers are conducted to assess a deeper understanding of EU research policy and priorities, and the research priorities of local socio-economic stakeholders.

In addition, a closer insight into the balance between the regional frameworks that regulate research and European policies is necessary. Aiming at **consolidating the practices and aligning them as effectively as possible**, this deliverable presents the outcomes of data collection activities (focus groups, EU papers) that took place among the following institutions:

+ Hochschule Darmstadt, University of Applied Sciences (h_da)
+ Rīgas Tehniskā universitāte (RTU)
+ Technological University Dublin (TUD)
+ Технически университет София, Technical University of Sofia (TUS)
+ Τεχνολογικό Πανεπιστήμιο Κύπρου, Cyprus University of Technology (CUT)
+ Universidad Politécnica de Cartagena (UPCT)
+ Universitatea Tehnică din Cluj-Napoca (UTCN)
+ Université de Technologie de Troyes (UTT)

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Executive Summary

EUt EXTRAS' ambition is to support the emergence of intercampus knowledge-creating terms across institutions, disciplines, and types of activities. This convergence aims to **provide a novel approach to the environment, steering and execution of research**. In this framework, we propose and apply a methodology for the positioning of the EUt+ alliance within the European Universities' ecosystem in terms of socio-economic development.

The first section of the deliverable provides a **qualitative analysis of the research policies of the European Union**. Citation of the current research policies that steer research and innovation is followed by the delineation of the priority research fields. In this framework, investigation of the following online official resources was conducted:

- European Commission (EC),
- Directorate-General for Research and Innovation,
- European Parliament ITRE Newsletters,
- Research and Innovation Office, and
- European Innovation Council.

The prioritized research fields, as defined by the EU, are then compared to the areas of activity of the EUt+ alliance members.

In the second section, a **comparative analysis of the research priorities of the alliance members** in a set of scientific fields such as Engineering, Computer Science, and Social Sciences is presented. The scientific publications of each member are being analyzed, followed by the definition of global priorities of research in each scientific field using a citation-based clustering methodology. Afterwards, a comparative analysis of the derived priorities of the alliance members is performed.

In the following section the above-mentioned EU research policies and priorities are studied using an automatic content analysis tool focused on topical research papers regarding their

strategic aims, policies, calls for proposals, etc. For validation, the results are compared to the findings of the qualitative analysis.

The analysis of the focus group discussions is presented in the final section, for a **more extensive understanding of these research policies and priorities**, as well as the functions within the alliance members' ecosystems. Researchers from different countries of the EUt+ alliance contribute to the discussion with their perspectives and opinions on the notions of research and innovation as well as the EU-wide policies' significance for 'governing' these sectors. Additionally, the findings of the interviews within the Cyprus University of Technology (CUT) are also presented in the same section, to shed insight on the perceptions of CUT personnel. Interviewees, from different backgrounds and departments, express views on research within the CUT borders, as well as the institute's primary research capabilities.

In sum, the proposed approach employs a combination of qualitative and quantitative methods, to undertake an **in-depth and comprehensive analysis of capacity, capabilities, missions, and goals** in relation to regional economic and social development objectives. The convergence of all those aspects will help to position the EUt+ alliance within the European Universities' ecosystem in terms of the **overall socio-economic development**.

Chapter 1: EU research policies and priorities

The European Union strengthens research within its boundaries by utilizing several, constantly updated policies. These direct and indirect guidelines are intended to set expectations and priorities, achieve objectives, define boundaries, ensure legal compliance, and enhance economic and societal development, resulting in a strong Europe ready to adapt and succeed in these difficult times.

EU research policies

Horizon Europe Funding

Horizon Europe is the EU's key funding program for research and innovation, from 2021 to 2027. Its significance is reflected in its €95.5 billion budget. Horizon 2020, funded by the European Commission (EC), aims to combat climate change, contribute to the UN's Sustainable Development Goals, boost the EU's competitiveness and growth, promote industrial competitiveness, and leverage investment impact within a strengthened European Research Area. While addressing global issues, the program encourages collaboration among EU and national actors in developing, supporting, and implementing EU policies.

European Commission's Directorate-General

To start with, the EC's Directorate-General for Research and Innovation (DG RTD), based in Brussels, is in charge of coordinating research and innovation activities as well as developing and implementing the EU's research and innovation strategy. DG RTD participates in the European Semester by examining national Research & Innovation (R&I) strategies, identifying their strengths and weaknesses, and, when appropriate, formulating recommendations for specific member-states.

RTD's key responsibilities are a) to create European Union policy in the fields of research and technological innovation, with a focus on improving the competitiveness of European companies; b) to organize member states' participation in European research initiatives; and c) to oversee the research programs of the EU. The last objective of RTD is to advance a better

understanding of the function of science in contemporary society and to incite public discussion on research-related issues at the European level[1].

The flagship program for the Innovation Union is being monitored and supported by the completed European Research Area. Utilizing a systematic approach to programming, it supports R&I through Framework Programmes (currently Horizon 2020). More information about each potential field that is prioritized will be provided below.

Innovation friendly legislation (New European Innovation Agenda and Innovation Principle)

A new European innovation agenda, adopted on July 5th, 2022, is set to position Europe at the forefront of the new wave of profound tech innovation and start-ups. Europe recognizes the critical importance of developing new technologies to address society's most pressing challenges and bringing them to market. This specific agenda will a) improve access to finance for start-ups in Europe; b) enable experimentation of new ideas with regulatory sandboxes; create regional innovation valleys to support and connect innovators; c) support talent; d) empower[1] and include women; and finally, e) improve the policy framework through clearer terminology, indicators, and data sets, combined with policy support to the Member States.

Aside from the new agenda, the Innovation Principle is intended to ensure that legislation is designed in such a way that it creates the best possible conditions for innovation to thrive and that the impact on innovation is considered when the Commission develops new initiatives. Furthermore, EU Regulation 2021/695 establishes the framework for EU support for research and innovation in terms of the scientific and technological goals to be achieved as well as the relevant priorities. It defines the broad lines of such activities and establishes the maximum amount and rules for EU financial participation in the framework program, as well as the respective shares in each of the activities specified. The regulation also defines the rules for participation by interested actors such as research centers, universities, etc.

[1] https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vg9ibeitf3yw

To put it in more specific terms, the regulation aims to strengthen excellent basic and frontier research, support the links between research, innovation, and other policies, including complementarities with national, regional, and EU research and innovation policies and activities. It also aims to close the gender gap in related areas and support the implementation of EU policy priorities. Moreover, it seeks to increase collaboration links in R&I across the continent and across different sectors and disciplines, with the inclusion of social sciences and humanities, as well as attract, train, and retain researchers and innovators in the European Research Area (ERA). Further, it focuses on improving the relationship between science and society, achieving the industrial transformation through improved skills for innovation, stimulating R&I activities in small and medium-sized enterprises (SMEs) and creating innovative companies (start-ups and SMEs). Through alliances with InvestEU, the program is also targeting easier access to risk finance, especially in cases where the market is not able to provide sustainable financing. Public exposure, free access to scientific literature, and data sharing all support open science. What is more, the regulation's purpose is to connect and develop research infrastructures across the ERA, as well as provide transnational access.

ERA, disparities, and smart specialization

The European Research Area (ERA) was established with the goal of creating a single borderless market for research, innovation, and technology across the EU. It is intended to help countries work more effectively as a team by aligning their research policies and programs. The new ERA intends to prioritize investments and reforms in research and innovation, increase market uptake, improve researcher mobility, and promote the free flow of knowledge and technology.

To achieve these goals, the new ERA governance allows for closer collaboration through the formation of a dedicated expert group in which the Commission and the EU member-states co-design and coordinate the implementation of ERA actions, prepare future policy agenda updates, and ensure the participation of associated countries and stakeholders. In addition, an advanced monitoring system with a scoreboard and dashboard, a policy platform, regular policy dialogues, and reports are foreseen. Furthermore, a research and innovation pact will

establish a set of ten common values and principles that will guide research and innovation in Europe and around the world.

The ERA policy agenda includes 20 actions beginning in 2022 and running through 2024. The actions include i) the enablement of Open Science through the European Open Science Cloud, the proposal of an EU copyright and data legislative framework for research, ii) the reform of the Assessment System for research, researchers, and institutions, iii) the promotion of attractive research careers, talent circulation and mobility, iv) the promotion of gender equality and fostering inclusiveness, and the protection of academic freedom in Europe, v) the upgrading of the EU guidance for better knowledge valorization, vi) the strengthening of research infrastructures, the promotion of international cooperation, vii) the acceleration of the green/digital transition of Europe's key industrial ecosystems, viii) the empowerment of higher education institutes, and ix) the establishment of an ERA monitoring system. Through the ERA agenda, it is aspired that EU research and innovation missions and partnerships become key contributors while the development of EU countries' national processes for ERA implementation is supported. Especially the support of research and innovation investments and reforms is put forward with the view to enhance the strategic capacity of public research institutions and bring science closer to citizens and the society overall. Finally, the green transformation constitutes also a major priority.

The EC is aware of the disparities between the different regions of ERA and focuses on strategies for resilient, inclusive, and sustainable growth, with a greater emphasis on less developed and industrial transition regions. The EC's communication on strengthening innovation in Europe's regions aims to boost the innovation and competitiveness potential of all EU regions while also laying the groundwork for long-term growth. It will also promote and strengthen interregional cooperation. The communication promotes a smart specialization strategy for EU regions that focuses on recognizing the region's comparative advantages, prioritizing research, and innovation investment in competitive sectors, and defining a shared vision for regional innovation. In this regard, the Commission encourages Member States to take advantage of EU assistance.

Agreement on reforming research assessment

The agreement reached by the Commission on reforming research assessment also establishes ground rules for the principles and objectives of research within the EU. Priorities for research include ethics and integrity; freedom of scientific research; respect for the autonomy of research organizations; and independence and transparency of data, infrastructure, and criteria. Researchers must prioritize quality and impact, as well as diversity, inclusivity, and collaboration. The agreement defines quality as "*research conducted through transparent processes and methodologies, as well as research management that allows for systematic re-use of previous results*.

The purpose of this agreement is to form an inclusive and collaborative space to achieve a higher quality, more impactful, more efficient, and inclusive research system, focusing on piloting and experimentation, developing new assessment criteria, methods, and tools, and providing opportunities for joint, critical reflection, exchange of good practices, and mutual learning, while fully respecting the autonomy of the organization.

European Innovation Council

The European Innovation Council, another Horizon Europe initiative launched in 2021, aims to support innovations throughout their lifecycle, from early-stage research to proof of concept, technology transfer, and the financing and scaling-up of start-ups and SMEs. It connects academia and business, beginning in the lab and ending in the market. Respecting equity, the European Innovation Council is attempting to improve gender balance through the WomenTech.EU scheme and a women's leadership program. Furthermore, it promotes the improvement of geographical balance, with a focus on "widening" countries.

It is made up of three main funding schemes. The EIC Pathfinder is for advanced research to develop the scientific basis to reinforce breakthrough technologies, where open access to scientific publications and application of research results is promoted. The second scheme, the EIC Transition, is designed for transforming research results into innovation opportunities, and the EIC Accelerator for supporting companies (start-ups, SMEs, and spinouts) to bring

their innovations into market and scale up. All candidates applying for the funding must present a long-term vision of a new technology with a transformative positive effect both on the economy and society. The project's intention is to enhance research, prepare for the transition to innovation, and increase business opportunities.

Joint Research Center (JRC) - EU Science Hub - science and knowledge for Europe

The JRC, i.e., Commission's science and knowledge service, conducts research to provide independent scientific advice and support to EU policy. It creates reference materials, harmonizes measurements in support of an EU-wide measurement system, and validates data and measurements. The European Union Reference Laboratory for Alternatives to Animal Testing, for instance, validates alternative methods to animal experiments for the cosmetics industry. The JRC also certifies specific types of equipment, such as solar cells and digital tachographs, and establishes standards for directives and pre-normative research, while providing reference data.

Coronavirus Research and Innovation – ERAvsCorona action plan

The EC has been at the forefront of funding and coordinating European and global research activities, including pandemic preparedness. Through the 7th Framework Program in Horizon 2020, from 2007 to 2019, €4.1 billion has been invested in infectious disease research. Following the outbreak of the coronavirus pandemic, the Commission also launched several actions in 2020 as part of a €1 billion pledge for coronavirus research, to address epidemiology, preparedness, outbreak response, development of diagnostics, treatments, and vaccines, and infrastructures and resources that enable this research. The EU R&I framework program for 2021–2027 is consistent with the initiatives listed above. This framework also includes initiatives to combat poverty-related and neglected diseases.

The Commission and national ministries have also agreed on the first ERAvsCorona action plan, which outlines ten priority short-term coordinated activities to combat coronavirus. These priorities include coordinating R&I funding against the coronavirus, extending and supporting large EU-wide clinical trials for the clinical management of coronavirus patients,

and providing new funding for innovative and rapid health-related approaches to respond to the coronavirus and deliver rapid results. Other priorities also refer to increasing support for innovative companies (for coronavirus-related applications), creating opportunities for other funding sources, and establishing a one-stop shop for coronavirus R&I funding as well as an ad hoc High-Level R&I Task Force on coronavirus. Finally, actions to enable access to research infrastructures, research data sharing platforms, and pan-EU hackathons to mobilize European innovators and civil society.

EU research priorities

Bioeconomy

The field of bioeconomy is one of the priority fields in the DG RTD. The DG RTD announced a competition in August 2022 for people between the ages of 14 and 35, legally residing in the EU-27 or Ukraine and having an interest in bioeconomy and/or bioeconomy-related fields such as food systems, forestry, climate change, rural development, and blue bioeconomy. The competition's objectives were to increase public understanding of the bioeconomy; engage young people and broaden their perspectives on various forms of the sector across Europe; show the variety of the sector, its opportunities, and its significance; and present different perspectives and realities to policymakers and to all of us.

Renewable energy

Renewable energy is another research area that the DG RTD emphasizes. The Long-term Europe-Africa Partnership on Renewable Energy (LEAP-RE), a five-year project co-funded by the EC under Horizon 2020, aims to foster long-term collaboration between Europe and Africa in renewable energy research and innovation (R&I). Overall, the activities of LEAP-RE fall under the umbrella of the AU-EU High Level Policy Dialogue on Science, Technology, and Innovation's collaboration on climate change and sustainable energy.

Bioscience and Bioindustry

The commission gives priority to bioscience and bioindustry fields. To specify, the Microbial Resource Research Infrastructure (MIRRI) received formal recognition as a European Research

Infrastructure Consortium (ERICS) on June 16, 2022, from the EC, making it the 24th ERIC to be founded since 2011. MIRRI-ERIC will improve complementarity, reduce redundancy, and increase the capacity of Microbial Domain Biological Resource Centres (mBRCs) to preserve microbial materials. The new European Research Area (ERA) aims are greatly facilitated by MIRRI-ERIC. In order to meet the needs of the academic and industrial communities, its actions will promote excellence in scientific research and bioindustry in the field of microbes in Europe.

Along with the above, the goal of implementing regulation is to support policy priorities, particularly the UN Sustainable Development Goals (SDGs) (elimination of poverty and hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, work and economic growth, reduced inequalities, sustainable cities, responsible consumption and production, climate action, peace-justice, and strong institutions). It lays out a framework for preventing severe climate change by limiting global warming to well below 2 degrees Celsius and attempting to limit it to 1.5 degrees Celsius. It also intends to help nations in their efforts and develop their capacity to deal with the effects of climate change.

Strategy Plan

The DG RTD designed a strategy plan with six targeted impacts for the years 2020–2024 as follows:

1. the European Green Deal combines sustainable development, green industrial policy and mitigation of climate change. The mission areas of this aim include soil health and food, adaptation to climate change, including societal transformation, climate-neutral and smart cities, healthy oceans, seas, coastal and inland waters, and cancer. Furthermore, the objectives of it are reducing greenhouse gas emissions, adapting to climate change impacts, lowering energy consumption, switching to biobased materials and renewables, decreasing pollution of seas, oceans, and inland waters (including micro-plastics), regeneration and conservation of oceans and seas, sustainable production and consumption of food, feed, energy, and medicines, and a

thriving bioeconomy. As mentioned, Horizon Europe will dedicate at least 35% of its budget to climate-related actions, contributing to the general 30% budgetary target of the Commission.

2. a Europe prepared for the digital era, includes a new European approach to artificial intelligence. This includes high-quality research, knowledge, and original ideas that assist Europe in adjusting to the digital era.
3. an economy that benefits the public, protects social rights, defends social equality, and aids small enterprises.
4. strengthening Europe in the world. Consequences include enhanced European involvement in international and multilateral initiatives, improved Horizon Europe's association strategy, and strategic international R&I collaboration.
5. strengthening and protecting people's health at all ages and developing innovative methods for disease prevention, diagnosis, monitoring, treatment, and cure.
6. push for European democracy, which involves creation of laws and new ideas that increase civic engagement and political involvement; improve accountability and legitimacy; uphold human rights; advance equality and inclusion; and support public confidence in democratic institutions.

Prioritized, by the EIC, sectors

In this section we present which sectors are being prioritized and, therefore, receive more funding. Evidently these sectors are those in which the respective fields of industries are most specialized.

The European Innovation Council (EIC) is the continent's premier initiative for identifying, developing, and scaling up ground-breaking discoveries and technology, emphasizing in four sectors. The first sector deals with the digital area and industry and includes AI, cloud services, big data, and ML Photonics, lighting, sensors, optical devices, magnets, digital media, IOT, Fintech & digital services. The second sector is green industry, which covers solar energy, electric and autonomous vehicles, water and waste of water, precision farming, sustainable food, nutraceuticals, safe food chains, and solutions to manage waste and minimize air

pollution. The third sector is health, and which combines telemedicine and patient care, clinical medicine and chronic diseases, blood tests and biomarkers, and clinical medicine. The fourth sector deals with cybersecurity, energy efficiency, renewable resources, sustainable carbon cycles, roaming on public communication networks, alternative fuels, greenhouse gas emissions, trans-European energy infrastructure, artificial intelligence, and support for the Ukrainian research community are among the most frequently discussed issues/reports by the committees in the parliament. To these, recently (since March) the issues of gas supply and digital identity in Europe have been added. Other topical issues that need to be addressed concern electricity and energy-related goods and their taxation, the social climate fund, solar energy, competitive and fair markets in the digital sector, whether there is a need for a single market for digital services, a pharmaceutical strategy for Europe, data governance, and the reduction of methane emissions.

Comparison between EU and EUt+ research policies

In this section we provide a comparison between Committee's focus areas and the eight universities that form the EUt+ alliance[2,3]. Key focus areas of the European Union (EU) are explained, and some of the relevant Masters and PhD programs offered by universities, along with corresponding labs and research centers, are listed to allow comparison.

Agriculture, forestry and rural areas

This involves topics as biodiversity, bioeconomy, circular economy, climate action, environmental observation, nature-based solutions, nitrogen and phosphorus pollution, urban development, and water.

These fields are a shared focus among the eight universities participating in the EUt+. Each university brings its unique expertise and resources to the table, and together they form a dynamic network of research institutions dedicated to advancing knowledge and solving

[2] Overview Expertise https://agora.univ-tech.eu/file/gM8yAl7F3ehEzx4bf9r2POmd06cQZa5J/xlsx/edit

[3] Research Strengths https://agora.univ-tech.eu/file/lSjEtFmV3iJ6v1wPYCcyk7R4TWxzug8b/xlsx/edit

complex challenges in these critical areas. Next, some of the EUt+ alliance universities' pertinent study programs, research centers and infrastructure are listed.

Study programs

Darmstadt University of Applied Sciences

- Master of Environmental Engineering (https://h-da.de/en/studies/study-programmes/study-programmes/engineering-sciences/environmental-engineering-masters-degree)

Cyprus University of Technology

- Master of Agricultural biotechnology (animals, plants, and food) (https://www.cut.ac.cy/faculties/gem/abf/degrees/postgraduate/)
- PhD in Agriculture Sciences, Biotechnology, and Food Science (https://www.cut.ac.cy/faculties/gem/abf/degrees/phd-studies/)

Polytechnic University of Cartagena

- Master of Water and Soil Engineering https://www.upct.es/english/content/studies/university_master_water_soil.php
- Master of Advanced Techniques in Agricultural and Food Research and Development https://www.upct.es/english/content/studies/master_agricultural.php

Research Centers & Infrastructure

The infrastructure supporting research for agriculture, forestry, rural areas, and the environment among EUt+ alliance members is listed below:

Technological University of Riga

- Institute of Energy Systems and Environment (IESE) for aquaculture (https://videszinatne.rtu.lv/en/about-us/institute/)
- High-Performance Computing (HPC) Lab (https://hpc.rtu.lv/?lang=en) for bioinformatics

Technological University of Dublin

- Environmental Sustainability and Health Institute (ESHI) (https://www.tudublin.ie/research/discover-our-research/research-institutes-centres-and-groups/eshi/)

Technical University of Sofia

- Bioautomation, Bioinformatics, and Bioengineering Systems Laboratory, for AgriTech research (http://fa.tu-sofia.bg/?page_number=45)
- Laboratory for vibrations and acoustic noise, for environmental assessment and monitoring (https://tu-sofia.bg/labs/161)
- Centre for Research and Design in Human Comfort, Energy, and Environment (CERDECEN) for sustainable engineering (https://cerdecen.wixsite.com/airmen).

Cyprus University of Technology

- Remote Sensing and Geo-Environmental lab (https://www.cut.ac.cy/faculties/fet/ceg/labs/cyprusremotesensing/?languageId=1)
- Excelsior: EXcellence Research Center for Earth Surveillance and space-based monitoring of the environment (https://excelsior2020.eu/)
- Sustainable Agriculture Group (research center for agricultural chemistry and edaphology) (https://www.sustagric.com/)

Polytechnic University of Cartagena

- Institute of Plant Biotechnology (IBV) (https://www.upct.es/~ibvupct/)
- Agrarian economy (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=44),
- Design and Management in Irrigated Agriculture (DYGAR) (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=15)
- Post-harvest and Refrigeration (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=17)

The Technical University of Cluj-Napoca

- Advanced Sensing Technologies Group, for Agritech (https://research.utcluj.ro/tl_files/research/Research%20Domain/Systems%20Engineering/GAST_MogaDaniel.pdf)
- GCDIA Food Industry Group, for Agritech (https://research.utcluj.ro/tl_files/research/Research%20Domain/Chimie-Biologie/GCDIA_Giurgiulescu.pdf)

Technological University of Troyes

- Computer Science and Digital Society (LIST3N), for Agritech (https://recherche.utt.fr/list3n),
- Interdisciplinary Research on Society-Technology-Environment Interactions (InSyTE), for bioeconomy, rural and agrarian economics (https://recherche.utt.fr/interdisciplinary-research-on-society-technology-environment-interactions-insyte/insyte).

Energy

The EC also emphasizes on energy research, which primarily focuses on bioenergy, energy storage, fusion energy, geothermal energy, hydropower, nuclear fission, ocean energy, solar energy, and wind energy. The eight universities of EUt+ have recognized their role in driving forward innovation and research in the energy sector, which will help to create a more sustainable and environmentally friendly future for the planet and humanity. The importance of energy is increasing rapidly due to the growing concerns over climate change and the need for sustainable energy sources.

The emphasis on the field of energy is evident in the diverse range of degrees offered by the universities.

Study Programs:

Hochschule Darmstadt, University of Applied Sciences

- Master of Energy Management https://h-da.de/en/studium/studienangebot/studiengaenge/wirtschaft-und-gesellschaft/energy-management-masters-degree

Technological University Dublin

- Master of Energy Management https://www.tudublin.ie/study/postgraduate/courses/energy-management/
- Master of Sustainable Electrical Energy Systems https://www.tudublin.ie/study/postgraduate/courses/sustainable-electrical-energy-systems/

Technical University of Sofia

- Master of Electricity from renewable energy (https://tu-sofia.bg/specialties/preview/734)
- Master of Technologies for utilization of renewable energy sources (https://tu-sofia.bg/specialties/preview/884)
- Master of Renewable Energy Electrical Power Systems (https://tu-sofia.bg/specialties/preview/742)

Cyprus University of Technology

- Master of Energy Systems https://www.cut.ac.cy/faculties/fet/mem/degrees/postgraduate/msc-energy-systems/?languageId=1

Research Centers & Infrastructure

The emphasis on energy and related fields is also reflected in the presence of several labs and research centers.

Technological University Dublin

- Environmental Sustainability and Health Institute (ESHI) (https://www.tudublin.ie/research/discover-our-research/research-institutes-centres-and-groups/eshi/)

Technical University of Cluj-Napoca

- Water and energy systems https://research.utcluj.ro/tl_files/research/Research%20Domain/Instalatii/WESYS_Vitan.pdf
- Energy Transition Research Center https://entrec.utcluj.ro/

Technological University of Riga

- Institute of Energy Systems and Environment (IESE) (https://videszinatne.rtu.lv/en/about-us/institute/)

Technical University of Sofia

- Center for research and design in human comfort, energy, and the environment (CERDECEN) (http://www.cfdc.tu-sofia.bg/)
- Laboratory "Vibrations and Acoustic Noise" for Climate and Environmental sensoring and monitoring (https://tu-sofia.bg/labs/161)

Cyprus University of Technology

- Archimedes Solar Energy Laboratory (ASEL) for energy efficiency (https://www.cut.ac.cy/faculties/fet/mem/research/research-units-and-laboratories/archimedes-solar-energy-laboratory/?languageId=1)
- Device Technology and Chemical Physics Laboratory for green hydrogen (https://www.cut.ac.cy/faculties/fet/mem/research/labs/devtech/)
- Renewable Energy Research Laboratory (https://www.cut.ac.cy/faculties/fet/eecei/research-labs/renewableenergy/).

Polytechnic University of Cartagena

- Electrical Engineering and Renewable Energies Lab (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=79)
- Advanced Materials for Energy Production and Storage Research Group (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=104)

Technological University of Troyes

- Laboratory of Mechanical & Material Engineering (LASMIS) https://recherche.utt.fr/laboratory-of-mechanical-material-engineering
- Interdisciplinary research on society-technology-environment interactions (InSyTE), for renewable energies (https://recherche.utt.fr/interdisciplinary-research-on-society-technology-environment-interactions-insyte/insyte)

Health

The EC has been paying increasing attention to health-related issues in recent years, recognizing that good health is essential for a high quality of life and sustainable economic development. In particular, the COVID-19 pandemic has highlighted the importance of a strong public health system and effective international cooperation in addressing global health challenges.

The key research topics concern antimicrobial drug resistance (AMR), brain research, cancer, cardiovascular diseases, chronic diseases, diabetes, Ebola, emerging and re-emerging infectious diseases, HIV/AIDS, human development and ageing, malaria, public health research, rare diseases, tuberculosis, and zika. The policies of EC focus on coronavirus research and innovation, the environment and health, and personalized medicine.

The universities of EUt+ recognize the importance of the health domain and are actively responding to this by offering relevant degree programs and infrastructure to support research and innovation in healthcare.

Study programs:

Technological University of Riga

- Master of Medical Engineering and Medical Physics https://apply.rtu.lv/courses/course/27-msc-medical-engineering-and-medical-physics

Technological University Dublin

- Master of Environmental Health and Safety Streams (https://www.tudublin.ie/study/postgraduate/courses/environmental-health-and-safety2/)

Cyprus University of Technology

- Master of Public Health (https://www.cut.ac.cy/studies/masters/master-programmes/master-in-public-health/) .
- PhD in Environmental and Public Health and Rehabilitation Sciences https://www.cut.ac.cy/faculties/hsc/cii/degrees/doctoral/?languageId=1

Research Centers & Infrastructure

Technological University of Riga

- Institute of Radioelectronics (FPGA, MCU, SoC, Sensors) (https://www.rtu.lv/lv/etf/zinatne-etf/mikrovilnu-inzenierijas-un-elektronikas-instituts)
- Institute of General Chemical Engineering (https://vkti.rtu.lv/?lang=en)

Technical University of Sofia

- Laboratories "Bioautomation, Bioinformatics and Bioengineering Systems (http://fa.tu-sofia.bg/?page_number=45)
- High-risk patients telemetry and AAL systems (https://goodbrother.eu/members/)

Cyprus University of Technology

- Water and Health Lab http://web.cut.ac.cy/waterandhealth/
- Nano/Micro Mechanics of Materials Laboratory, for electronic devices for healthcare https://cutnanolab.weebly.com/
- Cancer Research Center http://biolisys.cut.ac.cy/cancer-research-center-crc/
- Therapeutic Ultrasound (https://www.cut.ac.cy/faculties/fet/eecei/research-labs/therasound/),

Polytechnic University of Cartagena

- Innovation in Telematic Systems and Electronic Technology Division (DINTEL) (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=97)
- Neurotechnology, Control and Robotics (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=39)
- Systems and Electronic Engineering Division (DSIE), for electronic devices for health care (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=59)

Technical University of Cluj-Napoca

- Advanced Process Control Methods, Biomaterials Research Group, Additive Manufacturing and Rapid Product Development Research Centre (AMaRaP) (https://amarap.utcluj.ro/index.html)
- CESTER-Research Center for Industrial Robots Simulation and Testing (https://cester.utcluj.ro/)
- Image Processing and Pattern Recognition Research Center, for biomedical engineering (https://research.utcluj.ro/tl_files/research/Research%20Domain/Computer%20Science/IPPRRC_Nedevschi.pdf) .

Technological University of Troyes

- Living Lab ActivAgeing (LIST3N) (https://recherche.utt.fr/living-lab-activageing)

Industry

The industry sector is an area of focus that includes several target categories, such as Industry 5.0, ERA common industrial technologies roadmaps, advanced manufacturing, advanced materials and chemicals, artificial intelligence (AI), EU valorization policy, transition performance index (TPI), the future of work, knowledge valorization platform, metrology, and sustainable production processes. Research on subjects like digitalization, industry 4.0,

nanotechnology, data science, machine learning, artificial intelligence, etc. is included in this category. The most relevant research infrastructures of the EUt+ partners are listed below.

Darmstadt University of Applied Sciences

- Artificial Intelligence and Machine Learning Lab https://www.ai-da.tu-darmstadt.de/

Technological University of Riga

- Institute of Materials and Structures (IMS) (https://ims.rtu.lv/?lang=en)
- Software Engineering and Intelligent Information Systems Research Laboratory https://seiis.cut.ac.cy/
- Laboratory for Machines and Mechanisms Dynamics (Institute of Mechanics and Mechanical Engineering) (http://www.mmd.rtu.lv/zpla.htm)

Technical University of Sofia

- "Bioautomation, Bioinformatics and Bioengineering Systems" (http://fa.tu-sofia.bg/?page_number=45)
- Applied Electrochemistry Lab (https://tu-sofia.bg/labs/186)
- Applied Research Laboratory "Bella" (Contactless Apparatus) https://www.tu-sofia.bg/labs/107

Cyprus University of Technology

- Robotics Control and Decision Systems (RCDS) Laboratory (https://www.rcdslab.org/)
- Social Computing Research Center https://www.socialcomputing.eu/
- Microsoft Computer Games and Emerging Technologies Laboratory (GET Laboratory) (https://getlab.org/)

Polytechnic University of Cartagena

- Chemical-Industrial Applications, Chemical engineering and technology (QUIMYTEC) (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=35)

- Space for Constructive Solutions in Architecture (ESCA) (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=101) ,

Technical University of Cluj-Napoca

- Lighting Engineering Center (https://research.utcluj.ro/tl_files/research/Research%20Domain/Instalatii/LEL_Beu.pdf)
- ITEC-Information Technology in Electronics Research and Development Center (https://research.utcluj.ro/tl_files/research/Research%20Domain/ETTI/ITEC_Pitica.pdf)

Technological University of Troyes

- Light, nanomaterials and nanotechnologies laboratory https://recherche.utt.fr/light-nanomaterials-nanotechnologies-l2n

Information and communication technologies

The upcoming realm of intervention pertains to information and communication technologies, with emphasis on the following subjects: manufacturing technologies, key digital technologies including quantum technologies, emerging enabling technologies, advanced materials, artificial intelligence and robotics, next generation internet, advanced computing and big data, circular industries, low carbon and clean industries, and space including earth observation.

The EUt+ universities possess significant infrastructure and study programs that enable research in the field of information and communication technologies.

Study Programs

Technological University of Riga

- PhD in Computer Science and Information Technology https://apply.rtu.lv/courses/course/238-phd-computer-science-and-information-technology

- PhD in Telecommunications https://apply.rtu.lv/courses/course/202-phd-telecommunication

Technical University of Sofia

- Master of Computer science and communication https://tu-sofia.bg/specialties/preview/649

Polytechnic University of Cartagena

- Master of Information and Communication Technology https://www.upct.es/english/content/studies/master_in_information_communication.php

Research Centers & Infrastructure

Darmstadt University of Applied Sciences

- Machine Learning and Artificial Intelligence Lab (https://www.aiml.informatik.tu-darmstadt.de/)

Technological University of Riga

- High-Performance Computing (HPC) Centre https://hpc.rtu.lv/about-us-contacts/?lang=en

Cyprus University of Technology

- Robotics Control and Decision Systems Lab (RCDS) (https://www.rcdslab.org/)

Technical University of Sofia

- Center for Robotics and Automation (https://tu-sofia.bg/labs/view/270)

Polytechnic University of Cartagena

- Research center for neurotechnology, control, and robotics (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=39)

Technical University of Cluj-Napoca

- Robotics and Nonlinear Control Center (http://rocon.utcluj.ro/)

Technological University of Troyes

- Computer Science and Digital Society (LIST3N) (https://recherche.utt.fr/list3n)

Oceans and seas

This field encompasses a range of issues such as: integrated maritime policy, international policy, plastics in a circular economy, EU common fisheries policy, EU marine strategy framework directive, food 2030, bioeconomy strategy, and European digital twin of the ocean (European DTO).

Some research infrastructure of EUt+ partners is relevant to this field:

Technical University of Sofia

- Laboratory Bioautomation, Bioinformatics and Bioengineering Systems (http://fa.tu-sofia.bg/?page_number=45)

Polytechnical University of Cartagena

- Naval Technology and Ecosystems Research Groups for oceanography and marine sciences (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=53, https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=75)

Technical University of Cluj-Napoca

- Communications Networks and Protocols Research Lab (https://cnp.utcluj.ro/)

Security

The European Commission places great importance on security. One of the ways it does this is by providing support for civil security research that contributes to the accomplishments of the Security Union. The policy focus areas are fighting crime (organized crime, cybercrime, etc) and terrorism, border management, resilient infrastructure; cybersecurity, and disaster-resilient societies (against chemical, biological, radiological, and nuclear (CBRN) incidents; climate-related risks and extreme events; geological disasters and pandemics).

The objective is to increase awareness of security research and to aid in the global discussion surrounding the creation of cost-effective and innovative technologies for security practitioners and first responders. Lastly, the advancement of security research strives to address the disintegration of the security technology markets in the EU and to encourage the acceptance of security technologies by society.

TUS and RTU are the two universities within EUt+ alliance with a primary focus on security.

Technological University of Riga

- Institute of Electronics and Computer Science (EDI) https://www.edi.lv/en/

Technical University of Sofia

- Scientific and Applied Laboratory CIUU, for security systems https://ciuu.tu-sofia.bg/en/info

Small and medium-sized businesses

European Innovation Council, European Innovation Ecosystems, Single Market Programme and Interregional Innovation Investments (I3) Instrument, all support small and medium size-businesses (SMEs). All universities participating in the EUt+ offer business related programs. Some of the Masters Degrees are listed below:

Darmstadt University of Applied Sciences

- Master of Business Administration https://mba.h-da.de/#:~:text=Welcome%20to%20Darmstadt%20Business%20School&text=The%20Darmstadt%20MBA%20has%20been,transform%20your%20life%20and%20career.&text=You%20decide%20what%20suits%20you%20best.
- Master of Business Psychology https://h-da.de/en/studium/studienangebot/studiengaenge/wirtschaft-und-gesellschaft/business-psychology-masters-degree

Technological University of Riga

- Master of Business Finance and Business Information https://apply.rtu.lv/courses/course/26-msc-business-finance

Technological University Dublin

- Master of Business and Entrepreneurship https://www.tudublin.ie/study/postgraduate/courses/business-and-entrepreneurship/?courseType=Postgraduate&courseSubjects=Business%2C%20Law%2C%20Languages&keywords=

Technical University of Sofia

- Master of Management and Business Information Systems https://tu-sofia.bg/specialties/preview/887
- Master of Business Administration https://tu-sofia.bg/specialties/preview/689

Cyprus University of Technology

- Master of Shipping and Business https://www.cut.ac.cy/faculties/fme/cfs/degrees/postgraduate/MSc+Shipping+and+Business/

Social sciences and humanities

The EC seeks to promote and support research, innovation, and education in the social sciences and humanities, acknowledging their crucial importance and their essential role in addressing complex societal challenges and shaping the cultural and intellectual landscape of Europe.

As such, the EC has directed its attention towards the diverse contemporary topics within these fields, like the effects of coronavirus on human behavior, democracy and governance, cultural heritage, cultural and creative industries (CCIs), employment and new growth, global justice and stability, migration and mobility, reversing inequalities, gender equality in research and innovation and SSH integration.

While EUt+ is composed of eight technological universities, these institutes recognize the significance of social sciences and humanities as well. This is evident in the presence of numerous laboratories and research groups dedicated to exploring topics in these areas. Through interdisciplinary collaborations and a commitment to promoting diverse

perspectives, EUt+ institutions strive to cultivate a well-rounded education for their students and contribute to a more comprehensive understanding of complex societal issues.

Cyprus University of Technology

- Digital Politics Lab (DIGIPOLS) https://digipols.cut.ac.cy/?fbclid=IwAR0sV_RiDRHGoQmaTzTltzP5N5UtO2A1STwjm3H4-pZbjSE4IXZJ8NMyRpg
- Art + Design: elearning lab - design for social change https://elearningartdesign.org/about-us.html
- CYENS - Center of Excellence https://www.cyens.org.cy/en-gb/about/
- Heraclitus Research Center https://heraclitus.mitos.app/

Polytechnic University of Cartagena

- Foundations of Social Decisions in Economics group (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=87)

Space

The European Union places a high priority on space exploration and research. More specifically, the EU focuses a high priority on satellite control, electronics, and space instrumentation, and supports the development of cutting-edge technology and new solutions for exploring and comprehending space through a variety of research programmes and funding programs. This investment in space research not only enhances scientific understanding but also has significant practical implications, such as upgrading communication networks, monitoring climate change, and increasing global security.

Numerous laboratories and research centers within the EUt+ universities align with this research focus.

Cyprus University of Technology

- Molecular Electronics (http://web.cut.ac.cy/mep/)
- Molecular Electronics and Photonics Research Unit http://web.cut.ac.cy/mep/el/

- Excelsior: EXcellence Research Center for Earth Surveillance and space-based monitoring of the environment (https://excelsior2020.eu/)

Polytechnic University of Cartagena

- Electronic Design and Signal Processing Techniques (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=7)
- Devices and Microelectronic Design (DDM) (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=6)
- Astrophysics and Condensed Matter (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=13)

Technical University of Cluj-Napoca

- Digitally Enhanced RF and Analog IC (https://icdesign.utcluj.ro/)
- Numerical Modelling and Electromagnetic Compatibility Research Laboratory (NUMELEC) NUMERICAL https://research.utcluj.ro/tl_files/research/Research%20Domain/Electrical%20Engineering/NUMELEC_MunteanuCalin.pdf
- Centre of Competence in Intrasatellite Technologies (IntraSAT-Tech Centre) https://research.utcluj.ro/tl_files/research/Research%20Domain/ETTI/IntraSAT_PaladeTudor.pdf

Technical University of Sofia

- Analog Electronics labs, high-speed Satellite Communications labs (https://research.utcluj.ro/tl_files/research/Research%20Domain/ETTI/IntraSAT_PaladeTudor.pdf)

Technological University of Riga

- Institute of Radioelectronics (https://www.rtu.lv/lv/etf/zinatne-etf/mikrovilnu-inzenierijas-un-elektronikas-instituts)
- Institute of Aeronautics (https://www.rtu.lv/en/fmeta/about-faculty/institutes_and_departments/institute-of-aeronautics)

Transport

The primary areas of research in transportation include air travel, multimodal travel, rail transportation, road transportation, and waterborne transportation. Within the EUt+ alliance there are both relevant study programmes and research centers & infrastructure.

Study programs:

Technological University of Riga

- Masters of Aviation Transport https://international.rtu.lv/masters-studies/aviation-transport-masters/

Technical University of Sofia

- Masters of Aeronautical Engineering https://tu-sofia.bg/specialties/preview/751
- PhD in Management and Operation of Railways https://tu-sofia.bg/specialties/preview/789
- PhD in Management and Organization of Road Transport https://tu-sofia.bg/specialties/preview/573

Research centers & Infrastructure

Technological University of Riga

- Institute of Transport https://www.rtu.lv/en/fmeta/about-faculty/institutes_and_departments/institute-of-transport

Technical University of Sofia

- Department of Air Transport (https://tu-sofia.bg/department/preview/28?dep_id=35)
- Laboratory “Organisation and management of automobile transport” https://www.tu-sofia.bg/labs/194
- Department of Railway Engineering, Section "Technology and organization of railway transport" (https://tu-sofia.bg/department/preview/28?dep_id=34)

Cyprus University of Technology

- CYENS Centre of Excellence (https://www.cyens.org.cy/en-gb/about/)

Polytechnic University of Cartagena

- Telecommunications Networks Research Group (GIRTEL) (https://www.upct.es/grupos-investigacion/grupos_ID/info_grupo.php?id=105)

Technical University of Cluj-Napoca

- Sustainable Development (CAREESD) (https://memm.utcluj.ro/ccaiedd/en/index.html)
- Intelligent Methods for Solving Optimization Problems Lab (https://research.utcluj.ro/tl_files/research/Research%20Domain/Matematica-Informatica/sIMONE_PopSitar.pdf)

Frontier research + Synergies with structural funds

Frontier research is another focused area of the European Commission (EC). More specifically, frontier research is defined as the excellent science base from which many new discoveries will arise. In relation to frontier research, there are European Structural and Investment Funds (ESIF), which provide funding for investment in five areas: research and innovation, digital technologies, low-carbon economy, sustainable management of natural resources, and small businesses. The investment themes include jobs, growth and investment, digital single market, energy union and climate, internal market, economic and monetary union, justice and fundamental rights and migration.

Universities' grants and the EU priority fields

The wordclouds in this section illustrate visually the most prominent research keywords for each one the EUt+ alliance universities. These keywords were mined using the ***tool that mines all EU funded projects*** which has been developed by the CUT team in the context of TX4.3.

The EU grants received by TUS (22 projects with a total budget of 201.6 million euros the last decade) produced the wordcloud shown in Figure 1.1 below. The size of each word reflects its

frequency. We see that the most pertinent keyword is *energy* (with the keyword *renewable* being also important) which coincides with one of the key EU priority policies (*renewable energy*).

Figure 1.1: Wordcloud of TUS, created based on their EU funded research projects.

The last decade UPCT received 20 EU funded grants whose total budget was 94.2 million euros. The wordcloud of those projects is shown Figure 1.2. We observe keywords such as *Europe*, *technology*, *digital*, *development*, *deployment*, *cloud* and *diseases* which align with several EU research priority sectors, including *information and communication technologies, security* and *health*.

Figure 1.2: Wordcloud of UPCT, created based on their EU funded research projects.

The key terms (see Figure 1.3) identified based on UTCN's received EU funded grants (36 projects with a total budget of 1.39 billion euros the last decade) are: *innovation*, *SMEs*, *energy*, and *capacity*. We conclude, therefore, that university's EU funded projects focus on small and medium-sized enterprises (SMEs), which Is also an area of importance for the EU research policy.

Figure 1.3: Wordcloud of UTCN, created based on their EU funded research projects.

CUT received 69 EU funded grants, whose total budget was 273.3 million euros, the last decade. As shown in in Figure 1.4, CUT's EU funded projects focus on *cultural heritage*, *science*, and *education*. These terms are strongly associated with the *information and communication technologies* and *social sciences and humanities* EU priority areas.

Figure 1.4: Wordcloud of CUT, created based on their EU funded research projects.

Research, *data*, *knowledge*, *smart*, *energy*, *sustainable* and *applications* are the most often used keywords in TUD's grants funded by EU, as shown in the wordcloud of Figure 1.5. These terms are clearly associated with *bioscience and the bioindustry*, as well as with *renewable energy* which both are among the EU priority sectors. In total, TUD received 30 EU funded grants, whose total budget was 91.6 million euros, the last decade.

Figure 1.5: Wordcloud of TUD, created based on their EU funded research projects.

As shown in Figure 1.6, there are no key terms that stand out in H_DA's wordcloud. This is due to the rather low performance of H_DA in securing EU funded grants (5 projects with an overall budget of 13.4 million euros). Some interesting terms included in the wordcloud are *research*, *electronic*, *cancer*, *care* and *genomics* which are relevant to the EU's top focus on *health*.

Figure 1.6: Wordcloud of H_DA, created based on their EU funded research projects.

The most common keywords in the wordcloud created from the EU funded grants of RTU (see Figure 1.7) are *smart networks*, *innovation*, *technology*, and *biomaterials*. These are connected to the EU's *information and communication technologies* and *industry* research priority fields. The last decade, RTU received 32 grants, funded by EU, whose total budget is 241.7 million euros.

Figure 1.7: Wordcloud of RTU, created based on their EU funded research projects.

Digital is the term that stands out in the wordcloud of UTT's grants funded by EU. This term, along with the other terms that can be seen in the wordcloud shown in Figure 1.8, indicate a clear focus on *information and communication technologies* EU research priority field. In total, UTT received, the last decade, seven (7) EU funded grants whose total budget equals 35.8 million euros.

Figure 1.8: Wordcloud of UTT, created based on their EU funded research projects.

Chapter 2: EUT+ Research Capacity and Capabilities

The objective of this chapter is to present the quantitative analysis of the EUt EXTRAS alliance members' priorities of research in the scientific fields of Computers Science, Engineering and Social Sciences. Towards that end, we first analyze the scientific publications of each member of EUt+, we then define the global priorities of research in each scientific field through a citation-based clustering methodology (of the top performing publications) and finally we perform a comparative analysis and matching of the derived priorities with the alliance members' research priorities.

Currently, the rapid rate of scientific paper publications across all scientific fields creates a sprawling and ever-changing landscape that entails numerous promising research topics. Clustering scientific publications into topics and identifying promising areas of research can provide valuable insights for a) researchers to perform research evaluation and planning, and b) policy makers towards efficient strategic research planning. These clusters are the current global priorities of research with a direct correlation with socio-economic developments. By performing a comparative analysis on the research priorities of the alliance members with respect to the global research priorities we acquire insights on the positioning of the consortium in each scientific field.

The rest of the chapter is organized as follows. We first present the data collection and clustering methodology. This is followed by an in-depth analysis for each scientific field respectively, where for each field we present a) the research priorities of each EUt+ alliance member, b) the global research priorities, and c) the positioning of each member of the alliance.

Identifying Research Priorities via Citation Analysis

In this section, we present the clustering methodology used to identify global research priorities of each scientific field. The two variations of citation-based clustering utilized are a) bibliographic-coupling and b) co-citation clustering. The clustering methodology is performed on publicly available information and can be easily extended into a dynamic and automated

clustering process. This allows updating the results in an efficient manner and keeping the alliance positioning in each scientific field up to date.

The data collected consists of all publications in the respective field during a predefined period of 8 years (since 2014), indexed in Scopus. To collect this information, we utilized the Scopus API through the Pybliometrics python library, a wrapper implementation of the Scopus API. Scopus API provides several methods for retrieving data through three distinct API groups: Search APIs, Retrieval APIs, and Metadata APIs. The Search APIs are composed of Affiliation Search, Author Search and Scopus Search. The Retrieval APIs are composed of Abstract Retrieval, Affiliation Retrieval, and Author Retrieval. Finally, the Metadata APIs are composed of Citation Overview, PlumX Metrics, Serial Search, Serial Title, and Subject Classifications.

We utilized two of the above APIs and we collected the data in two phases, first using the Scopus Search API and then the Abstract Retrieval API. The former facilitates the conditional search of the Scopus database and was used for filtering the database and retrieving only the desired scientific field publications. However, the results of the Scopus Search API are limited to only some basic data about the publications, lacking some essential information for our analysis such as the “references” information. Thus, a second step using the Scopus Abstract Retrieval API deemed as necessary, augmenting the information extracted for each publication with the following fields: Authors, Subject Areas, Index Terms (idx terms), Authors Keywords, Affiliation List, References Count, References List. Since this information is required only for the most influential publications in our analysis, this second step was only applied to the top 1% cited paper per year per scientific field. The data was collected in April 2022 for Computer Science, June 2022 for Engineering and August 2022 for Social Sciences. Those data are accessible online using the *tool that mines Scopus publications filtered by institution, country and keywords*. (see Figure 2.1)

The overall clustering methodology for the most influential publications for each scientific field follows these steps:

1. Data collection of publications information for each year from Scopus
2. Creation of a subset of the Top 1% performing publications for each year

a. Data collection of references information of the Top 1% from Scopus

b. Extraction of the citation information among the Top 1%

3. Performance of Citation-based clustering for the most prominent papers

a. For Bibliographic Coupling clusters papers with a significant volume of common references (references threshold) were grouped

b. For Co-Citation clusters papers with a significant volume of common citations (citations threshold) were grouped

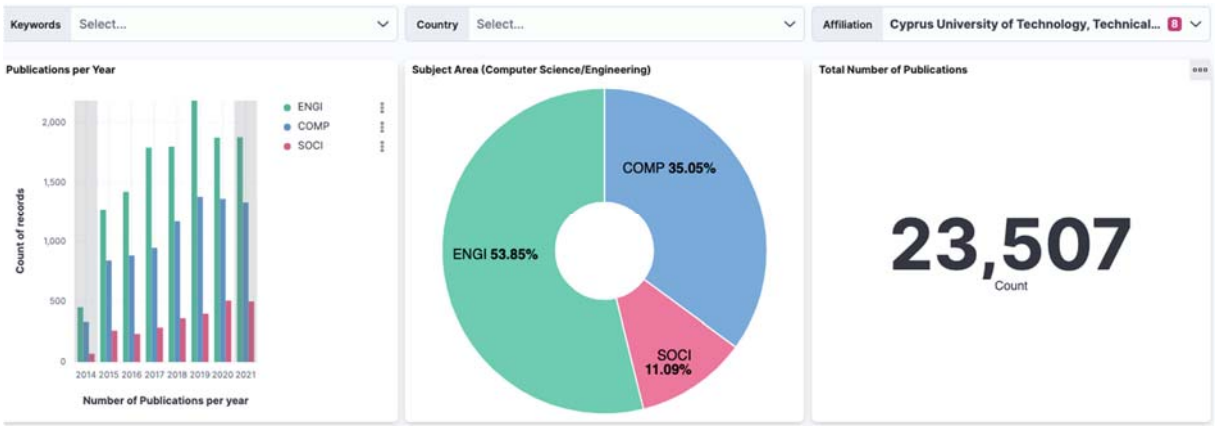

Figure 2.1: EUt+ publications from 2014-2021 in the fields of Engineering, Computer Science and Social Sciences

The main difference between the two methodologies is the computation of the relatedness measure between two publications. For bibliographic coupling clustering the relatedness between two papers is the intersection of their reference sets while for co-citation is the intersection of the citation sets of the two papers. It is worth nothing that the bibliographic coupling values do not change when new articles/papers are published while the co-citation values can change. A graphical representation of the clustering is shown in Figure 2.2.

We also note that publications are assigned to only one cluster when the threshold is reached. The thresholds for bibliographic coupling and co-citation are the hyperparameters of the proposed methodology. We used an empirical threshold of five throughout the analysis.

EUt+ Research Priorities in Computer Science

The scientific field of Computer Science (CS) is a prolific scientific field with around three million publications since 2014 and the EUt+ alliance has nine thousand publications. The data collected show a steady increase in the volume of publications of around 7% per year for the CS field and 6% for EUt+. Details are shown in Table 2.1.

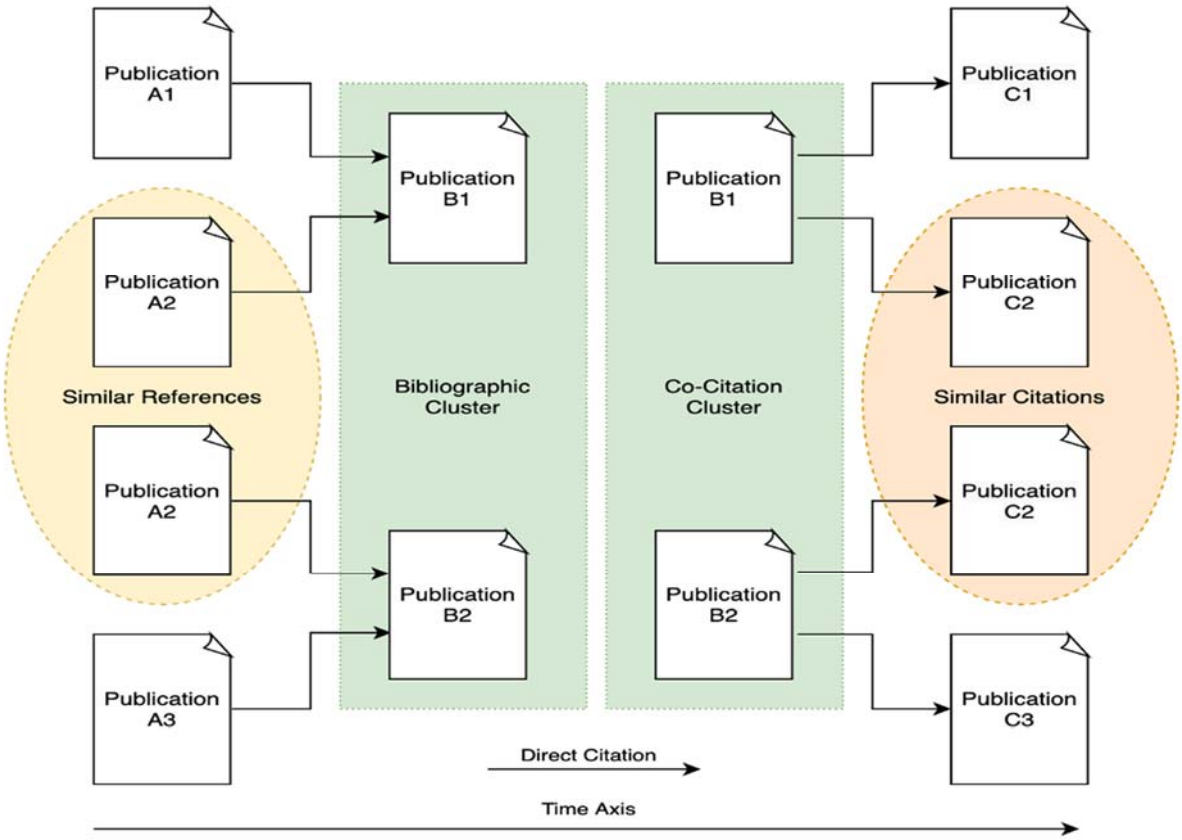

Figure 2.2: Bibliographic coupling and Co-Citation clustering

	2014	2015	2016	2017	2018	2019	2020	2021
CS Publications	329128	343650	376266	403636	453352	530627	495489	530230
Increase	-	+4%	+9%	+7%	+12%	+17%	-7%	+7%
EUt+ Publications	923	842	887	951	1176	1391	1375	1332
Increase	-	-9%	5%	7%	24%	18%	-1%	-3%

Table 2.1. Computer Science Publications within and outside EUt+ alliance

Through the WordCloud representation of the titles of publications (see Figure 2.1) we observe a similarity on the predominant keywords of CS publications within and outside and the EUt+ alliance. We observe that “Deep Learning” and “Machine Learning” dominate in the computer science field with Deep Learning being first globally while Machine Learning being first within the EUt+ alliance. A more detailed view on the volume of publications per year for each member of the EUt+ alliance is presented in Table 2.2.

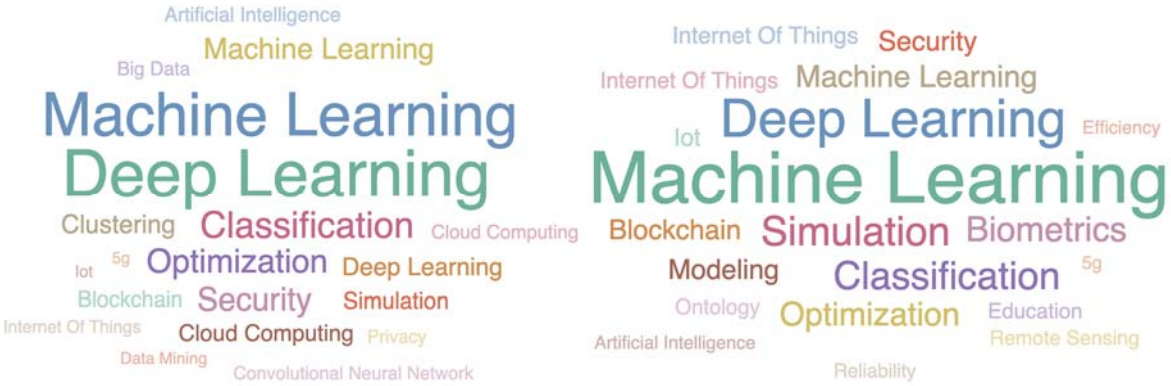

Figure 2.2: Wodlcoud of Computer Science publications within EUt+ (right) and globally (left)

	2014	2015	2016	2017	2018	2019	2020	2021
UTCN	246	259	261	201	303	274	356	324
TUS	71	66	65	110	230	271	312	307
RTU	126	115	129	157	154	231	141	204
CUT	122	93	131	134	121	120	132	112
UTT	129	120	91	94	109	147	95	96
TUD	67	43	66	104	86	119	124	118
HDA	63	42	56	48	62	64	84	51
UPCT	99	104	88	103	111	165	131	120

Table 2.2. Yearly volume of CS publications of EUt+ institutions

We observe that the most prolific member of the consortium is UTCN, followed by TUS and RTU. Additionally, TUS shows the largest increase in publications during the eight-year evaluation period.

Computer Science Research Priorities

Based on the clustering methodology presented in Section 1 (see also Tsapatsoulis et al., 2022), we cluster the most influential computer science literature with a) bibliographic coupling and b) co-citation relatedness measures. For CS, this methodology produced 659 bibliographic coupling clusters (of 18833 papers) and sixty-nine co-citation clusters (of 4035 papers). To derive the most representative keywords for each cluster, we first observe the most prevalent authors' keywords and then manually select the most representative keywords through experts' evaluation as the cluster's suggested keywords. Table 2.3 and 2.4 present information on the ten biggest clusters from each methodology.

No	Cluster Suggested Keywords	Authors' Keywords	# Publi-cations
1	CNNs; Object Detection; Image Classification; Segmentation	deep learning; convolutional neural network; convolutional neural networks; machine learning; retrieval; categorization; recognition: detection; object detection; transfer learning; segmentation	4883
2	RNNs; Speech Recognition; Attention Mechanism	deep learning; recurrent neural networks; lstm; speech recognition; convolutional neural networks; recurrent neural network; attention mechanism; long short-term memory; end-to-end; connectionist temporal classification	598
3	GANs; Image and Video Synthesis; Data Augmentation	deep learning; generative adversarial networks; image and video synthesis; categorization; recognition: detection; retrieval; data augmentation; vision applications and systems; gan; machine learning	481
4	Optimization; Swarm Intelligence; Feature Selection	optimization; swarm intelligence; global optimization; metaheuristic; feature selection; grey wolf optimizer; metaheuristics; particle swarm optimization; salp swarm algorithm; constrained optimization	377
5	Graph Neural Networks; Network Embedding; Recommended Systems	deep learning; machine learning; semi-supervised learning; graph neural networks; graph convolutional networks; graph neural network; network embedding; recommender systems; traffic flow prediction; graph embedding	290
6	Action Recognition; Transfer Learning; Domain Adaptation	deep learning; action recognition; convolutional neural networks; transfer learning; convolutional neural network; image classification; machine learning; lstm; anomaly detection; object recognition	275

7	Word Embeddings; Natural Language Processing; Sentiment Analysis	deep learning; natural language processing; sentiment analysis; word embeddings; machine learning; network embedding; neural network; classification; feature learning; graph embedding	274
8	Adaptive Fuzzy Control; Nonlinear Systems; Dynamic Surface Control	adaptive fuzzy control; adaptive control; backstepping; nonlinear systems; input saturation; adaptive neural control; neural networks (nns); fuzzy adaptive control; dynamic surface control (dsc); stochastic nonlinear systems	246
9	Multiple Attribute Decision Making; Aggregation Operators	multiple attribute decision making (madm); topsis; pythagorean fuzzy set; intuitionistic fuzzy set; aggregation operators; pythagorean fuzzy sets; todim; intuitionistic fuzzy sets; multi-criteria decision making; decision making	231
10	Evolutionary Algorithms; Cloud Computing; Multi-Objective Optimization	many-objective optimization; multiobjective optimization; evolutionary algorithm; differential evolution; decomposition; diversity; convergence; cloud computing; workflow scheduling; evolutionary computation	185

Table 2.3. Computer Science: Most influential bibliographic coupling topics

No	Cluster Suggested Keywords	Authors' Keywords	# Publi-cations
1	CNNs; Object Detection; Image Classification; Segmentation	deep learning; convolutional neural networks; convolutional neural network; machine learning; segmentation; retrieval; neural networks; categorization; recognition: detection; cnn	2682
2	5G; Energy Efficiency; Channel Estimation	massive mimo; non-orthogonal multiple access (noma); energy efficiency; non-orthogonal multiple access; 5g; intelligent reflecting surface (irs); channel estimation; mimo; stochastic geometry; 6g	174
3	Blockchain; Internet of Things; Security; Privacy	blockchain; internet of things; security; iot; internet of things (iot); big data; privacy; smart contracts; bitcoin; healthcare	131
4	Optimization; Swarm Intelligence; Feature Selection	optimization; feature selection; classification; global optimization; metaheuristic; swarm intelligence; constrained optimization; particle swarm optimization; metaheuristics; grey wolf optimizer	127
5	Edge Computing; Fog Computing; Cloud Computing	fog computing; edge computing; mobile edge computing; cloud computing; internet of things; mobile cloud computing; internet of things (iot); computation offloading;	99

		resource allocation; security	
6	Adaptive Fuzzy Control; Nonlinear Systems; Dynamic Surface Control	adaptive control; adaptive fuzzy control; nonlinear systems; backstepping; neural networks (nns); input saturation; dynamic surface control (dsc); adaptive neural control; fuzzy adaptive control; fuzzy logic systems (flss)	91
7	Multiple Attribute Decision Making; Aggregation Operators	pythagorean fuzzy set; aggregation operators; multiple attribute decision making (madm); pythagorean fuzzy sets; pythagorean fuzzy number; multi-criteria decision making; q-rung orthopair fuzzy sets; intuitionistic fuzzy set; hamacher aggregation operators; score function	48
8	Group Decision Making; Consensus Reaching Process	consensus; group decision making; consensus reaching process; social network; social network analysis; fuzzy logic; group decision making (gdm); computing with words; trust propagation; decision making	44
9	Parameter Estimation; Gradient Search; Iterative Identification	parameter estimation; least squares; gradient search; iterative identification; multi-innovation identification; hierarchical principle; signal modeling; bilinear system; hierarchical identification; newton search	35
10	Digital Twin; Big Data; Industry 4.0; Smart Manufacturing	digital twin; smart manufacturing; big data; industry 4.0; cyber-physical systems; manufacturing service; cyber and physical convergence; cyber-physical system; smart factory; data fusion	34

Table 2.4. Computer Science: Most influential co-citation topics

Even though the clustering is performed with two different relatedness metrics, we observe multiple similarities in the clusters. Moreover, recent literature work in clustering computer science publications show similar clusters with methods of larger computationally complexity and information requirements[4].

Matching with EUt+ Publications

To observe the direction of the publications of the EUt+ alliance with respect to the derived CS research priorities, we perform three complementary matching processes:

1. Highly cited EUt+ alliance publications and their respective research priority

4 Xia, Wanjun, et al. "Research Fronts of Computer Science: A Scientometric Analysis." *Journal of Scientometric Research* 10.1 (2021): 18-26

2. Matching EUt+ alliance publications' keywords with the global top ten research priorities
3. Matching EUt+ alliance publications' references with research priorities

Where the first approach depicts the publications of the EUt+ alliance that have managed to become influential in the computer science field, the second and third approaches show the general direction of the alliance with respect to the global computer science research priorities based on a) authors' keywords and b) references matching, respectively.

Highly cited EUt+ publications and their respective research priority

In CS the EUt+ alliance has published and achieved a high citation count (Top1%) on **thirty-two** scientific papers. Of these thirty-two, ten publications are part of the research priorities derived using bibliographic coupling and one publication of the research priorities derived using co-citation. Table 2.5 and Table 2.6 present the relevant publications and the associated research priority for bibliographic coupling and co-citation clustering methodology, respectively. For bibliographic coupling we also include an indication of the volume of publications of the cluster (small, medium, large).

Publications	Research Priority (size)	Uni.	Year
Overview of research on facial ageing using the FG-NET ageing database	CNNs; Object Detection; Image Classification; Segmentation (large)	CUT	2016
Generative Neural Networks for Anomaly Detection in Crowded Scenes	Action Recognition; Transfer Learning; Domain Adaptation (large)	UTT	2019
Large scale crowdsourcing and characterization of twitter abusive behavior	Social Media; Hate Speech; Twitter; Sentiment Analysis (small)	CUT	2018
Selection-channel-aware rich model for Steganalysis of digital images	Steganalysis; Minimal Distortion Embedding; Selection Channel (small)	UTT	2015
A unified solution framework for multi-attribute vehicle routing problems	Dynamic Vehicle Routing; Transportation (small)	UTT	2014
Detection of abnormal visual events via global	Anomaly Detection; Video	UTT	2014

optical flow orientation histogram	Surveillance; Action Recognition (small)		
A survey of recent research on location-routing problems	Electric Vehicles; Location Routing Problem; Autonomous Vehicles (small)	UTT	2014
Almost Periodicity in Impulsive Fractional-Order Reaction-Diffusion Neural Networks with Time-Varying Delays	Memristor; Synchronization; Time Varying Delays (medium)	TUS	2021
Interactive machine learning: experimental evidence for the human in the algorithmic loop: A case study on Ant Colony Optimization	Explainable AI; Human in the loop; Ant Colony Optimization (small)	UTCN	2019
IoT technologies for smart cities	Internet of Things; Communication Protocols; Security (small)	UTT	2018

Table 2.5. Highly cited EUt+ publications and their respective research priority (bibliographic coupling)

Publications	Research Priority	Uni.	Year
Selection-channel-aware rich model for Steganalysis of digital images	CNNs; Object Detection; Image Classification; Segmentation (large)	UTT	2015

Table 2.6. Highly cited EUt+ publications and their respective research priority (co-citation)

We observe that the most influential partners under the current methodology are UTT with six influential papers, followed by CUT with two papers, and one by TUS and UTCN.

Matching EUt+ publications' keywords with the top ten research priorities

The second approach entails the matching of the EUt+ publications' keywords with the keywords of Tables 2.3. and 2.4. Table 2.7 and 2.8 show the number of publications of EUt+ members that have at least one common keyword with the research priority keywords. The information in brackets limits the research priority keywords to the ten most common keywords of each research priority.

No	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
1	979 (126)	605 (58)	431 (24)	383 (30)	424 (49)	255 (49)	192 (12)	331 (45)
2	148 (32)	107 (16)	74 (7)	104 (12)	130 (24)	132 (16)	99 (4)	88 (14)
3	102 (47)	73 (25)	61 (10)	55 (20)	90 (28)	81 (40)	98 (9)	62 (30)
4	208 (20)	148 (18)	110 (6)	97 (1)	171 (33)	119 (3)	28 (5)	135 (13)
5	87 (39)	68 (23)	48 (9)	53 (19)	86 (27)	88 (36)	29 (9)	67 (29)
6	90 (49)	73 (25)	49 (14)	46 (19)	81 (46)	67 (39)	32 (11)	67 (29)
7	66 (44)	53 (28)	40 (13)	50 (24)	71 (29)	78 (45)	41 (11)	48 (30)
8	25 (1)	26 (2)	6 (0)	13 (0)	19 (0)	16 (1)	6 (0)	27 (1)
9	33 (0)	24 (0)	19 (1)	10 (0)	50 (3)	18 (0)	9 (0)	18 (1)
10	122 (8)	94 (2)	75 (0)	52 (3)	112 (8)	82 (6)	39 (0)	86 (8)

Table 2.7. Keyword matching in the ten largest research priorities (bibliographic coupling)

No	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
1	662 (135)	399 (80)	266 (26)	292 (34)	318 (41)	207 (50)	142 (11)	211 (47)
2	77 (4)	64 (6)	90 (14)	39 (1)	70 (6)	59 (6)	41 (5)	87 (19)
3	65 (17)	62 (22)	64 (30)	47 (17)	75 (19)	74 (16)	37 (16)	76 (24)
4	54 (17)	47 (13)	28 (3)	22 (4)	45 (17)	48 (7)	16 (5)	44 (8)
5	23 (7)	27 (5)	28 (6)	15 (5)	27 (6)	19 (5)	15 (4)	25 (9)
6	21 (1)	15 (1)	9 (0)	19 (0)	14 (0)	17 (1)	6 (0)	17 (0)
7	0 (0)	0 (0)	1 (0)	0 (0)	4 (0)	0 (0)	0 (0)	2 (0)
8	1 (0)	4 (2)	2 (2)	0 (0)	7 (0)	1 (1)	1 (0)	2 (1)
9	2 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
10	8 (2)	11 (1)	4 (1)	4 (1)	4 (3)	4 (1)	7 (3)	6 (3)

Table 2.8. Keyword matching in the ten largest research priorities (co-citation)

Matching EUt+ publications' references with research priorities

The third approach entails the matching of the EUt+ alliance publications' references with the research priorities publications therein associating this way each publication of the alliance to a cluster. A publication is considered associated with a cluster when it has at least one reference in the respective cluster (biographic-coupling or co-citation cluster). In case a publication is associated with more than one cluster, the cluster with the higher count of related references is selected. In this context and under the bibliographic coupling clustering methodology, we observe 13% of the publications of the alliance are associated with the global research priorities of computer science. UTT with 22% has the highest percentage of publications and UTCN with 309 publications has the highest volume. Under the co-citation clustering methodology, we observe that 9% of the publications of the alliance are associated with the global research priorities of computer science. Again, UTT with 15% has the highest percentage of publications and UTCN with 217 publications the highest volume. Tables 2.9 and 2.10 present the results per alliance member for bibliographic coupling and co-citation, respectively. Tables 2.11 and 2.12 show the ten most active clusters in the alliance and the volume of publications of each member.

	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
# papers	309	130	70	130	193	119	90	133
%	13.89%	9.08%	5.57%	13.47%	21.91%	16.37%	19.15%	14.44%

Table 2.9. EUt+ CS Bibliographic coupling-based research priorities

	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Papers	217	94	33	80	134	86	65	77
%	9.76%	6.56%	2.63%	8.29%	15.21%	11.83%	13.83%	8.36%

Table 2.10. EUt+ CS co-citation-based research priorities

Bibliographic Coupling Cluster	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
CNNs; Object Detection; Image Classification; Segmentation	121	30	9	31	38	24	40	2
RNNs; Speech Recognition; Attention Mechanism	22	4	1	7	3	12	1	1
Word Embeddings; Natural Language Processing; Sentiment	9	7	0	2	1	14	2	0
Action Recognition; Transfer Learning; Domain Adaptation	4	2	0	1	9	2	2	2
Image Steganography; Minimal-Distortion Embedding	0	0	0	0	24	0	0	0
Edge Computing; Fog Computing; Cloud Computing	1	7	0	2	5	0	0	0
Topology Optimization; Cellular Structure; Design Optimization	0	0	0	0	1	0	0	0
Simultaneous Localization and Mapping; Visual Odometry	6	1	4	2	1	1	0	0
Blockchain; Internet of Things; Security; Privacy	3	2	2	0	1	2	1	0
Anomaly Detection; Video Surveillance; Crime Detection	0	1	0	0	12	0	0	0

Table 2.11. The ten most active bibliographic coupling clusters in EUt+

Co-Citation Cluster	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
CNNs; Object Detection; Segmentation	172	46	10	55	98	65	51	30
Blockchain; Internet of Things; Security; Privacy	20	10	15	5	10	3	1	4
Edge Computing; Fog Computing; Cloud Computing	5	17	1	6	10	1	0	7
5G; Energy Efficiency; Channel Estimation	1	8	4	2	4	2	0	10
Interference Modeling; Channel	2	4	0	0	0	1	0	10

Access; Coverage; LoRaWAN								
Hate Speech; Abusive Language; Twitter; Cyper Hate	0	0	0	6	0	6	0	0
Face Recognition; Spoofing Detection; Biometrics	0	1	0	0	1	0	10	0
Digital Twin; Big Data; Industry 4.0; Smart Manufacturing	5	1	0	2	1	0	0	0
Optimization; Swarm Intelligence; Feature Selection	7	1	0	0	0	1	0	0
Channel State Information; Wifi; Activity Recognition	0	0	0	0	0	0	0	5

Table 2.12. The ten most active co-citation clusters in EUt+

EUt+ Research Priorities in Engineering

The scientific field of Engineering (ENG) is a prolific scientific field with around five million publications since 2014 and the EUt+ alliance has thirteen thousand publications. The data collected shows a steady increase in the volume of publications of around 3% per year for the ENG field and 6% for EUt+. Details are shown in Table 2.13.

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Eng Publications	609502	582828	608783	642363	699325	763376	734928	744750
Increase	-	-4%	+4%	+6%	+9%	+9%	-4%	+1%
EUt Publications	1351	1273	1425	1792	1808	2189	1881	1880
Increase	-	-6%	12%	26%	1%	21%	-14%	0%

Table 2.13 - Engineering Publications

In the Wordcloud representation of the titles of publications, we can observe a similarity on the predominant keywords of ENG and the EUt+ alliance publications. The Wordclouds are presented in Figure 3.1 where we can observe that “Machine Learning” and “Optimization” dominate in the Engineering field. A more detailed view of the volume of publications per year for each member is presented in Table 2.14.

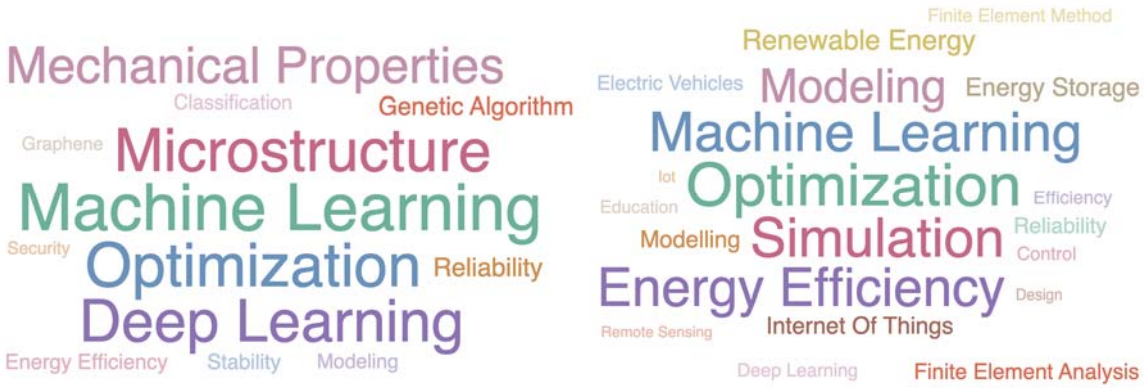

Figure 2.3: Wordclouds of Engineering publications within EUt+ (right) and globally (left)

	2014	2015	2016	2017	2018	2019	2020	2021
UTCN	438	325	399	518	412	577	476	442
TUS	121	105	177	253	389	560	438	457
RTU	262	309	287	477	366	405	308	401
CUT	84	82	102	118	110	108	140	110
UTT	147	133	154	122	145	174	141	143
TUD	130	134	133	130	161	144	157	124
HDA	18	15	25	27	34	27	27	37
UPCT	151	170	148	147	191	194	194	166

Table 2.14. Yearly volume of ENG publications of EUt+ members

We observe that the most prolific member of the consortium is UTCN, followed by RTU and TUS. Additionally, TUS shows the largest increase in publications during the eight-year evaluation period in the ENG field.

Engineering Research Priorities

Based on the clustering methodology presented in the previous section, we cluster the most influential engineering literature with a) bibliographic coupling and b) co-citation relatedness between publications. For ENG this methodology has produced 1273 bibliographic coupling clusters (27682 papers) and 119 co-citation clusters (3129 papers). To derive the most

representative keywords for each cluster, we first observe the most prevalent authors' keywords and then manually select the most representative keywords through experts' evaluation as the cluster's suggested keywords. Table 2.15 and 2.16 present information on the ten biggest clusters emerged from applying each methodology.

No	Cluster Suggested Keywords	Authors' Keywords	# Publi-cations
1	Perovskites; Nanocrystals; Light-Emitting Diodes	Perovskite Solar Cells; Perovskite; Perovskites; Stability; Solar Cells; Light-Emitting Diodes; Perovskite Solar Cell; Quantum Dots; Nanocrystals; Photodetectors	880
2	Graphene; Electromagnetic Wave Absorption; 2D Materials	2D Materials; Black Phosphorus; Transition Metal Dichalcogenides; Mos 2; Two-Dimensional Materials; Photoluminescence; Graphene; Chemical Vapor Deposition; Molybdenum Disulfide; Phosphorene	514
3	Stretchable Electronics; Pressure Sensor; Wearable Electronics	Stretchable Electronics; Flexible Electronics; Electronic Skin; Wearable Electronics; Graphene; Self-Healing; Carbon Nanotubes; Soft Electronics; Strain Sensors; 3D Printing	495
4	Intelligent Fault Diagnosis; Deep Learning; Neural Networks	Deep Learning; Convolutional Neural Network (Cnn); Convolutional Neural Network; Classification; Convolutional Neural Networks; Fault Diagnosis; Hyperspectral Image (Hsi) Classification; Feature Extraction; Transfer Learning; Machine Learning	411
5	Sodium-Ion Batteries; Potassium-Ion Batteries	Sodium-Ion Batteries; Anode; Potassium-Ion Batteries; Graphene; Sodium-Ion Battery; Sodium Ion Batteries; Energy Storage; Anodes; Anode Materials; Sodium Ion Battery	374
6	Lithium-Ion Batteries; Ionic Conductivity	Lithium-Ion Batteries; Lithium Metal Anodes; Lithium-Ion Battery; Silicon; Anode; Lithium Metal Anode; Lithium Dendrites; Lithium Ion Battery; Lithium Metal Batteries; Lithium Metal	368
7	Energy Storage; Supercapacitors; Solar Energy	Mxene; Mxenes; Solar Steam Generation; Energy Storage; Supercapacitors; 2D Materials; Desalination; Solar Energy; Graphene; Photothermal Conversion	331
8	Photothermal Therapy; Nanozymes	Photothermal Therapy; 2D Materials; Graphene; Transition Metal Dichalcogenides; Molybdenum Disulfide; Mos 2; Nanozymes; Two-Dimensional Materials; Photodynamic Therapy; Chemical Vapor Deposition	329

9	Object Detection; Semantic Segmentation; Convolutional Neural Networks	Deep Learning; Convolutional Neural Networks; Convolutional Neural Network; Transfer Learning; Convolutional Neural Network (Cnn); Machine Learning; Object Detection; Cnn; Convolutional Neural Networks (Cnns); Semantic Segmentation	312
10	Lithium-Sulfur Batteries; High Sulfur Loading; Energy Storage	Lithium-Sulfur Batteries; Lithium–Sulfur Batteries; Lithium-Sulfur Battery; Graphene; Polysulfides; Shuttle Effect; Li-S Battery; Li-S Batteries; Lithium Sulfur Batteries; Lithium Sulfur Battery	297

Table 2.15. Engineering: Most influential bibliographic coupling topics

No	Cluster Suggested Keywords	Authors' Keywords	# Publi-cations
1	Industry 4.0; Internet of Things; 5G; Digital Twin	Industry 4.0; 5G; Internet Of Things; Digital Twin; Channel Estimation; Resource Allocation; Cyber-Physical Systems; Massive Mimo; Non-Orthogonal Multiple Access (Noma); Mobile Edge Computing	455
2	Graphene; Electromagnetic Wave Absorption; 2D Materials	Mxene; Microwave Absorption; Black Phosphorus; Phosphorene; 2D Materials; Graphene; Electromagnetic Interference Shielding; Electromagnetic Wave Absorption; Molybdenum Disulfide; Transition Metal Dichalcogenides	261
3	Additive Manufacturing; Microstructure; Selective Laser Melting	Additive Manufacturing; Selective Laser Melting; Microstructure; Mechanical Properties; 3D Printing; Fatigue; Ti-6Al-4V; Additive Manufacturing (Am); Selective Laser Melting (Slm); Additive Manufacture	140
4	Intelligent Fault Diagnosis; Deep Learning; Neural Networks	Fault Diagnosis; Deep Learning; Intelligent Fault Diagnosis; Convolutional Neural Networks; Machine Learning; Feature Learning; Transfer Learning; Condition Monitoring; Convolutional Neural Network; Neural Networks	139
5	Perovskites; Nanocrystals; Light-Emitting Diodes	Perovskite; Perovskites; Light-Emitting Diodes; Nanocrystals; Photoluminescence; Quantum Dots; Electroluminescence; Perovskite Solar Cells; Nanocrystal; Nanoplatelets	122
6	Adaptive Fuzzy Control; Nonlinear Systems; Full State Constraints	Adaptive Control; Adaptive Fuzzy Control; Neural Networks (Nns); Nonlinear Systems; Backstepping; Vibration Control; Boundary Control; Distributed Parameter System; Full State Constraints; Input Saturation	90

7	Stretchable Electronics; Pressure Sensor; Wearable Electronics	Stretchable Electronics; Electronic Skin; Flexible Electronics; Wearable Electronics; Graphene; Ionic Conductors; Pressure Sensors; Wearable Devices; Pressure Sensor; Self-Healing	89
8	Bioprinting; Tissue Engineering; Hydrogels; Bioink	Bioprinting; 3D Printing; Tissue Engineering; Bioink; Hydrogels; Biomaterials; Hydrogel; 3D Bioprinting; Biofabrication; Additive Manufacturing	75
9	Lithium Metal Anodes; Batteries; Ionic Conductivity	Lithium Metal Anodes; Graphene; Lithium Metal; Lithium Metal Anode; Lithium Plating; Batteries; Coulombic Efficiency; Electrodeposition; Li-Metal Anodes; Lithium Dendrites	72
10	Polymer Solar Cells; Norfullerene Acceptors; Power Conversion Efficiency	Nonfullerene Acceptors; Polymer Solar Cells; Organic Solar Cells; Power Conversion Efficiency; Nonfullerene Acceptor; All-Polymer Solar Cells; Complementary Absorption; Conjugated Polymers; Fluorination; Fused-Ring Electron Acceptors	67

Table 2.16. Engineering: Most influential co-citation topics

Similar to the field of computer science, we observe multiple similarities in the derived clusters.

Matching with EUt+ Publications

Here we perform three complementary matching processes to observe the direction of the publications of EUt+ with respect to the derived engineering research priorities.

Highly cited EUt+ publications and their respective research priority

In the field of ENG, the EUt+ alliance has published and achieved high citation count (Top1%) on **fifty-six** scientific papers. Of these fifty-six, thirteen papers are a part of the research priorities derived using bibliographic coupling. Table 2.17 presents the relevant publications and the associated research priority for bibliographic coupling. As in the previous section, we also include an indication of the volume of publications of the cluster (small, medium, large).

Publications	Research Priority (size)	Uni.	Year
Generative Neural Networks for Anomaly Detection in Crowded Scenes	anomaly detection; steganalysis; action recognition (medium)	UTT	2019

Selection-channel-aware rich model for Steganalysis of digital images	anomaly detection; steganalysis; action recognition (medium)	UTT	2015
Detection of abnormal visual events via global optical flow orientation histogram	anomaly detection; steganalysis; action recognition (medium)	UTT	2014
Systematic testing of hybrid PV-thermal (PVT) solar collectors in steady-state and dynamic outdoor conditions	solar power; renewable energies; collector performance analysis (small)	CUT	2019
A small-scale solar organic Rankine cycle combined heat and power system with integrated thermal energy storage	solar power; renewable energies; collector performance analysis (small)	CUT	2015
All-Dielectric Colored Metasurfaces with Silicon Mie Resonators	metasurfaces; wavefront control; nanophotonics (medium)	UTT	2016
Biodegradable magnesium alloys for orthopaedic applications: A review on corrosion, biocompatibility and surface modifications	biodegradable materials; biosafety; biocorrosion (small)	TUD	2016
Sustainable product development in a circular economy: Implications for products, actors, decision-making support and lifecycle information management	circular economy; sustainable development; sustainable production (small)	UTT	2021
Understanding Small-Signal Stability of Low-Inertia Systems	distributed control; microgrids; power sharing (large)	CUT	2021
Testing and modelling of material behaviour and formability in sheet metal forming	ductile fracture; stress triaxiality; lode dependence (small)	UTCN	2014
Internal curing by superabsorbent polymers in ultra-high performance concrete	cement-based materials; internal curing; durability (small)	RTU	2014
A Review of Self-Healing Concrete for Damage Management of Structures	bacteria-assisted self-healing concrete; durability (small)	RTU	2018
Online extremum seeking-based optimized energy management strategy for hybrid electric tram considering fuel cell degradation	energy management systems; hybrid tramway; supercapacitor (small)	UTCN	2021

Table 2.17. Highly cited EUt+ publications and their respective research priority (bibliographic coupling)

We observe that the most influential partners under the current methodology are UTT with five influential papers, followed by CUT with three papers, UTCN and RTU with two and one by TUD.

Matching EUt+ publications' keywords with the top ten research priorities

Tables 2.18 and 2.19 show the number of publications of EUt+ members that have at least one common keyword with the engineering research priority keywords. The information in brackets limits the research priority keywords to the ten most common keywords of each research priority.

No	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
1	127 (6)	153 (12)	251 (9)	62 (4)	98 (9)	119 (1)	10 (2)	102 (5)
2	61 (1)	90 (4)	114 (2)	52 (1)	102 (8)	105 (7)	6 (0)	54 (8)
3	80 (2)	186 (7)	171 (3)	116 (1)	104 (1)	126 (11)	27 (0)	131 (11)
4	97 (7)	164 (30)	123 (15)	158 (26)	180 (30)	72 (18)	41 (3)	129 (24)
5	23 (0)	54 (15)	75 (19)	23 (3)	36 (2)	54 (5)	3 (0)	42 (9)
6	38 (0)	58 (0)	91 (0)	48 (1)	54 (0)	47 (1)	5 (0)	39 (0)
7	58 (2)	89 (17)	125 (26)	38 (6)	53 (4)	79 (4)	6 (0)	62 (12)
8	91 (0)	173 (2)	143 (0)	166 (0)	164 (4)	69 (8)	46 (0)	139 (7)
9	91 (6)	173 (26)	143 (11)	166 (19)	164 (25)	69 (17)	46 (3)	139 (26)
10	36 (0)	48 (2)	61 (0)	27 (0)	28 (0)	31 (2)	5 (0)	25 (4)

Table 2.18 - Keyword matching in the ten largest research priorities (bibliographic coupling)

No	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
1	166 (17)	239 (27)	220 (13)	124 (9)	252 (10)	107 (10)	32 (7)	226 (36)
2	26 (0)	59 (2)	72 (0)	29 (1)	47 (2)	63 (5)	6 (0)	33 (3)
3	22 (1)	41 (7)	45 (7)	24 (1)	69 (22)	23 (0)	11 (2)	42 (5)
4	12 (1)	52 (14)	35 (8)	58 (13)	46 (15)	20 (12)	14 (3)	30 (15)

5	4 (0)	14 (2)	13 (1)	7 (0)	15 (5)	14 (0)	3 (0)	8 (1)
6	7 (0)	7 (1)	3 (1)	8 (0)	2 (0)	3 (1)	2 (0)	4 (0)
7	2 (0)	5 (0)	8 (0)	5 (1)	7 (0)	2 (1)	4 (0)	4 (0)
8	0 (0)	4 (2)	5 (2)	2 (2)	10 (8)	4 (0)	5 (1)	4 (1)
9	1 (0)	5 (1)	8 (1)	4 (0)	2 (0)	4 (0)	1 (0)	2 (0)
10	1 (0)	0 (0)	0 (0)	0 (0)	4 (0)	1 (0)	2 (0)	1 (0)

Table 2.19. Keyword matching in the ten largest research priorities (co-citation)

Matching EUt+ publications' references with research priorities

Under the bibliographic coupling clustering methodology, we observe that 9% of the EUt+ alliance publications are associated with the research priorities of engineering. UTT, with 22%, has the highest percentage of publications and the highest volume with 254 publications. Under the co-citation clustering methodology, we observe that 3% of the publications of the alliance are associated with the research priorities of engineering. UTT with 7% has the highest percentage of publications and UTCN with ninety-four publications, the highest volume. Tables 2.20 and 2.21 present the results per alliance member for both bibliographic coupling and co-citation. Tables 2.22 and 2.23 show the ten most active clusters in the alliance and the volume of publications of each member.

	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Papers	252	145	206	90	254	94	15	164
%	7.0%	5.8%	2.3%	10.5%	21.9%	8.5%	7.1%	12.1%

Table 2.20. EUt+ ENG bibliographic coupling-based research priorities

University	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Papers	94	68	57	20	80	34	3	71
%	2.6%	2.7%	2.0%	2.3%	6.9%	3.1%	1.4%	5.2%

Table 2.21. EUt+ ENG co-citation-based research priorities

Bibliographic Coupling Cluster	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Adaptive Steganography; Anomaly Detection; Image Forensics	9	0	0	0	36	0	1	0
Edge Computing; Fog Computing; Cloud Computing	4	14	2	0	4	0	0	5
Electric Vehicles; Inductive Power Transfer; Dynamic Charging	3	10	15	0	0	0	0	0
Intelligent Fault Diagnosis; Deep Learning; Neural Networks	11	7	0	1	3	0	0	2
Perovskites; Nanocrystals; Light-Emitting Diodes	0	5	4	5	4	0	0	1
Distributed Control; Microgrid; Power Sharing; Droop Control	0	4	1	9	0	3	0	1
Object Detection; Semantic Segmentation; CNNs	10	3	1	3	0	1	0	0
Mechanical Property; Selective Laser Melting; Additive Manufacturing	4	0	0	0	14	0	0	0
Channel Modeling; Millimeter Wave Communications	0	3	1	0	0	1	0	12
Topology Optimization; Stress Minimization; Homogenization	0	1	0	0	1	0	0	15

Table 2.22. The ten most active bibliographic coupling clusters in EUt+

Co-Citation Cluster	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Industry 4.0; Internet of Things; 5G; Digital Twin	26	47	10	0	15	7	1	47
Additive Manufacturing; Microstructure; Laser Melting	6	0	2	0	17	3	1	1
Intelligent Fault Diagnosis; Deep Learning; Neural Networks	11	2	1	5	5	1	1	3
Electric Vehicles; Inductive Power Transfer; Dynamic Charging	4	7	10	0	0	0	0	0

Circular Economy; Sustainable Production; Environmental Impact	2	0	2	0	11	1	0	1
Blockchain; Decentralized Energy Trading; Smart Grid	7	0	4	0	2	0	0	1
Network Visualization; Software-Defined Networking	1	2	0	0	2	0	0	9
Remote Sensing Images; Feature Extraction; Scene Classification	7	3	0	1	2	0	0	0
Graphene; Electromagnetic Wave Absorption; 2D Materials	2	0	0	1	4	4	0	0
Perovskites; Nanocrystals; Light-Emitting Diodes	0	1	2	5	2	0	0	1

Table 2.23. Ten most active co-citation clusters in EUt+

EUt+ Research Priorities in Social Sciences

The scientific field of Social Sciences (Soc) is a prolific scientific field with around three million publications since 2014 and the EUt+ alliance has therein three thousand publications. The data collected shows a steady increase in the volume of publications of around 6% per year for the Social Sciences field and 16% for EUt+. Details are shown in Table 2.24.

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Soc Publications	283771	298607	317198	336715	347912	365736	377370	412533
Increase	-	+5%	+6%	+6%	+3%	+5%	+3%	+9%
EUt+ Publications	194	262	237	287	362	399	507	502
Increase	-	35%	-10%	21%	26%	10%	27%	-1%

Table 2.24. Social sciences publications

In the Wordcloud representation of the titles of publications, we can observe a similarity on the predominant keywords of Social Sciences and EUt+ alliance publications. The Wordclouds are presented in Figure 4.1 where we can observe that “Sustainability” dominates the social

sciences field. A more detailed view on the volume of publications per year for each member of the consortium is presented in Table 2.25.

Figure 2.4. Wordclouds of Social Sciences publications within EUt+ (right) and globally (left)

We observe that the most prolific member of the consortium is UTCN, followed by TUS and RTU. Additionally, TUS shows the largest increase in publications during the eight-year evaluation period.

	2014	2015	2016	2017	2018	2019	2020	2021
UTCN	246	259	261	201	303	274	356	324
TUS	71	66	65	110	230	271	312	307
RTU	126	115	129	157	154	231	141	204
CUT	122	93	131	134	121	120	132	112
UTT	129	120	91	94	109	147	95	96
TUD	67	43	66	104	86	119	124	118
HDA	63	42	56	48	62	64	84	51
UPCT	99	104	88	103	111	165	131	120

Table 2.25. Yearly volume of social sciences publications of EUt+ members

Social Sciences Research Priorities

Based on the clustering methodology presented in the previous section, we cluster the most influential social sciences literature with a) bibliographic coupling and b) co-citation relatedness between publications. For social sciences this methodology has produced 625

bibliographic coupling clusters (7981 papers) and 31 co-citation clusters (359 papers). To derive the most representative keywords for each cluster, we first observe the most prevalent authors' keywords and then manually select the most representative keywords through experts' evaluation as the cluster's suggested keywords. Table 2.26 and 2.27 present information on the ten biggest clusters from each methodology.

Even though the clustering is performed with two different relatedness metrics, we observe multiple similarities in the clusters but in a different order of influence. However, contrary to the previous scientific fields results, we observe that some of the clusters are not typical Soc fields. This is due to the cross-discipline feature of some of the derived clusters. For instance, a typical CS cluster that entails Natural Language Processing can be directly applied in various Soc challenges and thus creating a large amount of literature and in effect a Soc research priority cluster.

No	Cluster Suggested Keywords	Authors' Keywords	# Publi-cations
1	Natural Language Processing; Sentiment Analysis; Deep Learning	Sentiment Analysis; Aspect-Based Sentiment Analysis; Natural Language Processing; Deep Learning; Evaluation; Language Model; Lstm; Text Classification; Transformer; Arabic	218
2	Shared Autonomous Vehicles; Trust in Automation	Trust; Technology Acceptance Model; Acceptance; Perceived Risk; Continuance Intention; Autonomous Vehicles; Mobile Learning; Tam; Technology Adoption; E-Commerce	113
3	Planned Behaviour; Social Media; Behavioral Intention	Theory Of Planned Behavior; Attitude; Theory Of Planned Behaviour; Social Media; Sustainable Tourism; Behavioral Intention; Covid-19; Intention; Trust; Value-Belief-Norm Theory	112
4	Behavior Intentions; Place Attachment; Emotional Solidarity	Destination Image; Satisfaction; Loyalty; Destination Loyalty; Place Attachment; Behavioral Intentions; Customer Satisfaction; Emotional Solidarity; Emotions; Perceived Value	95
5	Technology Acceptance Model; Higher Education	Technology Adoption; Utaut; Technology Acceptance; Technology Acceptance Model; Adoption; E-Learning; Higher Education; Perceived Risk; Utaut2; China	89
6	Political Ideology; Social	Ideology; Partisanship; Motivated Reasoning;	72

	Identity; Motivated Reasoning	Polarization; Affective Polarization; Public Opinion; Political Ideology; Social Identity; Affect; Political Attitudes	
7	Renewable Energy; Ecological Footprint; Environmental Sustainability	Ecological Footprint; Economic Growth; Renewable Energy; Co Emissions 2; Natural Resources; Urbanization; Environmental Sustainability; Human Capital; Financial Development; Globalization	71
8	Diversity; Corporate Governance; Sustainable Development	Corporate Governance; Corporate Social Responsibility; Gender Diversity; Board Of Directors; Gender; Environmental Performance; Sustainable Development; Diversity; Leadership; Corporate Social Responsibility Disclosure	70
9	Smart Cities; Sustainable Cities	Smart City; Smart Cities; Governance; Big Data; Smart Governance; Sustainability; Technology; Citizenship; Infrastructure; Urban Planning	70
10	Aspect-based Sentiment Analysis; Domain Adaptation	Sentiment Analysis; Distributional Semantics; Semantic Similarity; Domain Adaptation; Sentiment Classification; Vector Space Models; Aspect Extraction; Aspect-Based Sentiment Analysis; Aspect-Level Sentiment Analysis; Big Data	70

Table 2.26. Social Sciences: Most influential bibliographic coupling topics

No	Cluster Suggested Keywords	Authors' Keywords	# Publi-cations
1	Natural Language Processing; Sentiment Analysis; Deep Learning	Sentiment Analysis; Aspect-Based Sentiment Analysis; Natural Language Processing; Deep Learning; Evaluation; Language Model; Lstm; Text Classification; Transformer; Arabic	45
2	Shared Autonomous Vehicles; Trust in Automation	Autonomous Vehicles; Shared Autonomous Vehicles; Willingness To Pay; Automated Vehicles; Connected And Autonomous Vehicles; Autonomous Vehicle; Trust In Automation; Age; Attitudes; Dynamic Ride-Sharing	37
3	Covid-19; Pandemic; Travel Behavior	Covid-19; Coronavirus; Pandemic; Public Transport; Resilience; Social Distancing; Travel Activity; Travel Behavior; Attitudes; Household Surveys	27
4	Smart Cities; Sustainable Cities	Smart City; Smart Cities; Governance; Smart Sustainable Cities; Sustainability; Ict; Innovation; Policy; Sustainable City; Big Data	24

5	Bicycle Infrastructure; Bike Share	Bicycle; Bikeshare; Bicycle Infrastructure; Transport; Bicycle Sharing Systems; Bike Share; Built Environment; Cities; Citycycle; E-Scooter	23
6	Highway Safety; Accident Analysis; Crash Severity	Unobserved Heterogeneity; Random Parameters Logit Model; Single-Vehicle Crashes; Temporal Stability; Crash Severity; Driver-Injury Severity; Heterogeneity In Means And Variances; Highway Safety; Transferability; Accident Analysis	20
7	Climate Change; Shared Socio-Economic Pathways	Climate Change; Scenarios; Mitigation; Shared Socioeconomic Pathways; Adaptation; Ssp; Economic Growth; Integrated Assessment; Integrated Assessment Modeling; Shared Socio-Economic Pathways (Ssps)	17
8	Teaching/Learning Strategies; Blended Learning; Engagement	Flipped Classroom; Blended Learning; Teaching/Learning Strategies; Active Learning; Applications In Subject Areas; Engagement; Higher Education; Improving Classroom Teaching; Interactive Learning Environments; Motivation	15
9	Peer-To-Peer Accommodation; Sharing Economy	Airbnb; Sharing Economy; Barcelona; Collaborative Consumption; Disruptive Innovation; Gentrification; Peer-To-Peer Accommodation; Tourism; Attractiveness; Authenticity	13
10	Urban-Rural Transformation; Land Use Transition	China; Urbanization; Land Use; Land Use Transition; Urban-Rural Transformation; Allocative Efficiency; Arable Land Depletion; Beijing City; Bohai Rim Region; Built-Up Land Efficiency	12

Table 2.27. Social Sciences: Most influential co-citation topics

Matching with EUt+ Publications

Similar to the CS section we perform three complementary matching processes to observe the direction of the publications of EUt+ with respect to the derived Soc research priorities.

Publications	Research Priority (size)	Uni.	Year
A critical review of academic approaches, methods and tools to assess circular economy at the micro level	Circular economy; environmental management (medium)	UTT	2020
Exploring the potentials of educational robotics in the development of computational thinking: A summary of current research and practical	educational robotics; computational thinking (small)	CUT	2018

proposal for future work			
Internal Drivers and Performance Consequences of Small Firm Green Business Strategy: The Moderating Role of External Forces	sustainable development; green human resources management (medium)	CUT	2017
The development and validation of the ARI questionnaire: An instrument for measuring immersion in location-based augmented reality settings	game experience; augmented reality; game-based learning (small)	CUT	2017

Table 2.28. Highly cited EUt+ publications and their respective research priority (bibliographic coupling)

Highly cited EUt+ publications and their respective research priority

In social sciences, the EUt+ alliance has published and achieved high citation count (Top1%) on **twenty-five** scientific papers. Of these twenty-five, four papers are a part of the research priorities derived using bibliographic coupling. Table 2.28 presents the relevant publications and the associated research priority for bibliographic coupling. Similarly to previous sections, we also include an indication of the volume of publications of the cluster (small, medium, large).

We observe that the most influential partners under the current methodology are CUT with three influential papers, followed by UTT with one paper.

Matching EUt+ publications' keywords with the top ten research priorities

Tables 2.29 and 2.30 show the number of publications of EUt+ members that have at least one common keyword with the social sciences research priority keywords. The information in brackets limits the research priority keywords to the ten most common keywords of each research priority.

No	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
1	3 (2)	6 (2)	0 (0)	2 (0)	2 (1)	5 (3)	2 (2)	0 (0)
2	46 (2)	42 (1)	65 (3)	59 (4)	12 (0)	69 (4)	14 (0)	71 (2)
3	49 (3)	35 (3)	72 (9)	97 (19)	16 (3)	65 (10)	11 (3)	76 (4)

4	22 (0)	13 (0)	42 (0)	52 (1)	8 (0)	30 (0)	6 (1)	32 (0)
5	57 (7)	32 (13)	62 (13)	53 (5)	15 (0)	54 (4)	9 (4)	44 (5)
6	1 (0)	2 (0)	6 (0)	5 (0)	1 (0)	7 (1)	3 (0)	5 (0)
7	7 (1)	7 (1)	10 (0)	8 (2)	11 (0)	6 (1)	3 (1)	13 (5)
8	15 (3)	3 (2)	31 (9)	11 (1)	9 (5)	27 (8)	4 (1)	27 (9)
9	25 (12)	21 (3)	44 (18)	27 (10)	15 (1)	29 (10)	9 (1)	27 (11)
10	3 (0)	1 (0)	1 (0)	1 (0)	6 (3)	3 (0)	2 (1)	0 (0)

Table 2.29. Keyword matching in the ten largest research priorities (bibliographic coupling)

No	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2	1 (0)	3 (0)	7 (1)	2 (0)	5 (0)	9 (2)	4 (0)	1 (0)
3	8 (1)	3 (0)	22 (8)	12 (5)	1 (0)	9 (5)	4 (1)	12 (1)
4	12 (6)	6 (2)	17 (16)	7 (1)	2 (1)	11 (4)	2 (0)	15 (10)
5	0 (0)	2 (0)	10 (2)	2 (0)	2 (0)	7 (2)	1 (0)	2 (0)
6	0 (0)	0 (0)	1 (0)	0 (0)	2 (0)	2 (0)	1 (0)	0 (0)
7	0 (0)	0 (0)	3 (0)	0 (0)	6 (0)	0 (0)	2 (1)	2 (1)
8	1 (0)	2 (0)	0 (0)	1 (0)	0 (0)	3 (2)	1 (1)	0 (0)
9	1 (1)	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)	2 (0)	1 (1)
10	0 (0)	0 (0)	0 (0)	1 (1)	1 (0)	1 (1)	0 (0)	0 (0)

Table 2.30. Keyword matching in the ten largest research priorities (co-citation)

Matching EUt+ publications' references with research priorities

Under the bibliographic coupling clustering methodology, we observe 7% of the publications of the EUt+ alliance are associated with the research priorities of social sciences. CUT with 14%, has the highest percentage of publications and the highest volume with 67 publications. Under the co-citation clustering methodology, we observe that 1% of the publications of the

alliance are associated with the research priorities of social sciences. UPCT with 2.7% has the highest percentage of publications and the highest volume with twelve publications. Tables 2.31 and 2.32 present the results per alliance member for both bibliographic coupling and co-citation. Tables 2.33 and 2.34 show the six most active clusters in the alliance and the volume of publications of each member.

	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Papers	15	5	12	67	8	41	5	54
%	4.6%	1.7%	3.4%	14.3%	8.0%	6.0%	5.8%	12.1%

Table 2.31. EUt+ Soc bibliographic coupling-based research priorities

	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Papers	4	-	2	11	-	9	1	12
%	1.2%	-	0.6%	2.4%	-	1.3%	1.2%	2.7%

Table 2.32. EUt+ Soc co-citation-based research priorities

Bibliographic Coupling Cluster	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Planned Behaviour; Social Media; Behavioral Intention	0	0	0	2	0	0	2	2
Augmented Reality; Teaching/Learning Strategies; Applications in Subject Areas	0	0	0	6	0	0	0	0
Sustainable Tourism; Quality of Life; Customer Satisfaction	0	0	0	2	0	0	0	4
Behavior Intentions; Place Attachment; Emotional Solidarity	0	0	0	5	0	0	0	0
Game Experience; Immersion; Game-Based Learning	0	0	0	6	0	0	0	0
Bicycle Infrastructure; Bike Share	0	0	0	0	0	3	0	3

Table 2.33. Ten most active bibliographic coupling clusters in EUt+

Co-Citation Cluster	UTCN	TUS	RTU	CUT	UTT	TUD	HDA	UPCT
Peer-To-Peer Accommodation; Sharing Economy	0	0	2	2	0	0	0	6
Smart Cities; Sustainable Cities	2	0	0	1	0	1	0	1
Augmented Reality; Teaching/Learning Strategies; Applications in Subject Areas	0	0	0	4	0	0	0	0
Natural Language Processing; Sentiment Analysis; Deep Learning	1	0	0	0	0	2	1	0
Bicycle Infrastructure; Bike Share	0	0	0	0	0	1	0	3
Shared Autonomous Vehicles; Trust in Automation	0	0	0	0	0	3	0	0

Table 2.34. Ten most active co-citation clusters in EUt+

Chapter 3: Automatic analysis of EU research policy documents for topics extraction

In this section we describe the architecture and the main functionalities of the automatic content analysis tool which we developed and used to analyze the EU research policy documents and calls (see the online version here: http://cis.cut.ac.cy:8501/). As in all similar approaches, our approach is split into three main steps: i) data collection, ii) data analysis, and iii) results visualization. These three steps are described in detail in the following sections. In the final section, we present two different examples of the way the tool is used on relevant documents.

Data Collection / Document Extraction

As mentioned above, the first step of the adopted pipeline is data collection. The process starts by an end-user by providing a URL that he/she wants to analyze (Figure 3.1).

Figure 3.1: URL input interface to the content analysis tool

After clicking the "Load" button, the tool fetches the requested web page and extracts its content. This is achieved using the Trafilatura[5] Python package using its discovery and extraction components. It is important to mention that the content is returned as a vector, each element of which corresponds to a paragraph of the original document.

Data Analysis

Having extracted the content, represented as a vector of paragraphs, the next step is the analysis. Extremely important to any automatic text analysis approach is cleaning the data

[5] Trafilatura: A Web Scraping Library and Command-Line Tool for Text Discovery and Extraction (aclanthology.org)

using a pre-processing process. The approaches adopted for data cleaning are described in the following subsection. Then we present the analysis that can be applied on the pre-processed text.

Pre-processing

As mentioned above, it is extremely important to clean the text before applying any automatic analysis technique. In our case, we implemented different techniques, all of which can be configured through an interface (see Figure 3.2). The preprocessing techniques to be applied are usually related to the analysis technique used. In our case, the analysis is topic modeling to automatically cluster paragraphs based on topics they contain.

There are seven preprocessing options implemented:

1. Remove emails, mentions, hashtags, urls, and punctuation. The rationale is that these elements have no contribution on topic identification.
2. Remove short paragraphs since very short paragraphs, for example containing a couple of words, do not carry enough information for identifying a topic.
3. Since Python is case sensitive, the same word written in different cases is considered as a different word. This problem is tackled by lowercasing all words.
4. Lemmatization is used to transform words into their basic inflected form. For example, the words "run" and "running" will be transformed into ran.
5. Remove stopwords, e.g., "and", "or", "if", "the", "a", etc., since they have no contribution in identifying topics.
6. Optional words, in addition to stopwords, are decided to be removed from the content. For example, one might want to remove "EU" and "European Union" from the data since they might appear across topics without any further contribution in identifying them.
7. Create n-grams, i.e., a contiguous sequence of *n* words of the content. There are three options implemented: None, bigrams, and trigrams. Creating n-grams can facilitate the prediction of next words in a sequence (i.e., in a sentence), with potential improvement in the performance of the topic modeling algorithm.

Topic Modeling

Having preprocessed the content of the extracted document, the next step is the analysis through topic modeling. In our case, we utilized the classic approach known as Latent Dirichlet

Allocation[6] (LDA). LDA is a generative probabilistic model that is widely used for topic modeling. The basic idea behind LDA is that documents, paragraphs in our case, are represented as mixtures of topics, where each topic is characterized by words with certain probabilities.

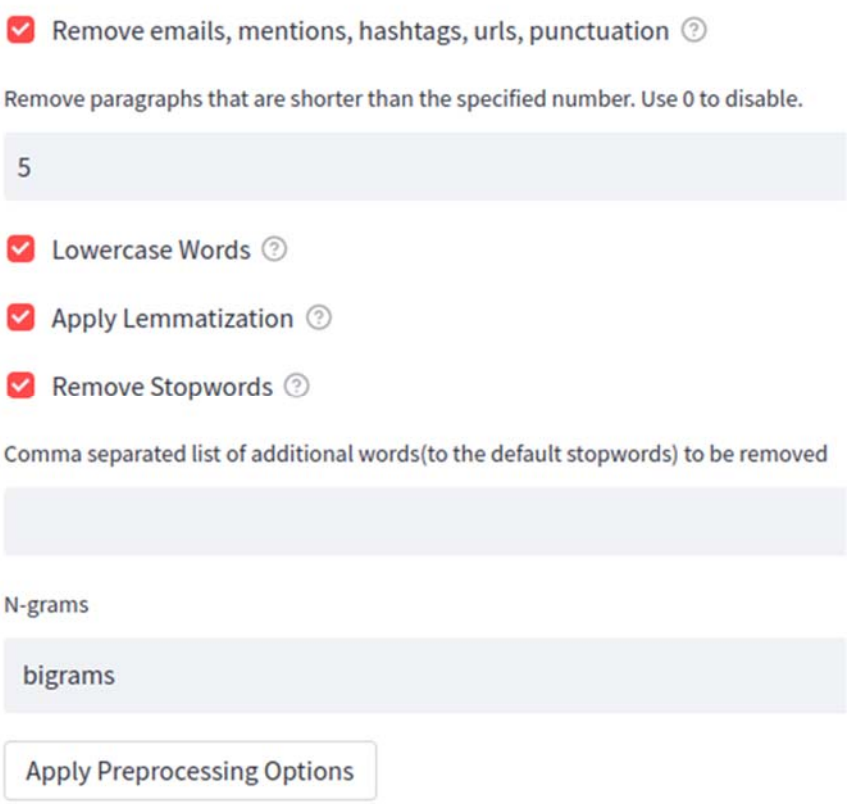

Figure 3.2: Preprocessing options configuration interface

For training a model using LDA, we employed the implementation provided by the Gensim[7] library. There is a number of different parameters that one can specify for calibrating and fine-tuning the training process. Describing all the parameters is beyond the scope of this report, however, additional information about all parameters can be found at Gensim's documentation web page[8]. Almost all parameters could be set at their default value, however,

[6] Latent Dirichlet Allocation (neurips.cc)

[7] Gensim: Topic modelling for humans (radimrehurek.com)

[8] https://tedboy.github.io/nlps/generated/generated/gensim.models.LdaModel.html#gensim.models.LdaModel

one of the parameters that should be carefully edited and adjusted is the number of topics to be generated, known as *K*. The user might be required to train the model multiple times using different *K* values, until finding a desirable topic clustering. The *K* might also be related to the granularity of the topic someone wants to discover. In some cases, we are interested in high-level topics (e.g., Social Sciences, Natural Sciences, etc.) but in other cases we could be searching for more specific topics (e.g., science disciplines like Journalism, Education, etc.).

Figure 3.3: LDA options configuration interface

Since multiple runs might be required using different *K*, one should be able to estimate the topic coherency in order to identify the best *K*. Topic coherence measures the degree of semantic similarity between words in the topic. Different coherence measures exist in the literature. In our case we used the C_{UMass} defined as follows:

$$C_{UMass} = \frac{2}{N \cdot (N-1)} \sum_{i=2}^{N} \sum_{j=1}^{i-1} log \frac{P(w_i, w_j) + \epsilon}{P(w_j)}$$

where $P(w_i,w_j)$ is the probability of seeing word w_i and w_j in a document; $P(w_j)$ is the probability of seeing word w_j in document and ϵ is added to avoid a logarithm of zero. Figure 3.4 shows the Coherency Score output provided by the tool. The green number at the bottom shows the change between the coherency score of the current run, i.e., after changing the *K*, with the coherency score of the previous run.

Figure 3.4: The Coherence Score output

Results - Visualization

The results of topic modeling are graphically presented by the tool after the completion of its execution. In our case, these visualizations are grouped into three categories. That is (a) a topic word-weighted summaries that presents the importance of each word in a topic (Figure 3.5); (b) a wordcloud for each topic generated (Figure 3.6); and finally, (c) the classic output of pyLDAvis (Figure 3.7) that shows the topics and their corresponding words.

Figure 3.5: Topic Word-Weighted Summaries

Figure 3.6: Word cloud of generated topics

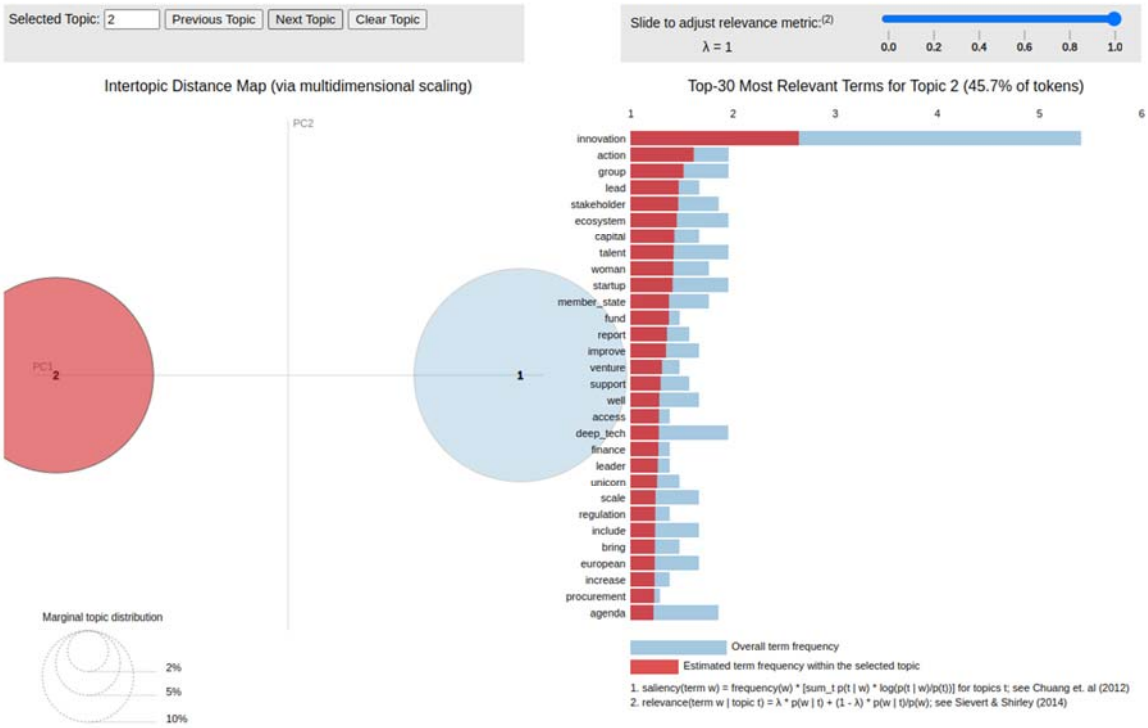

Figure 3.7: pyLDAvis output

Example of usage

In this last section of the automatic analysis tool, we present the output of applying the above-mentioned technique on two online documents[9]. In all trials presented, we used the default

[9] The URLs of the two documents used:

parameters and we only changed *K*, i.e., the number of topics to be generated. Table 3.1 summarizes the coherency score for the different *K* values used on the two documents.

Document	K=2	K=3	K=4	k=5
1	-14.2260	-11.3442	-11.3585	-13.5984
2	-18.7920	-15.6847	-17.6574	-16.4668

Table 3.1. Coherence Scores on different *K* values for the two documents

We can see that in both cases, the most coherent topics are achieved with *K* value equal to 3. Thus, below we present the word clouds of the two documents for those runs.

Figure 3.8: Word cloud of each topic for Document 1 and *K*=3

Figure 3.9: Wordcloud of each topic for Document 2 for *K*=3

1. https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls_en#health
2. https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/bioeconomy-creative-competition-show-us-bioeconomy-your-life-2022-07-22_en

Comparison of the automatic analysis tool's results with the EU research policies and priorities report

A comparison with the results of the report on EU research policies and priorities is performed to validate the findings of the automatic analysis tool.

Looking at Figure 3.8, information for funding programs and calls is included in "Document 1". As previously mentioned, Horizon Europe is the main funding program of the EU for the topics of research and innovation. The subsections of Health and Prioritized industry sectors provide examples of how funding projects connected to health should be given priority. Additionally, the cohesion fund is directly connected to the subsection of ERA, disparities, and smart specialization and the objective of mitigating economic and social disparities, with a focus and support on EU countries whose gross national income per inhabitant is less than 90% of the EU average. The importance of innovation for the development of research and society is confirmed in the subsection of Innovation friendly legislation (New European Innovation Agenda and Innovation Principle), and the description of new-established innovation-friendly legislations. Other topics that are prioritized through the funding programs of the EU are climate, sustainability, and environment, as seen in the subsections of Energy and Renewable energy.

Turning to Figure 3.9, the call posted in July 2022 by the Directorate-General for Research and Innovation[10], for the Bioeconomy Creative Competition, demonstrates the emphasis given by the EU on the field of bioeconomy, as described in the respective subsection of Bioeconomy. Because of the current tense situation in Ukraine, this need grew more rapidly after March 2022. As a result, the call is also open for applications in Ukrainian. The competition's purpose is to promote awareness among young people about the sustainable and circular transition of Europe, through artworks created by the participants.

[10] https://ec.europa.eu/info/departments/research-and-innovation_en

Chapter 4: EUt alliance research ecosystems: Analyzing the representations of Innovation, Research and Policies

Research Ecosystems

Definition of research

Research indicates the systematic exploration of a subject for the purpose of creating new knowledge, or enriching already established knowledge, leading to new concepts, approaches, and understandings. At the same time there is the need to delve into academics' and stakeholders' perception of research in order to better understand their stance, thinking and behaviors within this framework.

Ecosystem

The defining characteristic of an ecosystem is the interaction and collaboration among its interconnected elements, which compose a complex network of functions and relationships. In terms of research within EU borders, the ecosystems that are under examination, are the ones formed by the policies, the stakeholders, and the contextual socio-economic background.

Stakeholders

For the purposes of the current study, stakeholders are considered to be *individuals or groups, representing organizations, institutions, or individuals, who are engaged in research and innovation related activities*. This framework distinguishes three distinct types of stakeholders: representatives of governmental institutions, representatives of the industry sector, such as entrepreneurs, and representatives of the academic sector.

Objective

In the following sections we present a summary of the main conclusions derived through the organization of focus groups at various EUt+ institutions as well as through individual interviews with CUT staff. The aim was to gain a deeper understanding of the stakeholders' and researchers' perspectives on research-related topics by elaborating on the meaning of concepts like innovation, policies, and projects. To begin, the findings of interviews with CUT

researchers are presented in order to demonstrate the institutional framework within which research activities are conducted, as well as the institution's prospective contribution to the EUt+ alliance. Afterwards, the perspective on research and its policies of every EUt+ alliance member's stakeholders and researchers are discussed. This exercise presents the current state of research efforts within the framework of each EU+ institute, as influenced by the relevant policies.

Research views through the EUt+ universities

Research Question

The core research question that was addressed in the interviews with the academic researchers at CUT, was: "What innovations/advancements in the field of research can be expected from Cyprus University of Technology's (CUT) involvement in the European University of Technology (EUt+)?"

Interviews followed a specific protocol that includes the following battery of questions:

Introductory question:

- Few words about CUT's involvement with/CUT's participation in EUt+.

Predefined questions:

1. What are the research strengths of our university (CUT)?
2. Is there enough infrastructure at our university (CUT) to conduct research?
3. Which research projects are running this academic year at CUT and a few words about them?
4. How do you see research evolving at EUt+? / How do you envisage research changing at EUt+?
5. What are the main actions (and what is the reasoning behind each of them) of our university to promote academic research?
6. How do these actions differ from those of other universities in Cyprus?
7. Are there considered to be challenges or difficulties in processing the above?

Sampling

The research followed a non-probability sampling method, defined as convenience sampling. This approach was chosen based on its usefulness. The research sample consisted of five

academic researchers from CUT, four men and one woman. The objective of the study is to gain perspective on their views regarding EUt+ and the university's participation in the project.

Report of Findings

The purpose of this research is to highlight the types of innovations and improvements that CUT's participation in EUt+ will bring to the research community.

Overview of the EUt+ initiative

Having analyzed the collected answers, it seems that there is a general knowledge of EUt+ among the CUT researchers. The participants are aware that EUt+ is a partnership of European universities with the aim of developing a single, integrated system, and that CUT is one of the pioneers of the project. Yet, some of the participants were unsure of the precise number of participating universities. The opening ceremony that took place in Limassol in 2021, was also mentioned. Regarding the content of this new type of university, the coexistence of both joint and autonomous programs was cited.

> *In addition to the autonomous programs, whether they are studies, research, or doctorates, it will also have joint programs that will be not under the umbrella of A or B university but under the umbrella of the European University of Technology. [...] (P1)*

Participants also identified certain departments and individuals involved in EUt+. They were informed about the project through the rector, the Department of Communication and Internet Studies, and some strategic planning communications.

According to the academics, one of EUt+'s general goals is to establish collaborative programs such as research programs (Interreg, Horizon), national programs (Excelsior, Rise - CYENS), external programs (Erasmus), doctorate programs, undergraduate, graduate, and postdoctoral programs. The exchange of students and staff was also identified as one of the EUt+'s objectives.

The eight European technological institutions of EUt+ will also share cooperative synergy via joint research and joint research proposals. General collaboration activities, mobility, interdisciplinarity, and the establishment of joint programs (e.g., postgraduate ones) were all recognized as advantages for all participating institutions.

> *[...] We can learn a lot from these processes, so I believe that this exchange, the movement of people, students, professors, etc., will be very beneficial amongst universities. (P5)*

However, the responses regarding the EUt+'s true value and importance were ambiguous. Due to a lack of more presided information, it appears that the majority of participants are skeptical about the project. Some of them addressed concerns about its long-term benefits and whether this cooperation with the other institutes will truly assist CUT to overcome obstacles and develop. More clarifications were requested at the preliminary stage in order to develop more defined lines for university personnel.

> *[...] some things have not been clarified. When we asked what help they could provide us to develop a joint postgraduate program, there was clearly no answer. They are in the early stages, and they need to be clarified, so I cannot assess whether, at the end of the funding of this program, it will be a real benefit to our university or simply for its image. [...] (P3)*

CUT's contribution to the EUt+

The academics also shared their opinions on CUT and their perspectives on how the university may contribute effectively to the EUt+ alliance. They agreed on the high-quality research that is being conducted at the university and mentioned the indicators that demonstrate the above. Participants specifically emphasized publications in top international journals, citations, validation of the research, and the available guidance. Priorities in research are typically determined by smart specialization areas and global research objectives. Research in these high-priority areas will result in simpler and faster funding procedures.

The fact that CUT is a young institution with technological directions is another significant factor that contributes to its excellent position in terms of research, as it makes it more flexible to get into new projects, create new terms and partnerships. The CUT's Department of Communication and Internet Studies was specifically mentioned since it combines social and technological elements and improves the university's public image. The interviewees also consider the university's personnel a significant asset. The high-quality research index is also shown by the institute's high rankings.

Overall, CUT is an active university, engaged in various European programs. The Research and Innovation Center of Excellence in Cyprus, CYENS, was also brought up as one of CUT's assets.

> *As a university we have a lot of things to offer, a lot of good projects. The university is quite active in European programs and has acquired several centers of excellence, including the former RISE, the CYENS [...] (P5)*

Another goal of the CUT that will help EUt+ is the digitalization of processes, followed by the electronic global timesheet, the rise of academic excellence, and the assertion of new goals. Electronic signatures, payments, and other processes are instances of digital operations.

Furthermore, the faculty of Engineering and more specifically the departments of Electrical Engineering and Civil Engineering were identified as institutional strengths. ERATOSTHENES Center of Excellence, for example, is part of the Faculty of Engineering and Technology's Department of Civil Engineering and Geomatics and is a digital innovation hub in earth observation, space, and geo-spatial information. Additionally, the Department of Communication and Internet Studies' interdisciplinarity was underlined, as it combines social sciences with applied research and applied/computational sciences. The cultural heritage program was also cited as a significant and large research cluster.

It was stated throughout the interviews that CUT has already made a lot of notable advances since joining the EUt+ alliance. Participants include academics from the Social Computing Research Center (SCRC). CUT's other research initiatives are also linked to EUt+, and the project's researchers are becoming more involved in collaborations and consortiums.

Finally, the participants' ambition after CUT's participation in the EUt+, includes novel collaborations with well-known universities, and mutually beneficial collaborations between departments and universities.

CUT funding opportunities

When asked about the funds, participants noted various types of funding accessible in the CUT. One example they gave was the Startup fund, which was created specifically for recently recruited teaching and research academic professionals and can be utilized to purchase new laboratory equipment or to establish their team by hiring research associates.

> *There is the institution of inaugural funding where academics, newly recruited academics can either buy laboratory equipment or employ research associates to set up their team. (P1)*

The fact that CUT receives a lot of funding through research programs is another indicator that the institution is always conducting research and, as a result, is always receiving significant new funding. Research is frequently financed in engineering departments, and this demonstrates the faculty's ability to contribute to the field of research. In general, participants believe that CUT receives adequate funding given the organization's size. There are several European and national funds, as well as the possibility of state sponsorship.

CUT's challenges

All participants concurred that certain drawbacks remain despite the numerous advantages of the university. For example, the accounting department's delays, the bureaucracy of research services, which also results in delays, insufficient infrastructure, a lack of technological and office equipment, even for the essentials, like computers, a shortage of office rooms, resources, and -most importantly- a lack of vision. Procrastination of procedures in general acts as a disincentive.

> *[...] There are many challenges, the well-known ones: we need money, resources, and people who have a good vision of where they would like to go. (P5)*

Infrastructure was heavily stressed because it affects EUt+'s ambition for infrastructure upgrades. The departments are dispersed among numerous buildings scattered around Limassol's city. What is more, the existing infrastructure is substandard, and the rents for potential future infrastructure are extremely high.

The interviewees also discussed CUT's previous misconduct, which resulted in the imprisonment of some academic and administrative staff members, put pressure on how the university operates, necessitated strict supervision, and resulted in the creation of more stringent deterrents, causing the university to move at a much slower speed.

Participants noted that CUT lacks the infrastructure required for its existing projects, making the vision of building infrastructure with EUt+ far more difficult. They believe that once the current infrastructure is completed, then there will be enough room in Cyprus to build

infrastructure for EUt+. They are also concerned about the accessibility of Cyprus's infrastructure due to the country's geographical location.

> *[...] If we were a university in central Europe, people could come in an hour by train or car. However, creating infrastructure in Cyprus implies that it will only be for Cyprus. Nobody will come to Cyprus just to use the infrastructure and then go. Transportation is an issue, and it has gotten worse since the pandemic. (P2)*

Furthermore, participants believe that the culture of cooperation should be fostered first inside the context of the institution, and then on a European level through a project such as EUt+. This was noted because competition can be fierce at times, and researchers are not always willing to collaborate with others. They suggest an exchange of knowledge and ideas between faculty members and students from the same university, as well as student exchange and collaborative teams. Additionally, certain initiatives are being attempted to improve additional procedural obstacles, such as the use of electronic payments to avoid delaying certain processes.

Furthermore, it was suggested that for the EUt+ members' cooperation to be more effective, the members' acquaintance and interactions should begin at an early level. The participants suggested the idea of autonomous decisions that may reduce bureaucracy and expedite processes in response to delays.

> *It should be possible to make some of the decisions autonomously, which will allow the organizational structure of the university to be widened rather than become vertical. [...] (P4)*

Focus Groups Analysis

In this section we present the results from the analysis of three focus groups that were conducted aiming at gaining an understanding of the participants' perspectives on the two EUt+ extras aspects, research, and innovation, in order to create a joint Roadmap at the EUt+ level. Having said this, it is necessary to investigate related policies that define and create the environment in which research and innovation activities take place. The three core concepts that were discussed concerned research, innovation, and policies.

Participants

Three focus groups involving EUt+ stakeholders and researchers were held. Participants ranged from three to seven in number, depending on their availability. All focus groups were conducted in person, as parts of the physical EUt+ meetings in Riga (RTU), Troyes (UTT), and Darmstadt (HDA) on June 28, 2022, September 27, 2022, and November 24, 2022, respectively. The discussions were recorded with the participants' consent. The data collected during the meetings were analyzed using thematic qualitative analysis.

Report of Findings

Below we present the main findings of the conducted focus groups in three major axes: (1) the perception (by participants) of *the meaning of research*, (2) the perception (by participants) of *the meaning of research innovation*, (3) research priorities and criteria for prioritizing research fields.

Constructing the meaning of "Research"

Research is seen from very different perspectives in Academia, Industry and Society. Constructing the meaning of research across the local ecosystems of EUt+ partners is a key challenge and it is one of the main goals of Task TX4.2

Research in theory

All participants appeared to view research in a more abstract light: as the beginning of an inventive and methodical process initially stimulated by curiosity, which starts with a hypothesis, and results in new knowledge. Its outcome is not necessarily predictable, quantifiable or something which can be put immediately in a practice, but something that might be useful in the future. Research's importance and value lie in broadening one's horizons, contributing to newfound information, and most importantly, helping and improving society. It becomes clear that conceptualizing "research" in this way, its meaning is represented as inclusive, highlighting its idealistic goals.

Research in practice

However, research was also discussed in a different way by focus groups participants, which in practice strays from the aforementioned concept. Following this line of argumentation, research was constructed as frequently driven by very specific objectives, established by those who fund the projects. As a result, researchers must work under strict deadlines, and in competitive environments. Plus, there is a lack of permanent academic staff who can work on research for an indefinite time period, due to the contract duration policies of the universities. University scholars are rarely given the opportunity to conduct research on their own terms due to the constant pressure to publish.

> *«Because here, we are very much about action research. So sometimes, we even stray from what is research. We're really into being really practical.» (Participant 3, Figure)*

Participants emphasized that focusing excessively on a predetermined impact of research can lead to the omission of more abstract concepts, and as a result, research becomes synonymous to project management. Under these circumstances, groundbreaking results and innovation are severely constrained and research deviates from its philosophical foundation, especially since basic research is disregarded in favor of applied and action research. The invention of the laser was cited as an example of pure research, and as something that a funding agency would never finance today. Students and researchers are forced to perform with limited critical thinking and imagination as the outcome of extremely precise instructions. Under these conditions, creative and original ideas and concepts are not encouraged.

> *«If you tell the students to take this hammer and this nail and go hit there, this is project management. But if you tell them this is a hammer, and this is how it is used, and these are all the nails, do what you want, this is research. You can get art. I am looking at research from a very generous perspective, people should not be told what to do. We want a free person to think.» (Participant 2)*

Distinguishing this rationale as quite dominant among focus groups participants, it was suggested that to keep researchers motivated and to contribute positively to society, open-mindedness and freedom are essential. Not focusing on one solution or one problem but rather on the research procedure itself and its possibilities can lead to greater results. Ethical

dilemmas like dual use, were also mentioned to be crucial for researchers, especially when they receive funding for their projects.

Moreover, gaps were discovered while discussing the measurement of the effectiveness of research. Apart from the standard measures, such as the impact factor, the publication, and the rankings, the participants expressed a lack of suitable measures to assess a research's real impact or value for the people and the society, which according to them is the most important.

Research priorities

Despite the fact that the stakeholders stated that all research fields should receive equal attention, they did mention several criteria that influence the prioritization process: The financial interest of the local authorities and the industry; the geographical landscape of a region and socio-political factors; and people's and society's needs in general. . At the current time, it was admitted that the fields that are prioritized are mostly green energies and sustainability. Medical technologies were also mentioned, due to the COVID-19 pandemic. Having clarified that research priorities should be synchronized with societal rapid change and development, participants recognized that the priorities of research cannot be permanent and static. As a result, the emphasis should be on local contexts rather than global, because each country or region has its unique needs, behaviors, and challenges. As was emphatically put, 'we must first comprehend phenomena on a local level and in the context in which they occur'.

Stakeholders in Germany highlighted the importance of focusing on fundamental sciences as the basis for everything else. In this vein, they mentioned that in Germany there is a current focus on innovation, technology transfer and start-ups, with a more specific emphasis on engineering. They did, however, admit that an interdisciplinary approach will provide solutions to problems rather than focusing on one specific field every time.

Even though all participants agreed that social sciences and humanities receive insufficient attention and funding, stakeholders in France strongly emphasized the importance of incorporating sociology into all research domains, because the key for a better future lies in the balanced combination between social sciences and technology.

Constructing the meaning of "Innovation"

Surprisingly, the perspectives of innovation seem to be quite aligned across Academia people, Industry and Societal stakeholders. As, in the case of research, constructing the meaning of *innovation* across the local ecosystems of EUt+ partners is a key challenge and extremel relevant to the goals of TX4.2.

Defining innovation

The participants made a clear distinction between research and innovation, stating that research is the investment of money for an outcome that contributes to knowledge, whereas innovation is the investment of knowledge for a financially profitable outcome. Innovation refers to a new use, a new aspect, or an updated version of something that already exists, and is created to meet a need. It is linked to technology, applied sciences, the market, change management and problem solving.

> *«In our field, we say: when you turn money into knowledge, that's research, when you turn knowledge into money, that's innovation.» (Participant 1)*

Since alternating something or adding to it is easier and faster than building it from scratch, innovation often attracts more investors, and thus receives more funding than basic research. As a result, basic research is being neglected in favor of profit, and the pursuit of the new and the possibility of creation is forgotten.

The participants mentioned both technological and social innovation. Participants in Latvia and Germany focused on the technological aspect of the term, while participants in France focused on its social side.

Influencing actors for research and innovation activities' framework

As stated by the participants in the focus group, the two primary duties of the players in the R&I ecosystem are first, the simplification of the processes for participating in R&I activities, and second, the establishment of time frames. Through inclusive policy-making, stakeholders must co-create constructive frameworks for R&I.