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ROMANIAN TECHNICAL UNIVERSITIES: A VIEW OF THE INNOVATION SYSTEM THROUGH ERASMUS+ PROGRAMME

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Abstract:

This paper is analysing within the framework of innovation systems the characteristics through the Erasmus+ programme for higher education for technical universities in Romania. The indicators are providing insights about the innovation system implications. The data was analysed using Excel for statistical measurements and comparisons.
The Erasmus+ programme was implemented 36 years ago having as scope the mobility of students among EU countries, evolving throughout time and spreading even all over the world. One of the strengths of this successful programme is the innovative character based on cooperation and collaboration between entities.

Research and development are one of the key activities helping the business environment to move on. Universities mastering the research and development activities and taking advantage of the exchange experience of students and staff can consider that they have some qualitative inputs over the performance of the business environment.

The analysis of this paper could bring to fellow researchers, business environment, and academia a general overview about the development of trend of outbound and inbound mobilities and the implications over the innovation cluster at regional level.

The purpose of this paper is to identify the trends of the Erasmus+ programme Higher Education mobility and main characteristics showing the character of regional innovation systems.

Keywords: *Innovation System, HEI mobility, Erasmus+ Programme, Erasmus+ grant, Inter-Institutional Agreements*

INTRODUCTION

Nowadays innovation plays a very important role in economic and social development. World economies rely not only on trade, industry, and productivity but also on research and development and collaboration among stakeholders. The markets are becoming more and more global and through the innovative character, emphasizing the importance of innovation systems.

One of the most round and fruitful environments interacting with all three components, promoting, and enhancing innovation, is the academia. Nowadays universities are the core of the research and development world, being part of innovation systems having the role of cohesion between society and the business environment. Using their status and dynamics, they become decision makers shaping the global markets.

Understanding the contribution of a Higher Education Institution (HEI) in these systems is very important not only for the local markets, but also for the national and regional development. This paper is tackling the subject of regional innovation system, taking into consideration the stakeholders representing only by pure technical universities and the opportunities offered by the Erasmus+ Programme.

According to World Intellectual Property Organization (WIPO) and Global Innovation Index (GII) the innovation can be measured through several indicators such as scientific publications, R&D expenditures, international patent filings and venture capital deals, but also through Human Capital and Research, one important package of indicators being related to tertiary education and another one with the R&D. [1,2]

This article explores the relationship between academia and regional innovation systems, tackling as intermediate connection an Erasmus+ Programme analysis for HEIs in Romania, to be more specific the sample was extracted, representing only the technical universities: Universitatea Tehnica De Constructii Bucuresti - Technical University of Civil Engineering of Bucharest (UTCB), Universitatea POLITEHNICA DIN Bucuresti – University POLITEHNICA of Bucharest (UPB), Universitatea Tehnica Cluj-Napoca – Technical University of Cluj-Napoca (UTCluj), Universitatea Tehnica Gheorghe Asachi din Iasi - Gheorghe Asachi Technical University of Iaşi (TUIasi) and Universitatea Politehnica Timisoara - Politehnica University Timisoara (UPT).

As drivers for education and innovation, the Erasmus+ programme is the most representative initiative developed by the European decisions makers, bringing European Union Member States and not only, closer to the innovation mindset. The research paper is structured as it follows: literature review, methodology, findings based on the review and secondary data gathered and conclusions.

LITERATURE REVIEW

Education is considered a public good that should, and it is made available (in some regions) to all citizens, similarly with health and culture. However, this mentality is applied in certain cases. From the economic stability and prioritization aspects to policy implementation and society involvement, each nation is free to have an opinion about it. What is certain is that starting with 1980 higher education and research institutions made their entry into regional policy. One of the first countries to recognise the importance of universities and research in its economy was the United States of America (USA). They permitted universities and small business to be directly involved in the commercialisation of ownership of inventions and patents. This was meant to strengthen the connections among knowledge institutions, trade, and industry in the region. [2]

It is assumed that the performance of individuals, firms, regions, and countries is increasingly determined by the capacity to learn and adapt to new conditions. The current dominant understanding is that innovation is linked to interactive learning processes involving many organisations and institutions. [2]

How else can be structured the environment for innovation than within a system. The Regional Innovation System (RIS) concept “help to shape and produce uneven innovation outcomes inside particular national innovation systems”. That means that RIS can shape regional outcomes rather than just connecting the stakeholders and policy makers. According to Cooke and Piccaluga, the RISs can be subdivided in two key elements, the knowledge production sector (universities, research institutions, and commercial research facilities) and the knowledge using sector (firms and commercial development facilities). [2,6]

UNIVERSITIES PART OF THE REGIONAL INNOVATION SYSTEM

Universities are positioned within the innovation systems networks, being dependent on the work validation and recognition of their academic staff and students. By engaging at the regional level, universities can bring improvement and funding that can be invested in the internationalization activities. And on the other hand, businesses working with regionally engaged universities could learn more quickly and be more competitive on the market. [2]

The purpose of an innovation system is to facilitate the generation and implementation of new ideas, products, and processes, thereby fostering innovation and competitiveness. [1] An innovation system must include three components to drive economic growth and development. Human capital, research and development activities, and the presence of institutions and organizations that facilitate knowledge creation, diffusion, and application. [1]

HEIs and research institutes are usually seen as core actors of the innovation system. Concentrations of HEIs in capitals and important cities of strong countries of EU relate to the global competitiveness. But it is more than just the number of universities it is also the connection to the innovation mindset. Not all regions are well positioned to absorb the competitive strengths of high-performance university. [2]

Nowadays the education trends are defining HEIs as leaders and designers of entrepreneurship, technology, and interactive learning. European industry and some of the governments put a higher stake on access to qualified labour, problem solving and innovation. [2]

The HEI nowadays is considered an autonomous body, being able to manage its own structure but also gravitate within the innovation system environments. The globalisation brought tertiary education closer than ever to the students, making possible for them to study and gather knowledge from university and professors on the other side of the world, hence the limitation of space was dissipated thanks to technology. In this situation the competitiveness became global, and they must find ways to attract students in their regional innovation system.

For example, the Erasmus+ Programme is one of the EU programmes enhancing innovation. With the introduction of this programme, the human capital and the innovation capacity became more known in the EU first and after outside, improving learning of digital skills, and gaining competences related to sustainable growth and cohesion. [3]

OVERVIEW OF THE ERASMUS PROGRAMME

The story of Erasmus+ Programme started in 1987, when was established as an exchange programme for higher education students. Ever since the programme took a wider shape and is evolving continuously. What started with students from 11 European countries nowadays covers all EU countries plus North Macedonia, Iceland, Norway,

Serbia, Liechtenstein, and Türkiye. And non-EU collaborations all over the globe. Romania has already some experience and tradition in European programs dedicated to learning in a transnational context, the year 2023 marking the 26th year of participation. [3,5]
The Erasmus+ Programme offers several directions into impacting the youth and the society at the same time. The focus on this article will be on Erasmus+ HEI mobility and the connection to the innovation clusters. This article summarizes the importance of Erasmus+ Programme increasing trend and the innovative character. The participation at the Erasmus+ programme is achieved through the Erasmus Charter for Higher Education application and acceptance. [3,4,5]
The Erasmus programme has contributed in many ways to the European Higher Education Area (EHEA) by stimulating internationalization and bringing value to the tertiary education. Within the Erasmus+ professionals there are defined several types of mobility depending on the characteristics. These types of mobility usually refer to students and academic staff exchanging experience at another institution in a different country than the residence one.
Within the many directions of the Erasmus+ Programme, there are two key actions which are focused on higher mobility, Key Action 1 (KA1) representing the mobility of individuals at HEI level, and its subdivisions KA103 which has transformed during the years in KA131, mobility flows among EU countries, and KA107, recently changed to KA171 mobility flows to non-EU countries. This paper tackles only the mobility at HEI level and interactions among universities. [3,4] The regions in the Erasmus programme are classified differently, there are no regions within a country but a classification of the EU countries depending on their income level and innovation status. The classification is split in three regions as it presented in Table 1.

Table 1 - E+ Country classification [3]

Group 1 Countries with higher living costs	Denmark, Finland, Iceland, Ireland, Liechtenstein, Luxembourg, Norway, Sweden. Third countries not associated to the Programme from Region 14 (Faroe Islands, Switzerland, United Kingdom)
Group 2 Countries with medium living costs	Austria, Belgium, Cyprus, France, Germany, Greece, Italy, Malta, Netherlands, Portugal, Spain. Third countries not associated to the Programme from Region 13 (Andorra, Monaco, San Marino, Vatican City State)
Group 3 Countries with lower living costs	Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia, Türkiye.

Source: Erasmus+ Guide 2023

The institutions from each country must comply with the funding rules agreed for each group. The Erasmus+ Programme offers a grant to help both student and the academic staff get more knowledge, create connection and projects among the EU partners. The characteristics of the mobility are measured using some indicators, the period of mobility (duration), the funding (grant), and human capital mobility purpose (study/traineeship/teaching/training), scope of mobility (objective). [3,5]

Table 2 - Erasmus mobility characteristics [3,7]

Characteristics	**Description**
Mobility Direction	Incoming / outgoing
Type of participants	Students / staff
Duration of the period spent	Short term (3-30 ECTS) / long term (30-60 ECTS)
Purpose of learning student mobility	Study / traineeship
Purpose of mobility staff	Teaching / training
Type of participation	Physical / virtual / mixed
Grant	Depending on the Group classification
Measuring Results	Feedback, project completion, level of competences

Source: information structured by the authors from Erasmus+ Guide 2023

Another very essential aspect in the life of the Erasmus Programme for HEI is the collaboration. The programme it relies on mutual inter-institutional agreements to create networks for exchange of students and staff.
There are many activities which enhance the innovation mindset within the Erasmus+ mobilities, from study visits, networking activities, short-term student mobility for studies, student mobility for placements, to staff mobility for teaching assignment and staff mobility for training, all of these are part of an education reality to improve the quality and efficiency. [7,8]

The Erasmus Programme is a strong framework which helps students to gain skills related to their psychological traits, gain creativity, citizenship spirit and understand social cohesion and environmental issues. The main point is to enhance creativity and innovation at all levels of education and training.
Even though each EU Member State is largely responsible for its own education and training systems and its content of teaching programmes (curricula), the Erasmus programme brings common benefits and indicators to all Erasmus+ stakeholders. [10,11]

GLOBAL INNOVATION INDEX REPORT STATISTICS

Besides the indicators offered by the Erasmus+ Programme, innovation at HEI level it is measured by the Global Innovation Index through the number of graduates, inbound mobility, R&D funding, patents and scientific research.
According to the GII report which is tracking the current state of innovation globally and ranking the innovative performance of 132 countries, there are several innovation metrics which are employed to measure the implications of academia in innovation. The indicators are structured in seven pillars of innovation capacity in the report, Institutions, Human capital and research, Infrastructure, Market Sophistication, Business Sophistication, Knowledge and technology outputs and Creative outputs. Just four of the pillars integrate indicators measuring academia national performance. Human Capital and Research, Business Sophistication and Knowledge and Technology Outputs.
Table 3 - Romania GII indicators relevant for academia in 2018-2022 [1]

Indicators	Score (Value)				
	2018	2019	2020	2021	2022
Tertiary Education					
Tertiary enrolment, % gross	48.0	48.0	49.4	51.0	51.4
Graduates in science and engineering, %	28.8	28.8	28.8	28.1	29.1
Tertiary inbound mobility, %	4.8	4.8	5.2	5.4	5.7
R&D					
Researchers, FTE/mn pop.	912.4	890.2	882.4	896.0	952.9
Gross expenditure on R&D, % GDP	0.5	0.5	0.5	0.5	0.5
QS university ranking, top 3*	13.2	0.0	7.7	7.1	0.0
Innovation Linkages					
University-industry R&D collaboration	35.7	38.7	40.9	38.2	39.5
Patent families/bn PPP$ GDP	0.1	0.1	0.1	0.0	0.1
Knowledge creation					
Scientific and technical articles/bn PPP$ GDP	11.5	10.6	12.4	14.2	15.3
Citable documents H-index	14.2	13.9	18.2	18.8	18.9

Source: GII Reports 2018-2022

Another important indicator is the top 100 GII S&T clusters worldwide, however none of the important cities or region from Romania are part of this top. Pointing out this, there can be made a positive correlation between the university performance and the cluster ranking. Bucharest it is considered a science and technology cluster according to GII, however did not made it to top 100 worldwide. Also, according to the Scimago Jornal and Country Rank for engineering, the H index in the previous 5 years (2018-2022) has not change, there index is constant 180.[9]
Hence, the importance of attracting tech partners and enhancing international collaboration which encourage and fund international scientific collaborations, exchanges, and internationalization.
The universities are considered engines of development for cities and regions and there is the need to engage young people and prepare them for the jobs of tomorrow. Through study programmes like Erasmus Mundus, Erasmus+ mobility and university alliances, RISs are formed connecting the dots between the knowledge production stakeholders (universities, R&D centres) and the business environment. [3,8]
The universities have worldwide connections, they circulate their resources and "recycle" them. These behaviours representative for the innovation systems are assimilated naturally by the universities.
There are some common characteristics of the innovation systems which are assimilated by the Erasmus+ programme structure. For example, the collaborations, in this the international partnerships, the R&D activities, and funding. Besides this there is the main beneficiary, the human capital which as main purpose has to participate in learning and R&D activities, sharing knowledge and feedback as main outcomes. [3,10]
For both of the systems, communications play a very important role, from different points of view as, forming channels of communications with the human capital and international partners, using the infrastructure to communicate and keep the connection in time and find objective for short, medium and long term to maintain the collaboration and work together.[12]

METHODOLOGY

There are few universities in Romania which are focused only on technical study. This paper aims to show the evolution of the Erasmus Programme that could be relevant for a RIS. The main indicators shown are the level of E+ funds received by the universities within the period 2018-2022, and international collaborations.
For this research was considered two types of secondary data, data provided by the EU statistical instruments, Erasmus statistics (2018-2022) and international innovation reports, and primary data provided by the database of the University POLITEHNICA of Bucharest.

The main indicators analysed, for all five technical universities in Romania, were: the Erasmus budget for 2018-2022 period, the number of up-to-date Erasmus+ Inter-institutional agreements, clustering the agreements within regions, and the number of research centres together with the fields of work. After gathering all this data, a comparison between the technical universities was made.

FINDINGS

After gathering the secondary data from the websites of the five technical universities in Romania, and understanding the context of the university environment, the data shows that during the pandemic all five universities hit the bottom point from the point of view of funding and number of mobilities.
All the five technical universities have been playing a role at local level, attracting, and shaping students to become educated engineers but also, they formed their own network of connections through partnerships and agreements. Each one of the five universities has their own research centers and grow innovative projects gaining experience through their solutions and quality educated human capital.
Both students and academic staff interact with stakeholders enabling the innovative environment. The five technical universities have different dimensions, regarding the number of students and faculties. However, there are some similarities from the point of view of study and research areas and number of E+ agreements.
Each one of the five technical universities from Romania are part of the Erasmus+ Programme, developing inter-institutional agreements based on the historic connection and present performance and international image. All five universities are located in big cities which coincide with the biggest four cities in Romania. All of them have tradition and history in educating engineers and doing research in the main field of engineering.
Table 4 - Technical university's general data [14,15,16,17,18]

Technical University	Location (city name)	Founded in	Number of faculties	Number of Research Centers	Number of students (approx.)
UTCB	Bucharest	1851	7	18	4000
UPB	Bucharest	1818	15	32	25000
UTCluj	Cluj-Napoca	1948	12	26	19400
TUIasi	Iasi	1937	11	23	16500
UPT	Timisoara	1920	10	31	13500

Source: each university's website data gathered in July 2023

UTCB - industrial and agricultural civil constructions, hydromechanics, railways, roads and bridges, installations, technological equipment, geodesy, and faculty of engineering in foreign languages. [14]

UPB – electrical, energy, automation and computers, electronics, telecommunications and information technology, mechanics and mechatronics, industrial engineering and robotics, biotechnical systems engineering, transports, aerospace, material science and engineering, chemical engineering and biotechnologies, faculty of engineering in foreign languages, applied sciences, medical engineering, entrepreneurship, engineering, and business management. With 20 major technical fields in foreign languages: English, French and German. [15]

UTCLUJ - automation and computers, architecture and town planning, electrical engineering, electronics, telecommunications and information technology, constructions, installations, material and environment engineering, transports, industrial engineering and robotics, sciences, and letters. [16]

TUIASI - include the main fields of study in the field of engineering, such as automation and computers, electronics and electrotechnics, civil constructions and installations, textiles and leather, chemical engineering and environmental protection, mechanics, hydromechanics, machine constructions, material science and engineering, and architecture. [17]

UPT: architecture and town planning, automation and computers, chemistry and environment engineering, constructions, electronics, telecommunications and information technology, electrical and energy engineering, production management and transports, mechanics, and communication sciences. [18]

All universities offer study and research programs in Romanian and in several foreign languages, as English, French, German. Thie allowed them to build a strong database of international university collaborations and benefiting from the

Erasmus+ funds. In the past five years the number of KA1 projects funded kept a positive trend, as seen in Figure 1, beside the year 2021 where the pandemic situation had clear consequences. Both the students and academic staff interacted less and less with the mobility idea because most of the activities moved to mostly the digital environment.

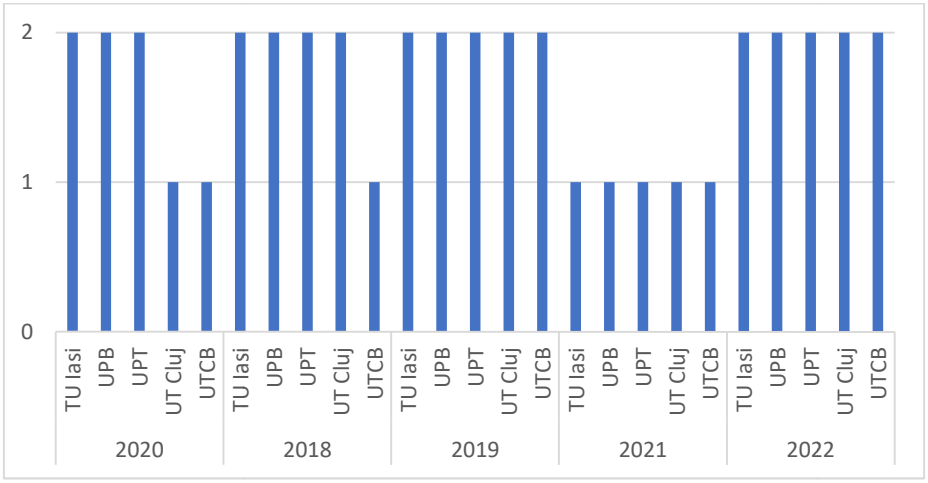

Figure 1 - Erasmus+ KA1 projects 2018-2022

Regarding the budgets received by the universities, there can be depicted a positive trend since 2018, with a small gap in 2021. After the pandemic the Erasmus+ programme started to be back on track, participants increasing their numbers. Hence mobility flows for both EU and Non-EU have increased and funding also.

For example, UPB had a small decrease funds absorption in 2021, the peak of the pandemic period, however in 2022, the funds increased and recovered the gap from 2021, as seen in Figure 2. Regarding the other universities, they have different evolutions. For example, UTCB, has oscillated from 2019 with the highest fund received, to 2020 when they did not apply for any E+ grant, back to 150 000 euros received in 2022.

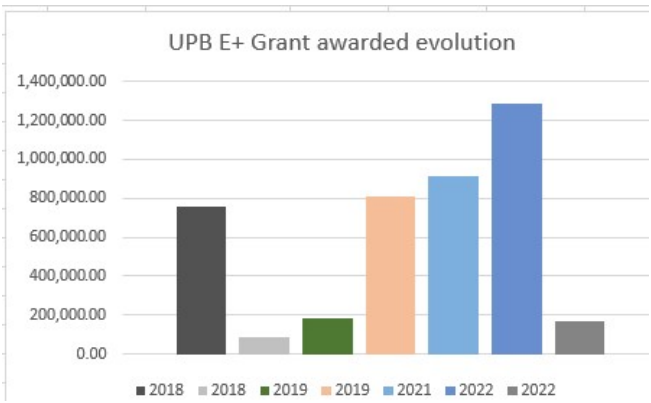

Figure 2 - UPB E+ grant awarded evolution

UPT had a peak of grant absorption in 2019, UTCluj had a similar trend with UPB, in the past three years, and TUIasi was constant and is showing an increase of the funding projects in 2022.

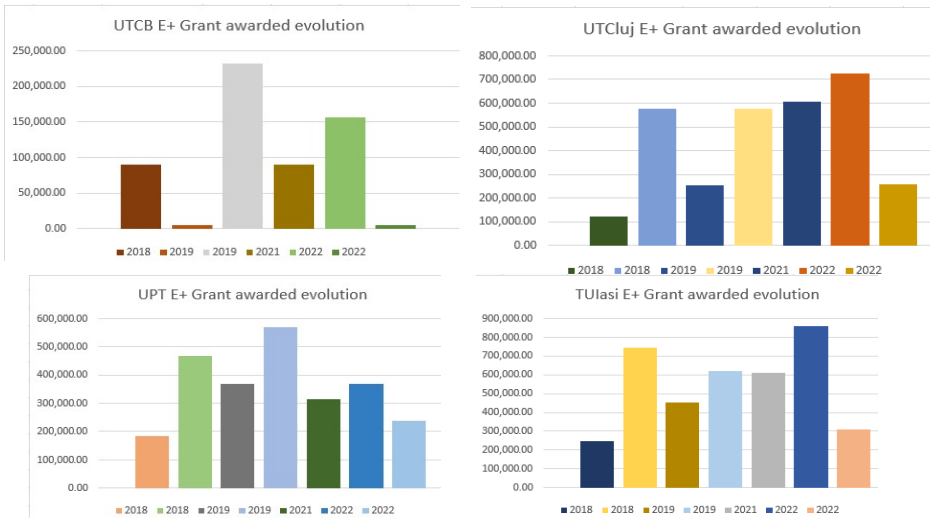

Figure 3 - E+ grant trend 2018-2022

If the budget and the funding had some fluctuations over the years, that shows how the programme and the innovation systems are affected by the external factors influencing the global economy, how was in the case of the pandemic which hit in 2022. The access to funding is framed by the opportunities from the market at that certain time. The innovation system components are affected by it as any other economy component. Even though the education systems, the university are usually more stable than the business environment this depends on the type of external factor influencing at that time. For example, during the 2020 pandemic in the search of fighting the virus many technological breakthroughs had to do with the medical field, other had to do with the digital work procedures other had to do with the pharmaceutical industry. Therefore, in time of crisis, the science and technology knowledge, the engineering and researcher are essential to advance and find solutions.

This is why partnerships are very important, they are considered a center aspect of an innovation system, the bridge of collaboration between the stakeholders. In the case of the E+ agreement, the analysis was made on the latest version of the collaboration databases. The process of handling the agreements in the academic world is very fluid by the point the agreement is signed by the parties involved. In the case of the Erasmus+ inter-institutional agreements for KA1, there are always two parts involved, both must be accepted and recognized with the E+ charter. After the agreement is negotiated and the human capital involved establishes their objectives about the certain agreements, the agreement is signed and is usually valid for all the period of the Erasmus program in progress.

In 2023 according to the secondary data gathered from the technical universities and from the database of UPB, the situation is as presented in Figure 4. Compared with the number of organizational units (faculties) found in each university, the E+ inter-institutional agreements can show a positive relation with the total number of faculties or research centers.

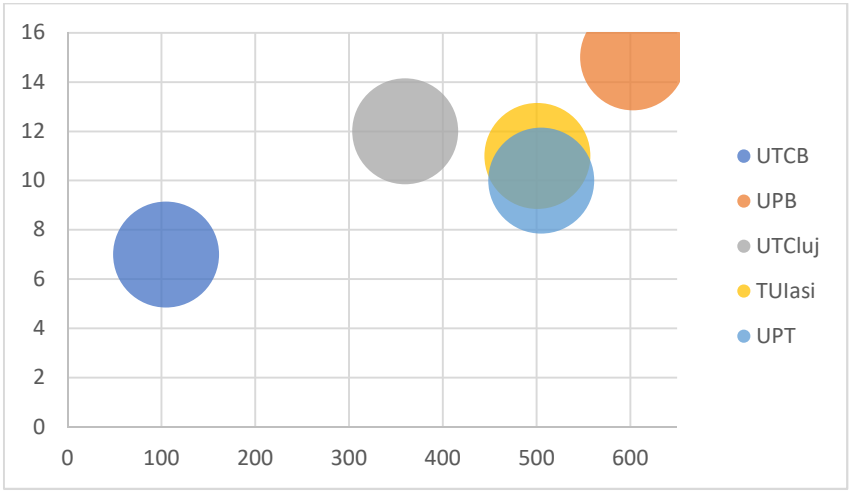

Figure 4 - Technical universities E+ Inter-institutional Agreements July 2023 [18,19,20,21]

Going back to the classification of the countries and the agreements clusters, all five technical universities from Romania touch all regions. With more than 600 agreements UPB covers 20 fields of study, 30 of research and 15 faculties. UTCB covers fields of engineering in 7 faculties and 18 research centres with over 100 agreements. UTCluj has over 350 agreements within the field of engineering mostly but also letters. With 11 faculties, TU Iasi has a quite big number of agreements compared with the number of faculties, about 500 agreements, and 23 research centres. And UPT with the smallest number of students among the technical universities, has 505 agreements, 10 faculties and 31 research centres.

As a general trend there is a lower number of agreements for Group 1 which involved the northern region of Europe, and it covers depending on the university from 2% to 15% of the total E+ inter-institutional agreements. The agreements from the other two groups filling the rest of the collaborations and presented in Figures 5,6 and 7.

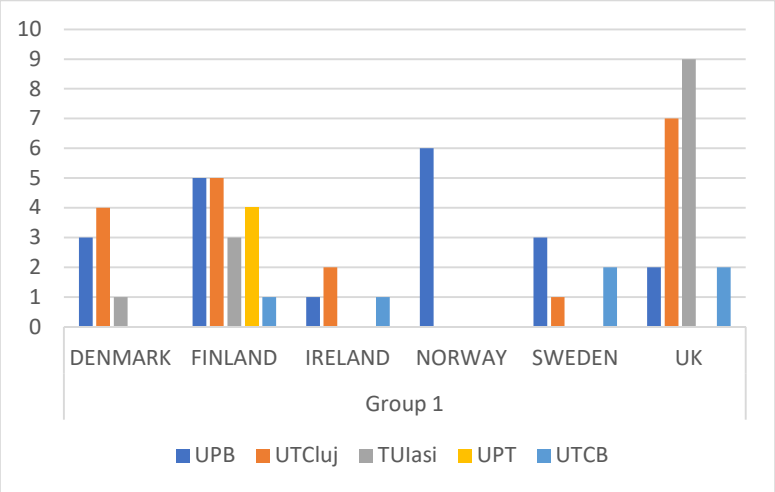

Figure 5 - Distribution of E+ agreements Group 1 [18,19,20,21]

The technical Romanian universities have the closest Collaboration with the universities from Group 2, including countries as France, Italy, Germany, Greece, Spain and so on. There is still a tight connection with the institutions from France, at least in academia, for example UPB has around 140 agreements with universities and engineering schools from all over the country, and close by is also TUIasi with more than 100 agreements. Then there are the connections with Spain, Italy and Portugal, for all five universities showing a tight connection with the Latin world. And Germany is considered an important partner, UPT having the highest number of agreements with universities from Germany.

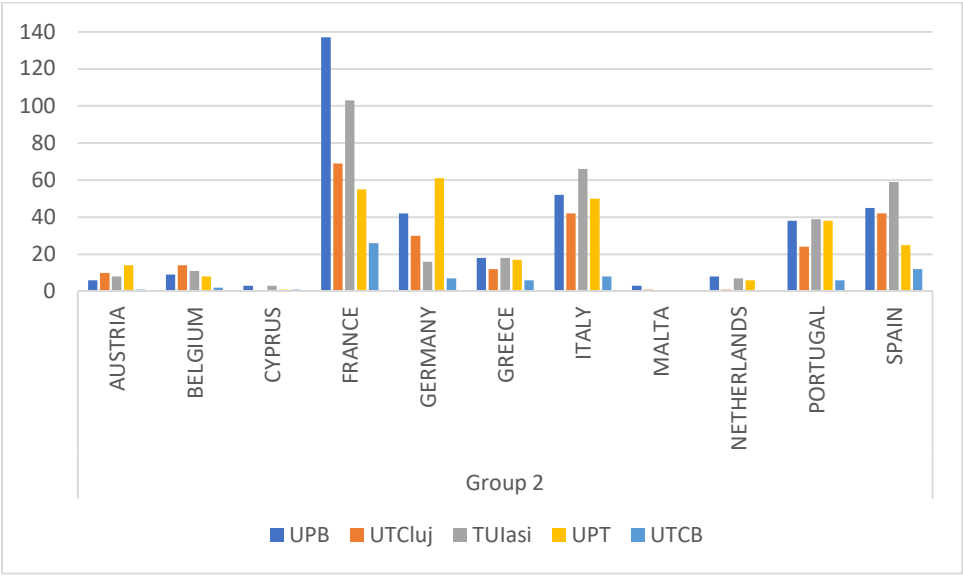

Figure 6 - Distribution of E+ agreements Group 2 [18,19,20,21]

Depending on the distance and regional conenctions, there are some important aspects to mention, for example UPB has a higher number of agreements with Bulgaria, then the other universities which are further away from the south of Romania. Therefore, UTCluj and UPT have a tighter connection with institution from Hungary. Also, UPT has a better

connection than the other with Serbia and Lithuania. Poland is another destination with tight connections with all technical universities from Romania, oscillating between 30-40 each. And even though is not part of the EU, Türkiye is partner country in the Erasmus+ Programme, and one of the most active countries in collaborating with European universities. All five technical universities have connection with the Turkish academia. However, UPB, UPT and TUIasi have significant number of agreements with universities from Türkiye.

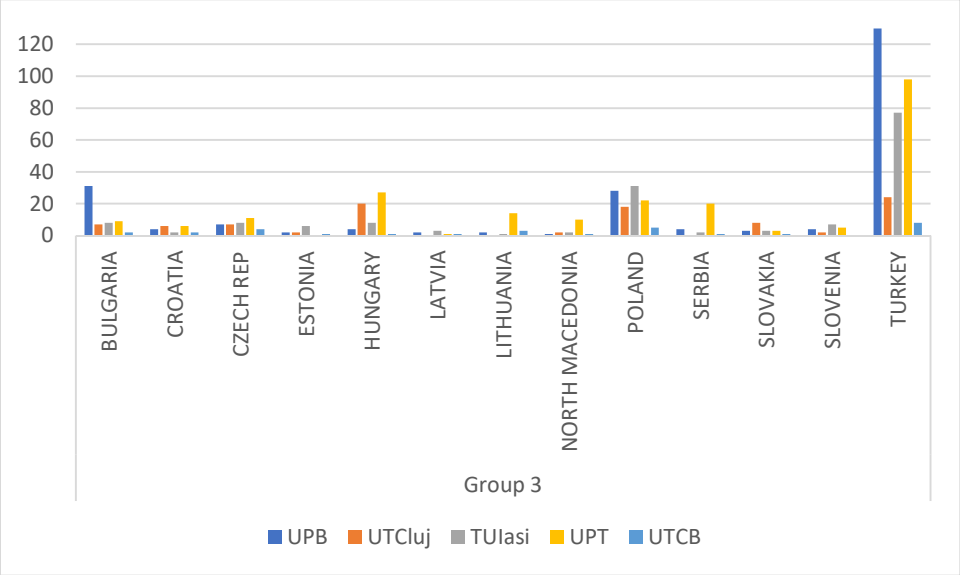

Figure 7 - Distribution of E+ agreements Group 3 [18,19,20,21]

CONCLUSIONS

The paper tackles the Erasmus+ programme HEI trends regarding the innovation systems characteristics. The regional innovation systems emphasize the attention given to the economic role of knowledge. [7] In Table 5 is presented a short intersection of the knowledge flow indicators from RIS with HEI Erasmus programme.

Table 5 - Knowledge flows RIS-HEI Erasmus+

Knowledge flow	Indicator	
	RIS	HEI Erasmus+
University – R&D centres	Citable documents H-index	Research mobilities for PhD and master students
	Publications analysis	
	University-industry R&D collaboration	Placement/training mobilities
	University annual reports	
University – business environment	University ranking	Inter-Institutional Agreements
	Number of collaborations with the stakeholders	Placement mobilities
	Companies' surveys	EU feedback report
Academic staff/student mobility	University reports	Study/teaching mobilities outbound
	Individual evaluation	Study/teaching mobilities inbound
	Annual evaluation	ECTS recognition

Source: adapted from Tables 2 and 3

The international collaboration in academia is very useful to create networks of professionals which could form working teams and start research projects together, new courses and even study programs. The Erasmus+ programme at HEI level is one of the main frameworks which oblige the participant to interact with specialist and create a pool of human capital.

The collaboration had by the five technical universities from Romania are following some patterns, can be emphasized that the proximity of countries can increase the interactions between universities, for example, Romania and Bulgaria, because UPB is situated in Bucharest. Another pattern could be related to related to the number of faculties and number of research centres. As bigger is the size of the university, as much the number of agreements is higher than universities that have less faculties but similar size.

All in all, the distribution of the agreements for all five technical universities are not distributed equally among the three groups of countries. And this shows the big impact it has the level of income between different countries in EU.
The main contributions of this paper are related to the assimilation of HEI Erasmus+ programme as being part of the RIS, and the data analysis and interpretation. As limitations the secondary data available was useful for an analysis that barely presented generally the topic, and a more detailed insight of the mobility flows for each university would have be useful to dimension even better the implication of the Erasmus+ programme in RIS.

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