# Erasmus+ Programme: a social network analysis study of the 2014-2019 exchanges

Academic Year 2021/2022
University of Padova

**Social Network Analysis:** Martina Cavallanti, Anna Giambarda, Rachele Regina, Anna Stella
**Network Science:** Filippo Bragato, Nicola Dal Bello, Elia Dallapellegrina, Giovanni Donghi, Tommaso Lotta, Gianmaria Ventura

# Overview:


01 Introduction

02 Literature review

03 Data and Analysis

04 Country Analysis

05 Institutions Analysis

06 Italian Institutions Analysis

07 Fields of study Analysis

08 Communities

09 Conclusion

# 01.
# INTRODUCTION

**EUROPEAN**
Higher Education Area

The circulation of students, teachers and staff constitutes **directed** and **weighted** networks that connect institutions and countries.

In the academic year 2013–2014 there were **272.497 students** in **34 countries** who take part in Erasmus student mobility for studies (SMS) or student mobility for practice (SMP).

This project will be focused on **five academic years only**, in the period 2014-2019, not taking into account the year 2020 in which the Covid-19 pandemic began.

The analysis will be based on a **dataset** which contains the raw data for Erasmus+ mobility for students and staff concerning various fields ( e.g age, gender, duration, field of study area, level of, sending and receiving country, etc).

# 02.
# LITERATURE REVIEW

The concept of *brain circulation* is introduced

(FINDLAY, STETWART AND LOWELL, 2004; KNIGHT, 2012)

Positively influence the economy in their country of origin through skills transfer upon return or can produce opportunities for renovation and multinational cooperation from abroad.

(RUIZ, 2014; HAN ET AL. , 2015)

«Countries with a higher income receive more students than those with a lower income»

(MACRANDER, VÖGTLE AND OTHER AUTHORS)

Shields identified that there is a strong connection between developing territories and the growth of student mobility.

(SHIELDS, 2013)

Considering culture and language as the motivation for the choices of trading countries

(SHIELDS, 2013; BARNETT ET AL. , 2016)

The importance of the linguistic component has decreased, leaving room for curiosity. The geographic distance also represents an element of great importance in terms of choosing the arrival country.

(KONDAKCI ET AL. , 2018)

Professor Otero writes about the socio-economic background

(SOUTO-OTERO (2008)

# 03.
# DATA AND ANALYSIS

# Main metrics

In and out degree

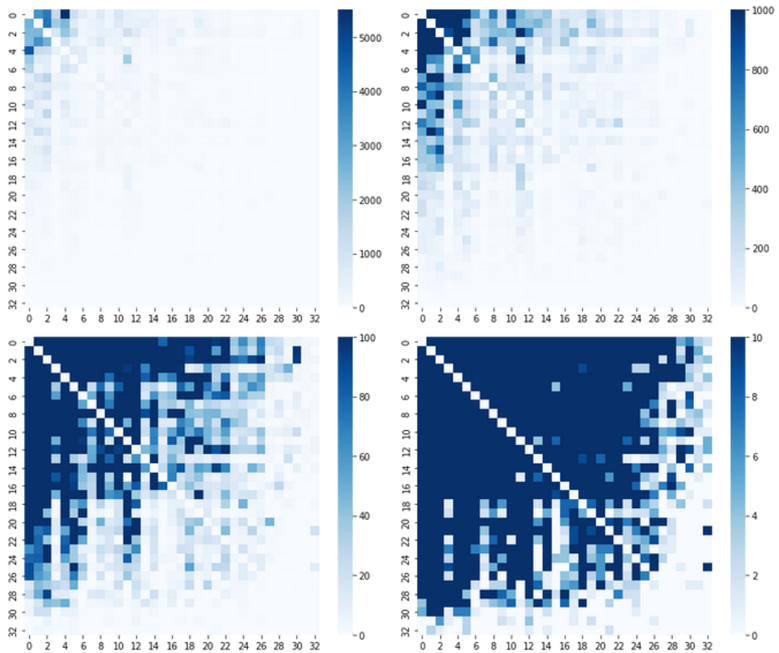
PageRank Score

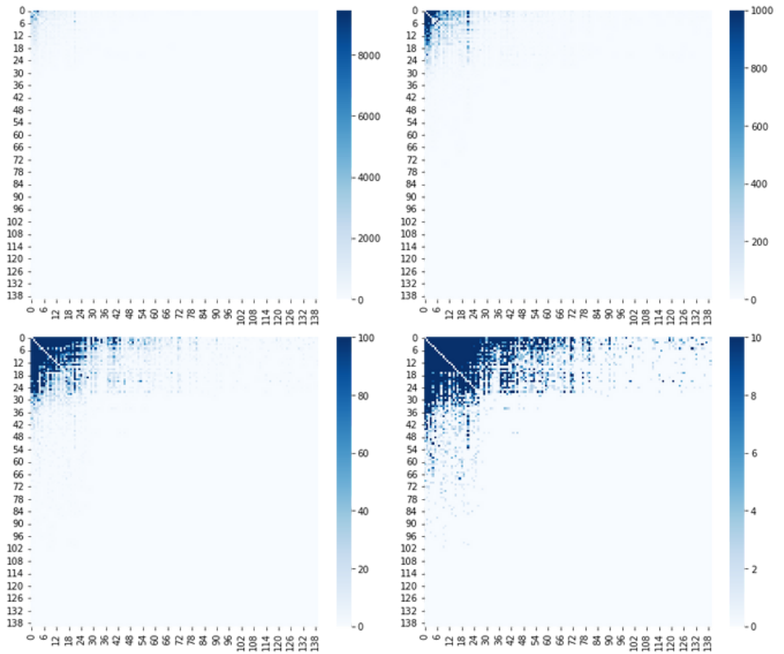
HITS score

Assortativity

Robustness

# Erasmus+ over the period 2014-19





# 04.
# COUNTRY ANALYSIS

# Research questions

In order to analyze the trends on Erasmus+ study exchanges we have decided to focus our studies starting from a macro perspective, therefore, from the original dataset, we created a network where nodes are corresponding to the countries involved in the exchanges and edges are taken as the shifts of students from one state to another.

01 What is the general state of the network of mobilities between countries?

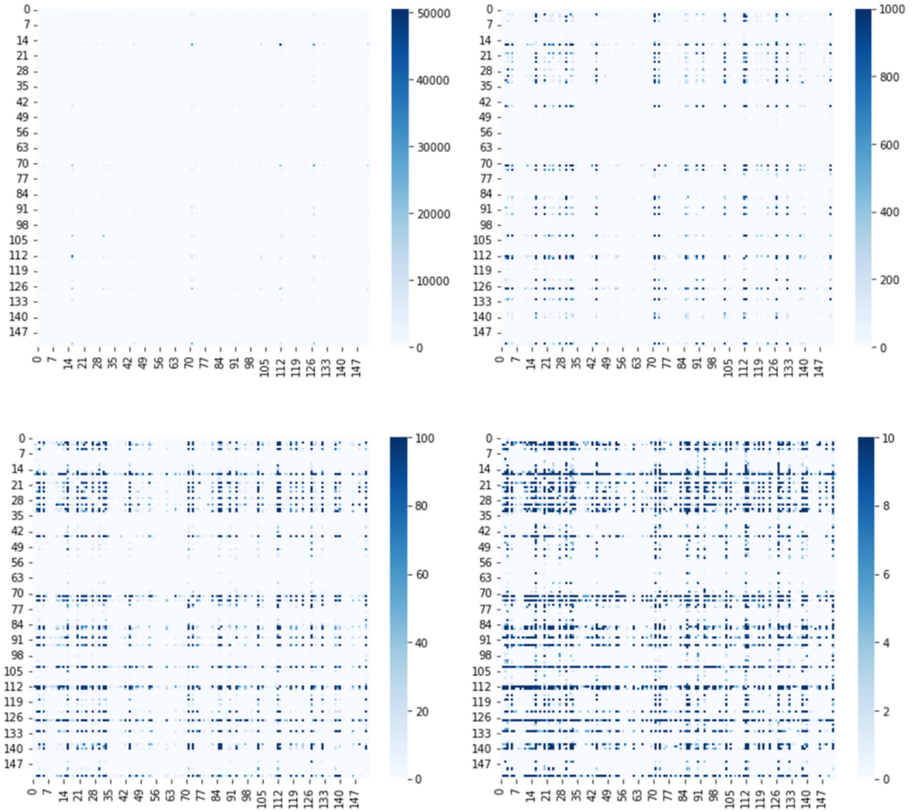
02 Which are the most central countries in the network?

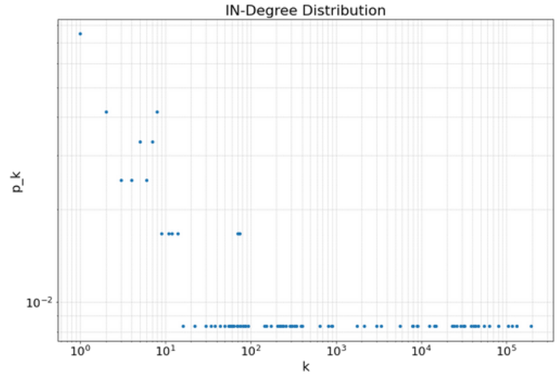
03 Do countries with many links tend to connect with equally linked countries?

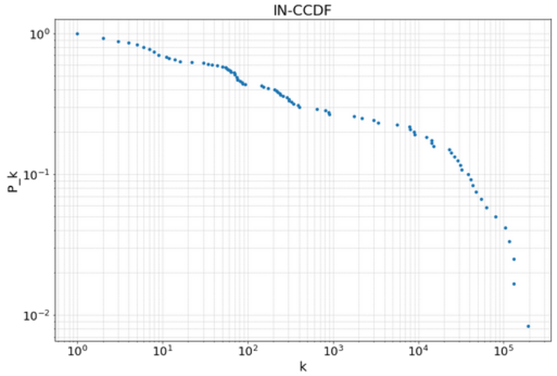
04 According to PageRank hub vs authority scores, can we define whether a country is a sender or a receiver?

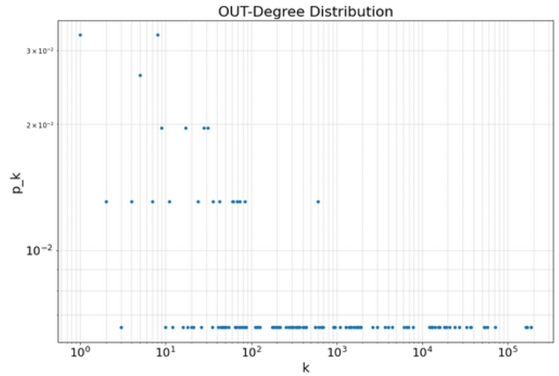
05 Does the size of the country influence its role in the network?

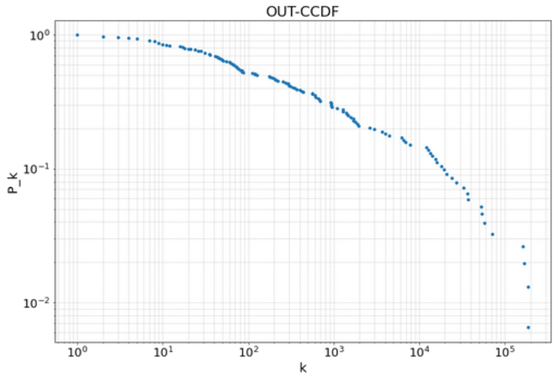
# Countries' Network & Degrees





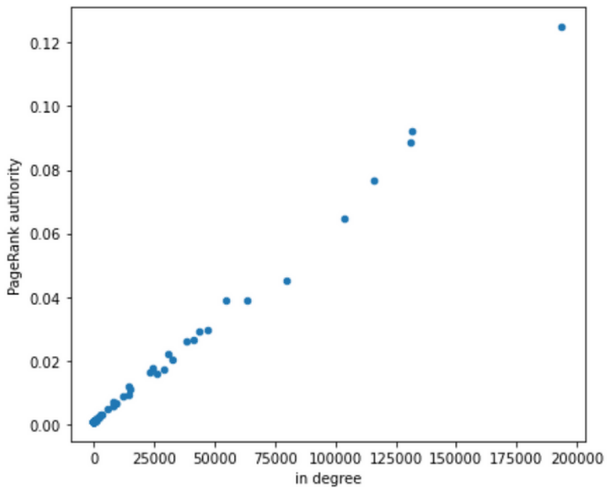



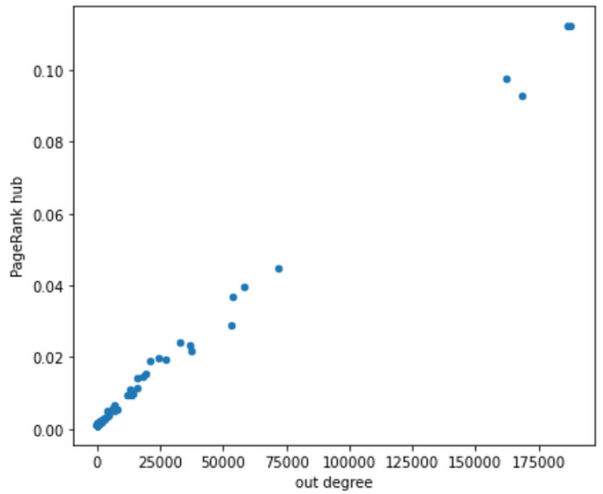



# PageRank

***PageRank authority vs in-degree***



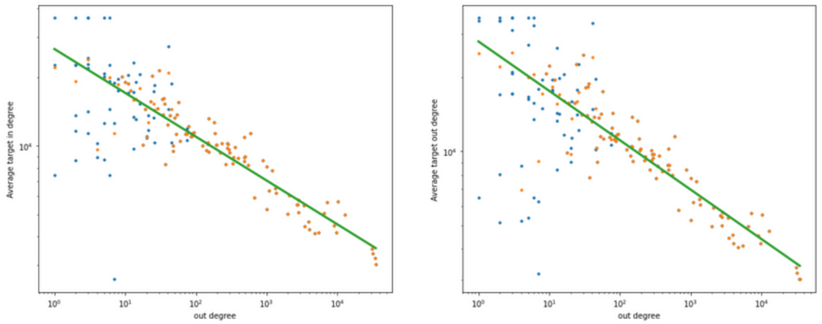

***PageRank hub vs out-degree***

**TOP 10 PAGERANK AUTHORITY**

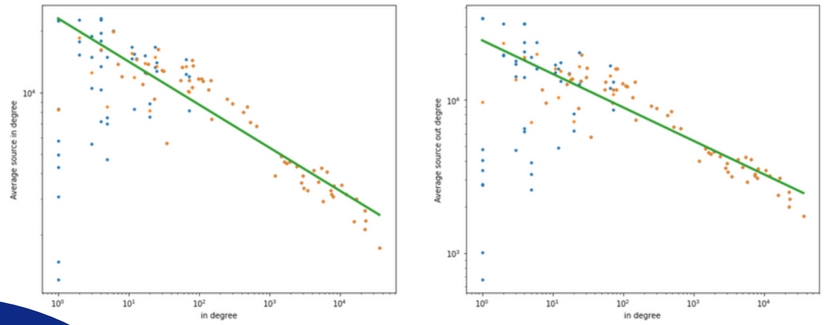
| | Authority | Hub | in-degree | out-degree |
|---|---|---|---|---|
| SPAIN | 0.124829 | 0.112138 | 193628 | 186670 |
| GERMANY | 0.092253 | 0.112125 | 131451 | 187627 |
| FRANCE | 0.088529 | 0.092776 | 130821 | 168162 |
| ITALY | 0.076540 | 0.097475 | 116180 | 162235 |
| UK | 0.064553 | 0.036884 | 103962 | 53862 |
| POLAND | 0.045153 | 0.039472 | 79774 | 58299 |
| PORTUGAL | 0.039174 | 0.023171 | 63268 | 36678 |
| NETHERLANDS | 0.038861 | 0.028761 | 54828 | 53340 |
| SWEDEN | 0.029709 | 0.015339 | 47028 | 19337 |
| CZECHIA | 0.029178 | 0.024009 | 43532 | 32912 |

# Assortativity

***Average target degrees vs out degree 2019***




***Average source degrees vs in degree 2019***

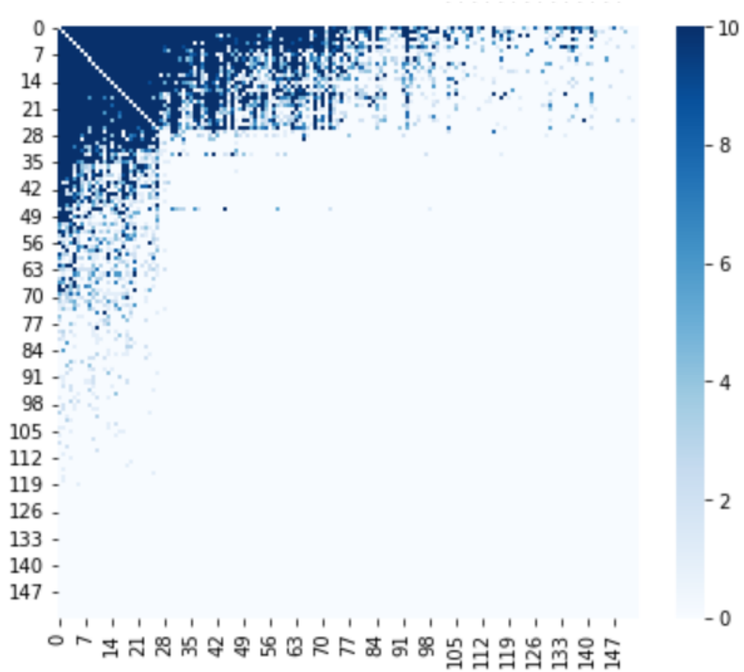



***Assortativity coefficients 2019***

| $\mu_{in,out}$ | $\mu_{out,out}$ | $\mu_{in,in}$ | $\mu_{in,out}$ |
|---|---|---|---|
| -0.1919 | -0.2010 | -0.2114 | -0.2185 |

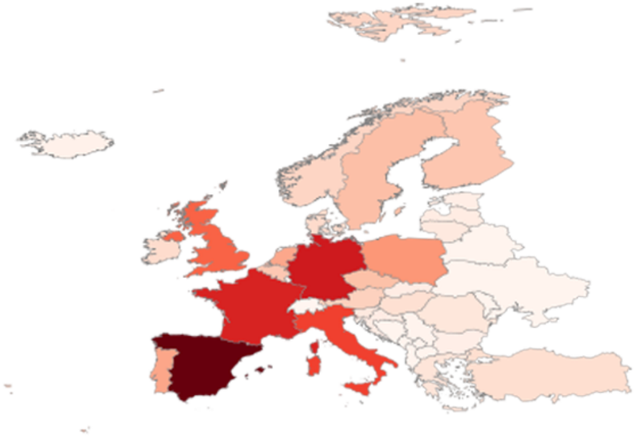
***Assortativity coefficients 2015***

| $\mu_{in,out}$ | $\mu_{out,out}$ | $\mu_{in,in}$ | $\mu_{in,out}$ |
|---|---|---|---|
| -0.0956 | -0.1076 | -0.1268 | -0.1215 |

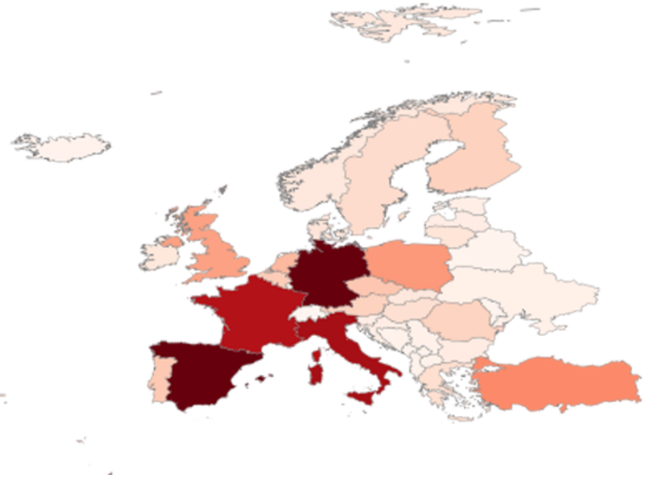


# Geographic visualizations

***PageRank-based geo-heatmap - authorities***



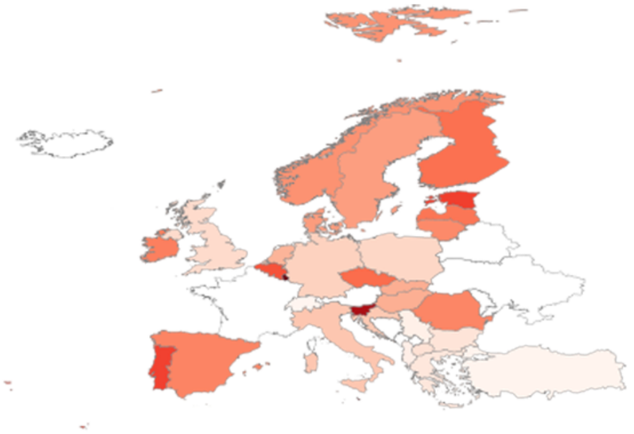
***PageRank-based geo-heatmap - hubs***



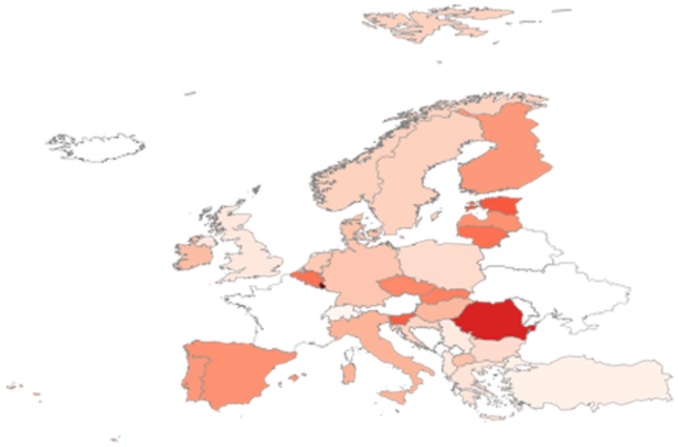
**weights**

based on 2016 enrollments in
ISCED 5,6 and 7 educational levels

***PageRank-based geo-heatmap - authorities (weighted)***



***PageRank-based geo-heatmap - hubs (weighted)***



# Answers to research questions

## 01

What is the general state of the network of mobilities between countries?

- A rich network, in constant growth (more countries join + mobility flows increase);
- Gap in the participation in the network between big and small countries;
- Smaller countries are still able to contribute to the network.

## 02

Which are the most central countries in the network?

Biggest countries are also the most central countries:

- Spain
- Italy
- UK
- Poland
- Germany
- France
- Turkey

## 03

Do countries with many links tend to connect with equally linked countries?

- **Disassortative** network: few links between nodes of similar degree;
- As time progresses, the network tends to be **more disassortative**: hubs are more likely to link with nodes with lower degree measures.

## 04

According to PageRank hub vs authority scores, can we define whether a country is a sender or a receiver?

- Highest ranking countries (Germany, Italy, France, the UK, Poland) are both good senders and good receivers;
- Spain is a particularly good **receiver**;
- Turkey is a particularly good **sender**.

## 05

Does the size of the country influence its role in the network?

- Bigger countries occupy central places in the network;
- According to weighted PageRank scores, smaller countries (Malta, Luxembourg, Liechtenstein, Slovenia, Estonia etc) seem to have similar mobility flows to those of bigger countries;
- According to the disassortative nature of the network, smaller countries are still able to be well-connected in the network.

While in absolute terms the **size of a country** influences its role in the network, **it does not prevent the country from occupying a relevant role in the network,** especially when relative measures are employed.

# 05.
# INSTITUTIONS ANALYSIS

# Research questions

01 How many components are there in the network?

02 Do all universities interconnect between themselves?

03 Which universities are the most connected ones?

04 On average, how many connections are there between the universities?

05 How are the connections distributed?

06 Which universities are the most centred?

07 Do most connected universities tend to connect with other universities with similar connections?

# Institutions Analysis

We have model the network as a directed graph, differentiating between sending and receiving institutions, setting the organizations as nodes and the edges's weight as the total number of participants in the exchange.

**NETWORK STRUCTURE STATISTICS**

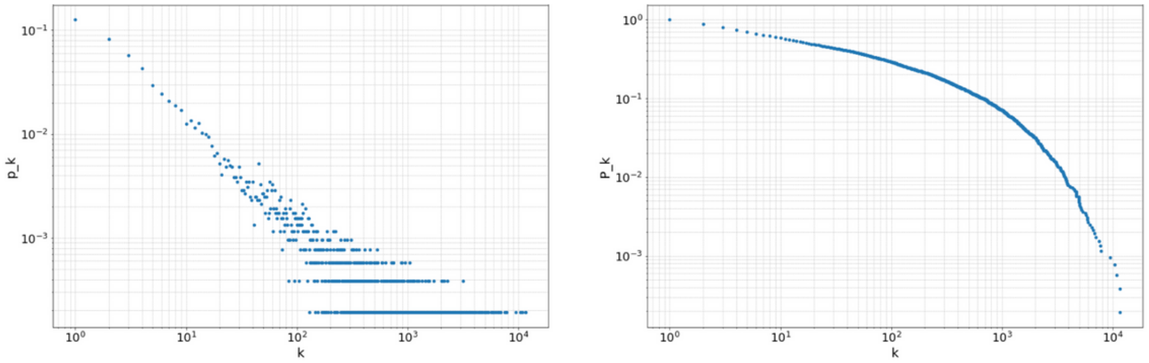
| Nodes | Edges | Avg. Degree | Density |
|---|---|---|---|
| 7140 | 1324895 | 185.56 | 0.0260 |

We obtain a disconnected graph, with a giant component and a few isolated components.

The giant component is a weakly connected graph.

# Degrees

***In Degrees Distribution***



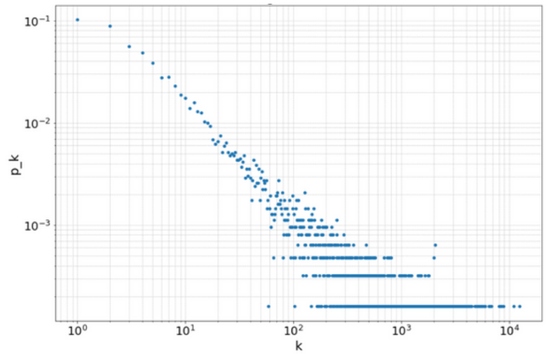


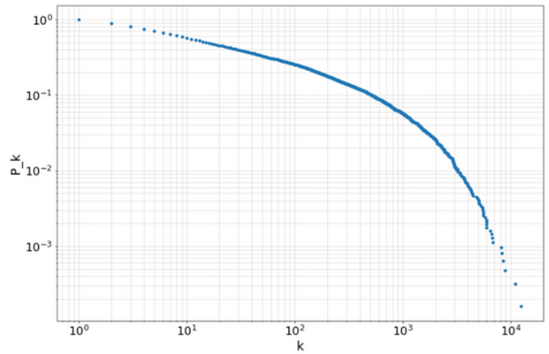


**TOP 5 IN-DEGREE**

| | |
|---|---|
| UNIVERSITAT DE VALENCIA | 11611 |
| UNIVERSITA DI BOLOGNA | 11540 |
| UNIVERSIDAD DE GRANADA | 10809 |
| UNIVERSIDADE DE LISBOA | 10424 |
| UNIVERSIDAD COMPLUTENSE DE MADRID | 9414 |

***Out Degrees Distribution***




**TOP 5 OUT-DEGREE**

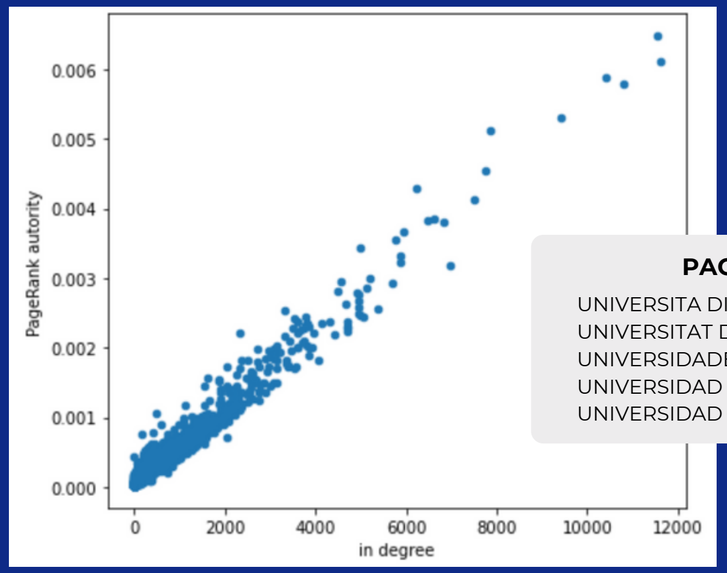
| | |
|---|---|
| UNIVERSITA DI BOLOGNA | 12477 |
| UNIVERSIDAD DE GRANADA | 11026 |
| UNIVERSITAT DE VALENCIA | 8866 |
| UNIVERSIDAD COMPLUTENSE DE MADRID | 8467 |
| UNIVERSITA DEGLI STUDI DI PADOVA | 8302 |

*We can say that our network has the scale-free property.*

# HITS & PageRank

- The more a university receives Erasmus students the more it will have a higher authority score.
- On the other hand the more a university promotes the Erasmus project and encourages students to practice it, the more it will have a high hub score.

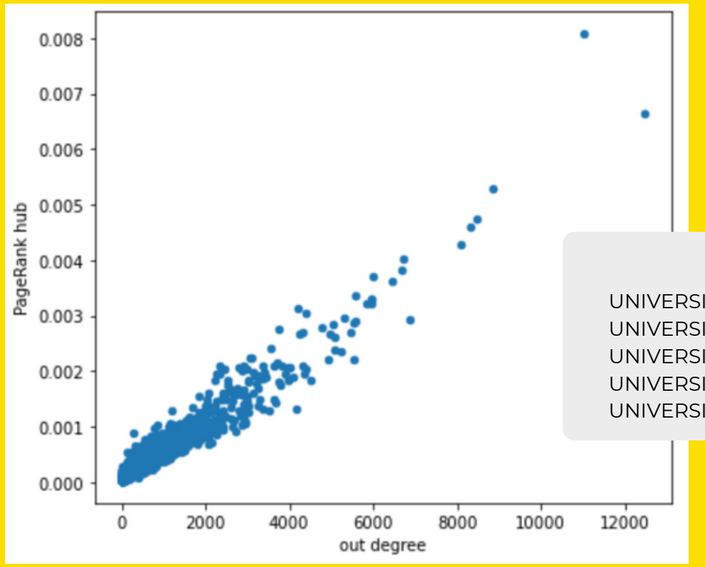
***PageRank Authorities vs In Degree***




**PAGERANK AUTHORITIES**

| | |
|---|---|
| UNIVERSITA DI BOLOGNA | 0.006472 |
| UNIVERSITAT DE VALENCIA | 0.006109 |
| UNIVERSIDADE DE LISBOA | 0.005881 |
| UNIVERSIDAD DE GRANADA | 0.005778 |
| UNIVERSIDAD COMPLUTENSE DE MADRID | 0.005299 |

***PageRank Hubs vs Out Degree***



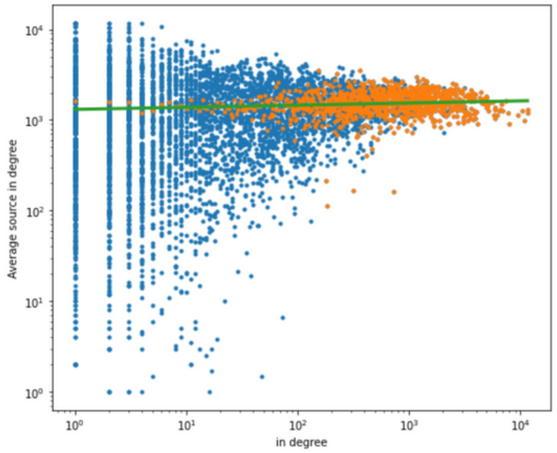

**PAGERANK HUBS**

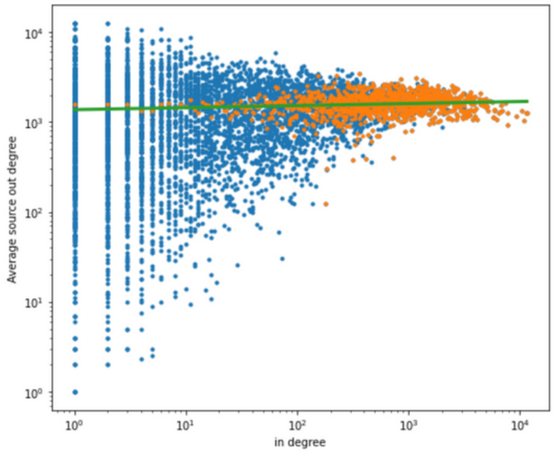
| | |
|---|---|
| UNIVERSIDAD DE GRANADA | 0.008073 |
| UNIVERSITA DI BOLOGNA | 0.006650 |
| UNIVERSITAT DE VALENCIA | 0.005288 |
| UNIVERSIDAD COMPLUTENSE DE MADRID | 0.004742 |
| UNIVERSITA DEGLI STUDI DI PADOVA | 0.004606 |

# Assortativity Analysis

Assortativity analysis (degree of homophily) in order to understand how much a university tends to have exchanges with another with the same degree and to avoid those with a different degree.

***Average degrees vs in degree***

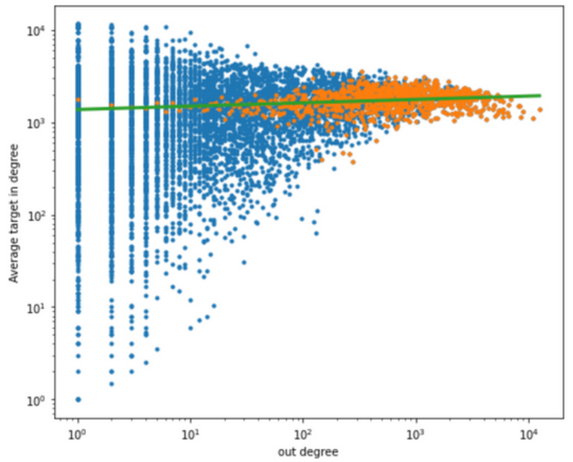


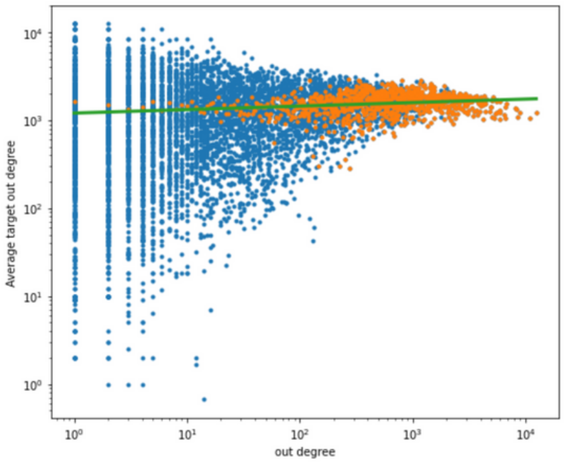




***Assortativity coefficients***

| $\mu_{in,out}$ | $\mu_{out,out}$ | $\mu_{in,in}$ | $\mu_{in,out}$ |
|---|---|---|---|
| 0.0364 | 0.0398 | 0.0234 | 0.0226 |

***Average degrees vs out degree***



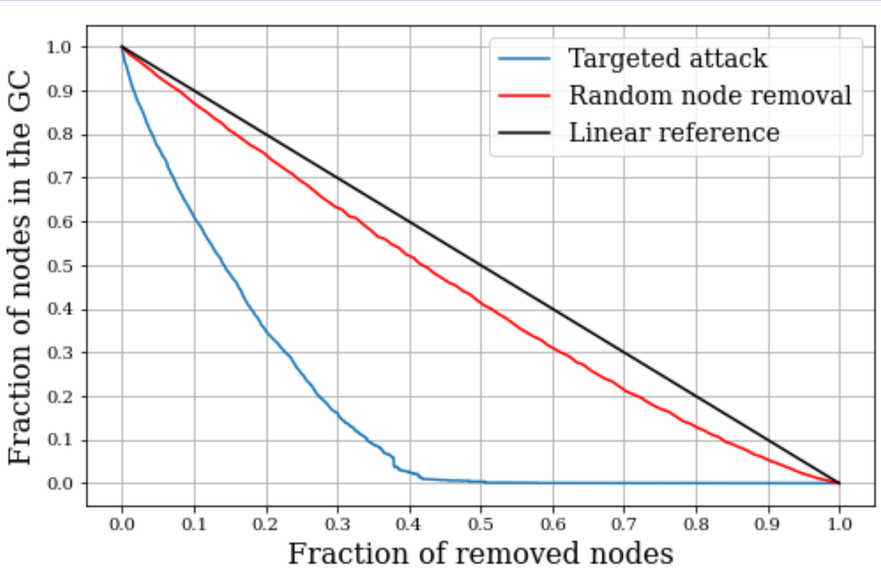




We can consider our network as a **neutral network** as there is no clear behavior.

# Robustness

We wanted to test the ability of the network to survive the removal of some of its nodes.

***Robustness of the network***

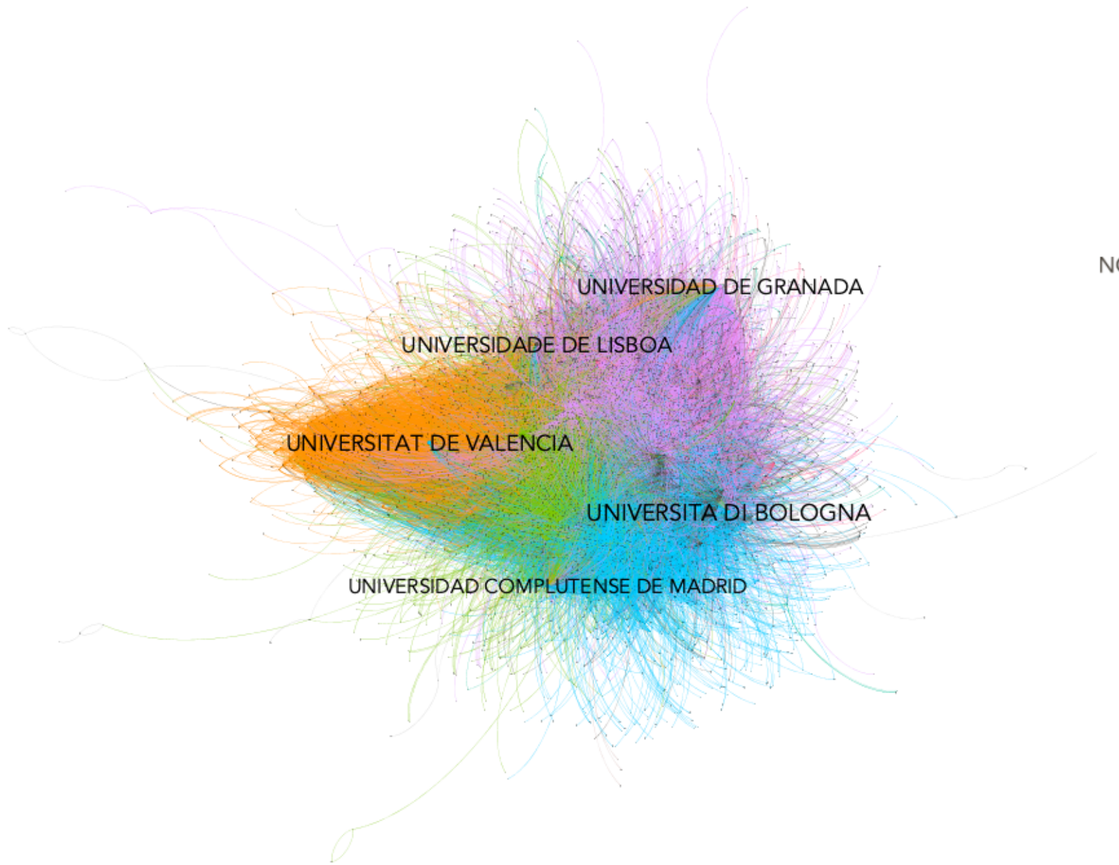



We took into account:
- **Robustness to random node removal;**
- **Robustness to attacks.**

We can see that the network is extremely robust to random node removal, confirming the breaking point *fc* close to 1.

It is much more vulnerable to targeted attacks due to the presence of large hubs, with a breaking point that in this case is *fc*≈0.4.

# Modularity, gephi representation




# Answers to research questions - pt. 1

01 How many components are there in the network?

Our analysis took into account a total amount of 7 140 organizations in the network, of which 27% do not receive incoming students, consequently owning an in-degree equal to zero.

02 Do all universities interconnect between themselves?

03 Which universities are the most connected ones?

Considering the aspect of **in-degree**, the most connected universities in Italy are:

- Universitat de València
- Alma Mater Studiorum Università di Bologna
- Universidad de Granada
- Universidade de Lisboa
- Universidad Complutense Madrid

Considering the aspect of **out-degree**, the most connected universities in Italy are:

- Alma Mater Studiorum Università di Bologna
- Universidad de Granada
- Universitat de València
- Universidad Complutense Madrid
- Università degli Studi di Padova

04 On average, how many connections are there between the universities?

The average degree of connections between the institutions is equal to 185.56.

# Answers to research questions - pt. 2

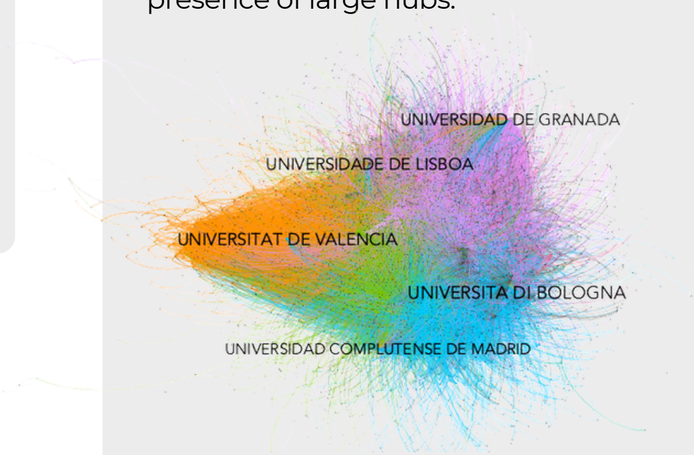
How are the connections distributed? **05**

From the top 5 rankings, we can notice how both Spanish and Italian universities dominate the list, having Bologna University as the most connected one, when the total of in and out degrees is taken into account.

Which universities are the most centred? **06**

- The more a university receives Erasmus students the more it will have a higher authority score.
- The more a university promotes the Erasmus programme and encourages students to practice it, the more it will have a high hub score.

Our network is characterized by the presence of large hubs.




Do most connected universities tend to connect with other universities with similar connections? **07**

Since the calculated slopes μ in the assortativity analysis are all positive values but are not large enough to confirm an assortative attitude, it refutes our research question of most connected universities tend to connect with other with similar connections.

# 06.
# ITALIAN INSTITUTIONS ANALYSIS

# Research questions

01

Which are the more connected Italian institutions?

02

Do bigger institutions use to connect to equally big institutions?

03

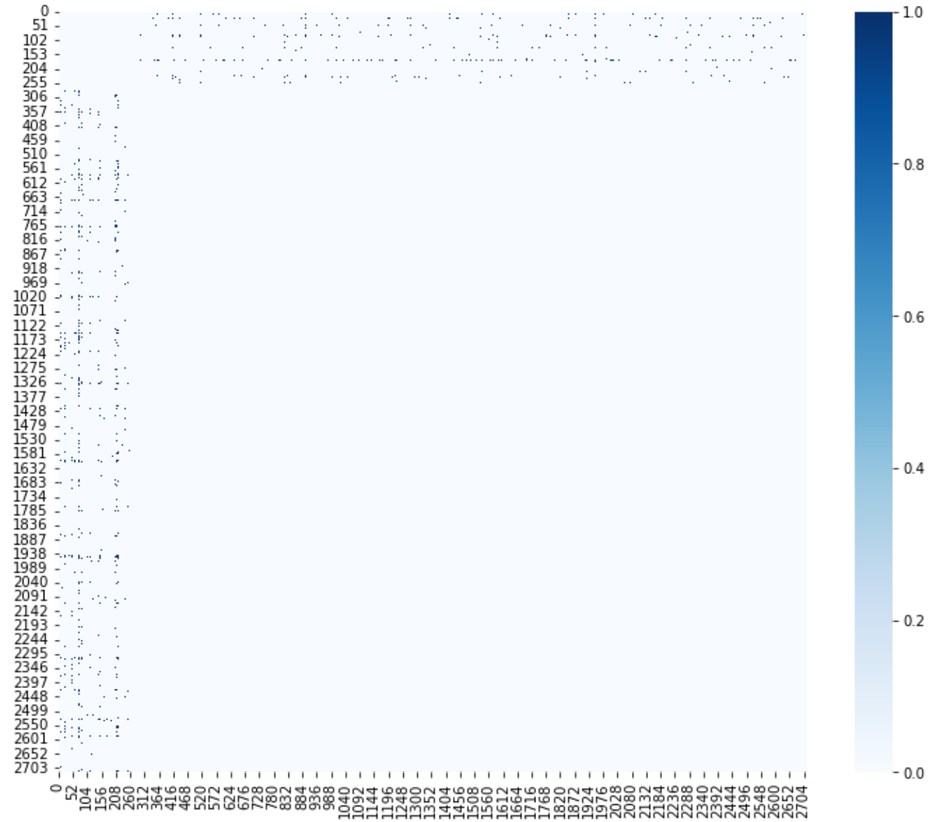
Is there a difference between the mobility of institutions located in the North of Italy versus those in the South?

04

What is the role of Italian institutions in the European Erasmus+ network?

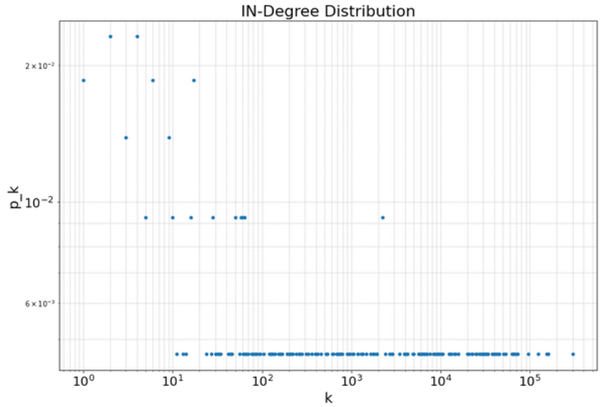
# Our network

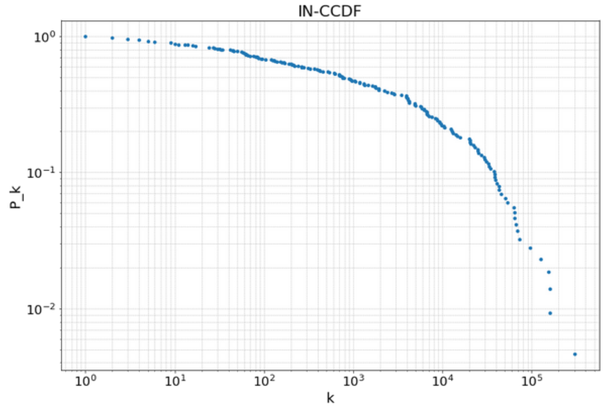
- Erasmus exchanges 2014-2019
- Bipartite graph
- Italian sending institutions vs Italian receiving institutions
- #sending = 241
- #receiving = 220



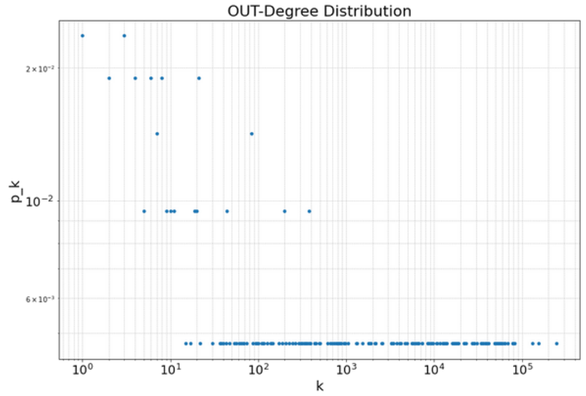
# Degree

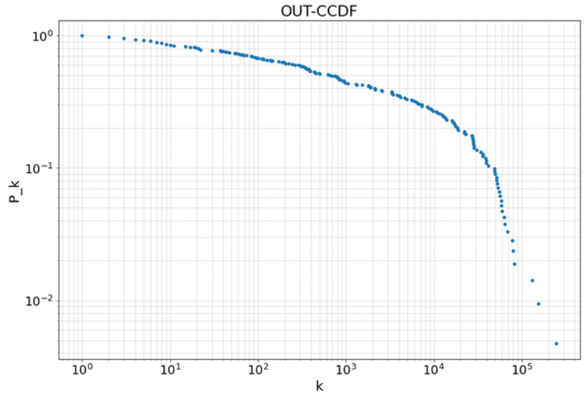
***In Degree Distribution***




***Out Degree Distribution***




**TOP 5 IN-DEGREE**

| | |
|---|---|
| UNIVERSITA DI BOLOGNA | 301706 |
| POLITECNICO DI MILANO | 160089 |
| UNIVERSITA DEGLI STUDI DI PADOVA | 159396 |
| UNIVERSITA DEGLI STUDI DI ROMA "LA SAPIENZA" | 153476 |
| UNIVERSITA DEGLI STUDI DI FIRENZE | 124632 |

*Heavy-tail distribution = few hubs*

**TOP 5 OUT-DEGREE**

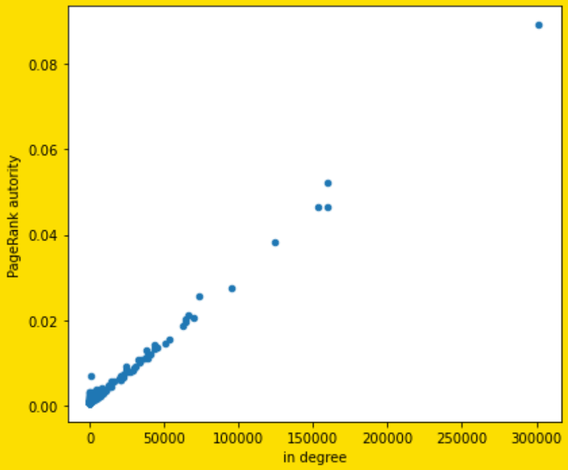
| | |
|---|---|
| UNIVERSITA DI BOLOGNA | 25660 |
| UNIVERSITA DEGLI STUDI DI TORINO | 153099 |
| UNIVERSITA DEGLI STUDI DI ROMA "LA SAPIENZA" | 131231 |
| UNIVERSITA DEGLOI STUDI DI PADOVA | 82361 |
| UNIVERSITA DEGLI STUDI DI MILANO | 79256 |

# HITS & PageRank

Centrality measure

- more incoming edges = more important = authority
- more outgoing edges vs authority = more valuable links = hub

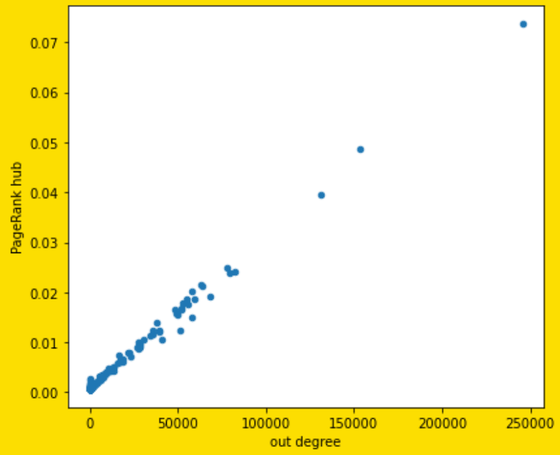
***PageRank Authorities vs In Degree***




**PAGERANK AUTHORITIES**

| | |
|---|---|
| UNIVERSITA DI BOLOGNA | 0.0890 |
| POLITECNICO DI MILANO | 0.0521 |
| UNIVERSITA DEGLI STUDI DI ROMA "LA SAPIENZA" | 0.0463 |
| UNIVERSITA Di PADOVA | 0.0463 |
| UNIVERSITA DI FIRENZE | 0.0382 |

***PageRank Hubs vs Out Degree***



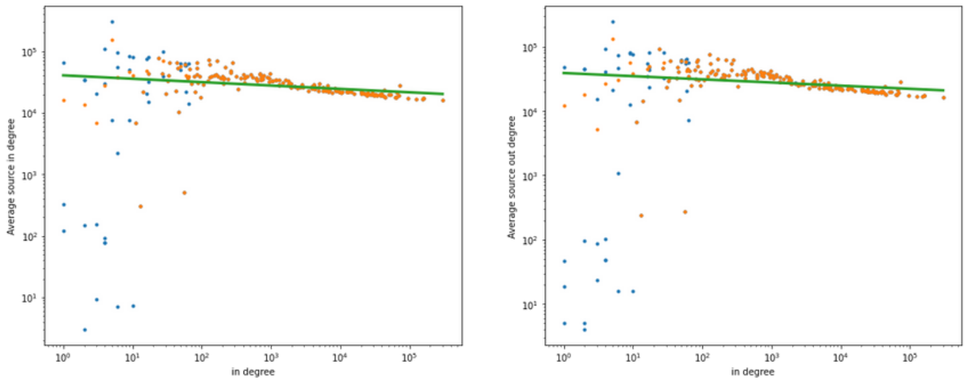

**PAGERANK HUBS**

| | |
|---|---|
| UNIVERSITA DI BOLOGNA | 0.0736 |
| UNIVERSITA DI TORINO | 0.0486 |
| UNIVERSITA DI ROMA "LA SAPIENZA" | 0.0395 |
| UNIVERSITA DI MILANO-BICOCCA | 0.0248 |
| UNIVERSITA DEGLI STUDI DI PADOVA | 0.0242 |

# Assortativity Analysis

How much universities have links with other universities with same degree?

***Average degrees vs in degree***

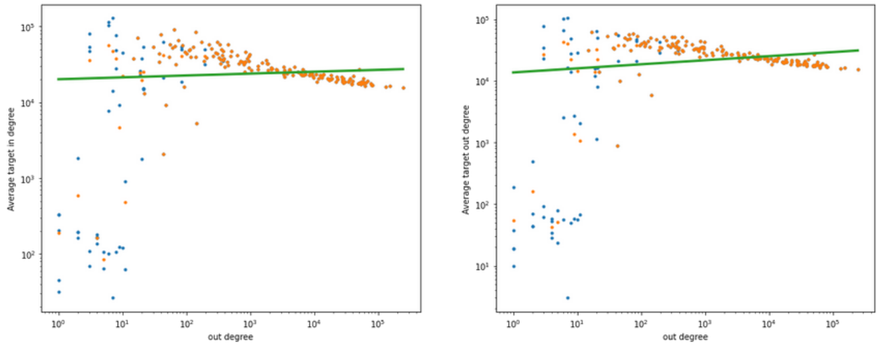



***Assortativity coefficient***

| $\mu_{in,out}$ | $\mu_{out,out}$ | $\mu_{in,in}$ | $\mu_{out,in}$ |
|---|---|---|---|
| 0.0247 | 0.0660 | -0.0550 | -0.0491 |

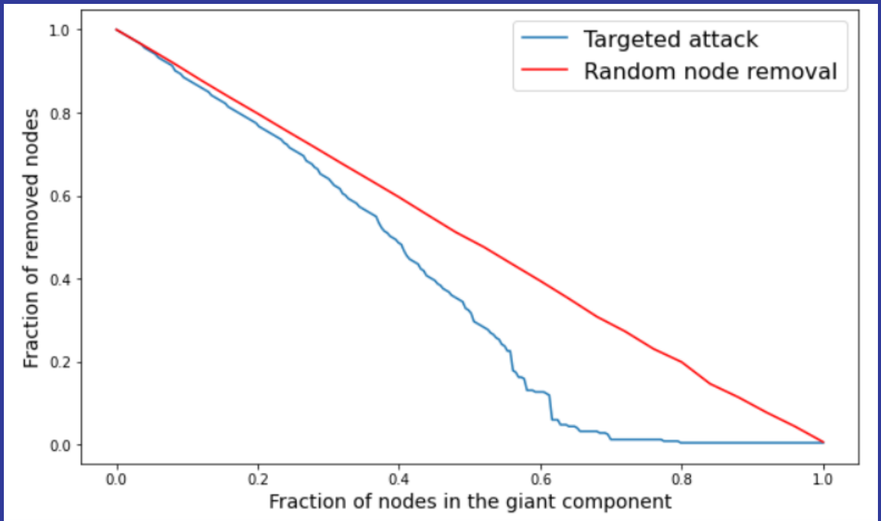
- *2 positive coefficients*
- *2 negatives coefficients*
- *neutral network*

***Average degrees vs out degree***



# Robustness

***Robustness of the network***




We took into account:

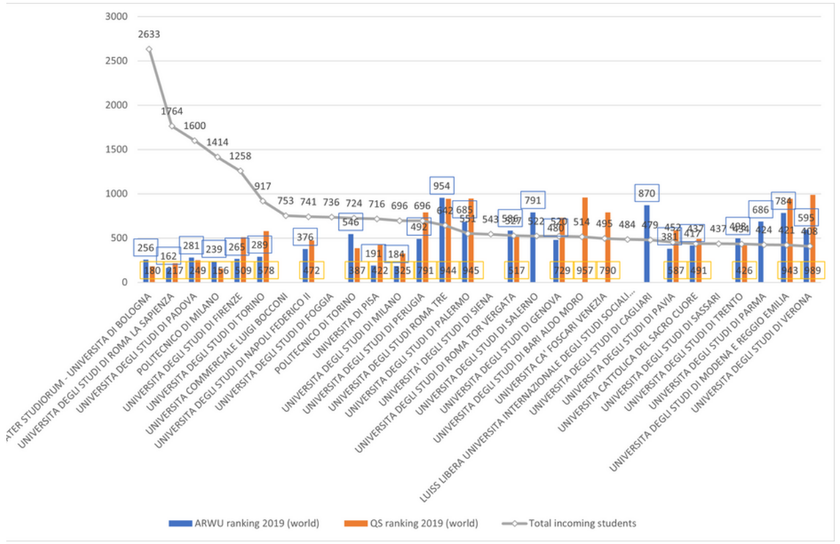
- Robustness to random node removal
- Robustness to targeted attack

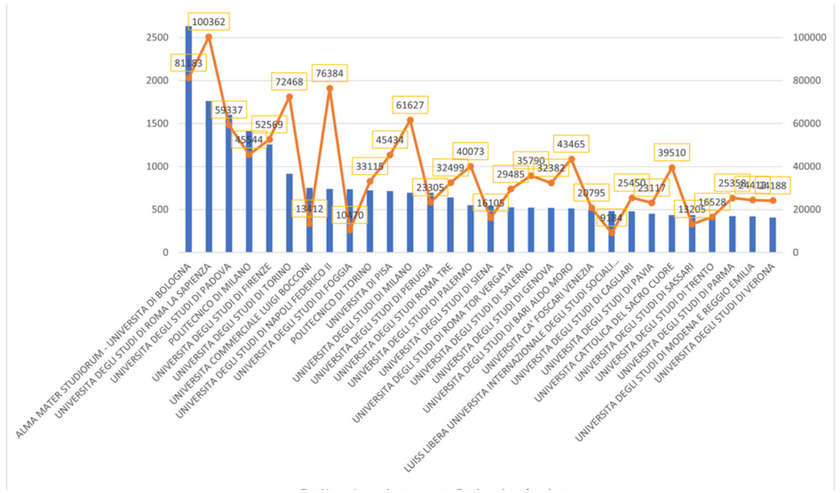
- randomly removed 10 nodes at a time, almost linear behaviour (extremely robust), breaking point close to 1
- removed nodes in decreasing order of PageRank hub score, sublinear behaviour (still quite robust), breaking point close to 1
- typical of scale-free network

# Ranking and number of students

We compared mobility vs ranking/number of students:

- sending institutions IT/EU, receiving institutions IT/EU
- QS/ARWU vs #incoming/outgoing students
- #total students vs #incoming/outgoing students
- not clear relation for ranking vs mobility
- more enrolled students ≈ more Erasmus exchanges (similar trend)



# Answers to research questions - pt. 1

Since this study considers that **two** Italian universities are connected if both are linked to a common foreign university in the **Erasmus network**, the weight of the link is given by the **number of mutual universities** that the Italian institutions share.

Which are the more connected Italian institutions?

01

Considering the aspect of **in-degree**, the most connected universities in Italy are:

- ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
- POLITECNICO DI MILANO
- UNIVERSITÀ DEGLI STUDI DI PADOVA
- SAPIENZA UNIVERSITÀ DI ROMA
- UNIVERSITÀ DEGLI STUDI FIRENZE

Considering the aspect of **out-degree**, the most connected universities in Italy are:

- ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
- UNIVERSITÀ DEGLI STUDI DI TORINO
- SAPIENZA UNIVERSITÀ DI ROMA
- UNIVERSITÀ DEGLI STUDI DI PADOVA
- UNIVERSITÀ DEGLI STUDI DI MILANO

# Answers to research questions - pt. 2

Bigger institutions use to connect to equally big institutions? 02

It can be affirmed that while bigger universities understandably deal with a larger number of partners, smaller universities might be able to link their students to a smaller but more varied pool of international partners.

Is there a difference between the mobility of institutions located in the North of Italy versus those in the South? 03

It appears that, there is only one university located in the South of Italy, that is the University of Neaples "Federico II" in the ranking of Italian institutions . This element sheds light to the fact that universities in the South do not have good connections with other universities in Europe: students are more limited in their mobility than other students attending universities in northern and central Italy.

What is the role of Italian institutions in the European Erasmus+ network? 04

Italy plays a very central role in European exchanges, especially with those countries that have a geographical proximity which are: Spain, France, Germany, United Kingdom or Portugal.

# 07. FIELDS OF STUDY ANALYSIS

# Research questions

01

What are the most relevant fields of study?

02

Are there any significant changes over the years?

03

Is there an increase in mobility for some faculties?

04

Are the institutes with greater mobility those who offer the greatest number of fields of study?

05

Which field of study appears to be more ”central” than others?

06

Are there overlaps between the different areas or are some more independent than others?

# Fields of study Analysis

We considered the following fields of study from the dataset:

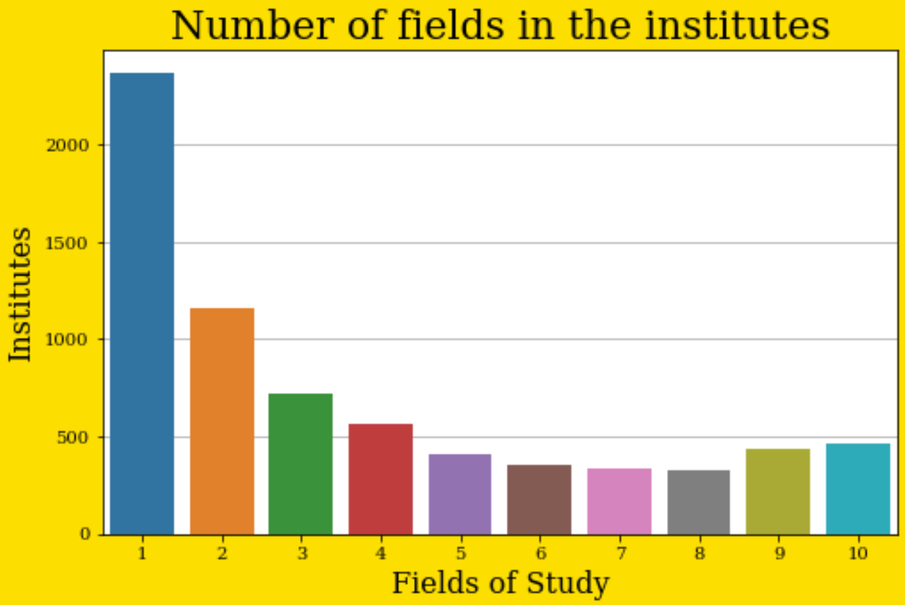
01) Education
02) Arts and Humanities
03) Social sciences, Journalism and Information
04) Business, Administration and Law
05) Natural sciences, Mathematics and Statistics
06) Information and Communication Technologies (ICTs)
07) Engineering, Manufacturing and Construction
08) Agriculture, Forestry, Fisheries and Veterinary
09) Health and Welfare
10) Services

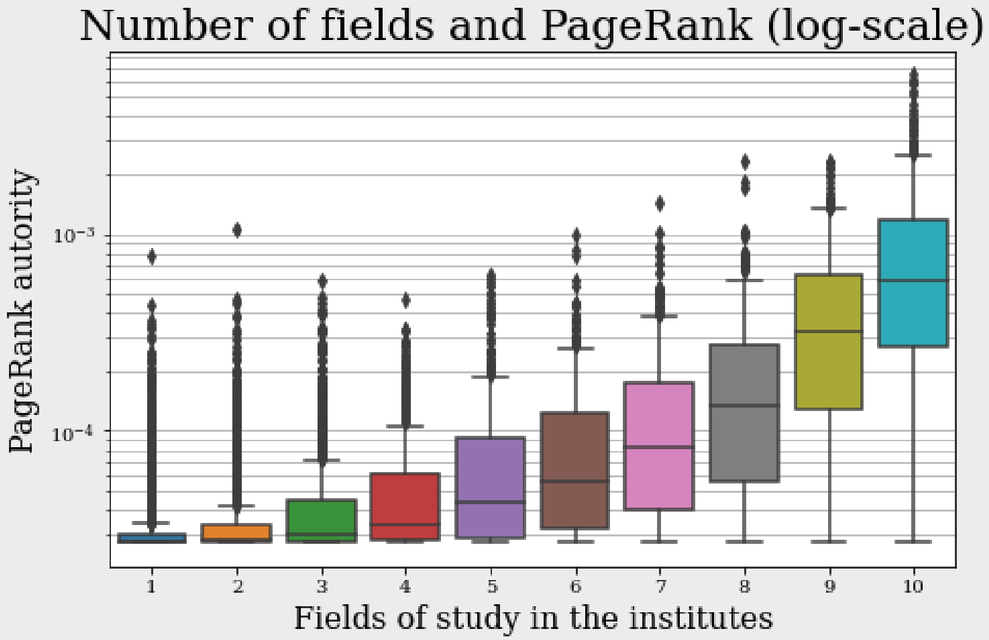
| Field of study | N. Students | |
|---|---|---|
| Business, Admin. and Law | 351816 | 26.55% |
| Arts and Humanities | 278919 | 21.05% |
| Engineering, M. and C. | 200065 | 15.10% |
| Social sciences, J. and I. | 195460 | 14.75% |
| Health and Welfare | 72680 | 5.48% |
| Natural sciences, M. and S. | 72202 | 5.45% |
| Education | 48950 | 3.69% |
| Services | 46997 | 3.55% |
| ICTs | 38182 | 2.88% |
| Agriculture, F., F. and V. | 19873 | 1.50% |

| Field of study | N. Institutes | |
|---|---|---|
| Arts and Humanities | 3890 | 54.48% |
| Business, Admin. and Law | 3813 | 53.40% |
| Social sciences, J. and I. | 3383 | 47.38% |
| Engineering, M. and C. | 3317 | 46.46% |
| Natural sciences, M. and S. | 2459 | 34.44% |
| ICTs | 2433 | 34.08% |
| Services | 2381 | 33.35% |
| Education | 2196 | 30.76% |
| Health and Welfare | 1903 | 26.65% |
| Agriculture, F., F. and V. | 1036 | 14.51% |

# PageRank

Abundance of **specialised institutions**, many of which are academies of arts or music, providing one single field of study. Significant is also the number of more well rounded universities offering to their students a broader range of subjects.




One thing appears clear: to be between the most important nodes in the network an institution must have a well rounded, complete spectrum of subjects of study.

# Role in the network

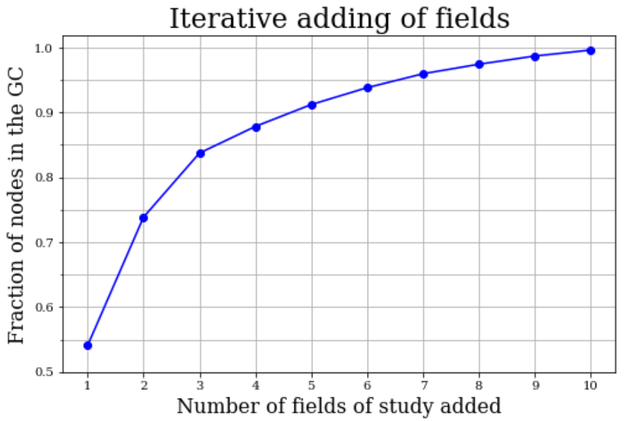
Two approaches to test the role of the fields of study in connecting the network, considering only edges of some fields.

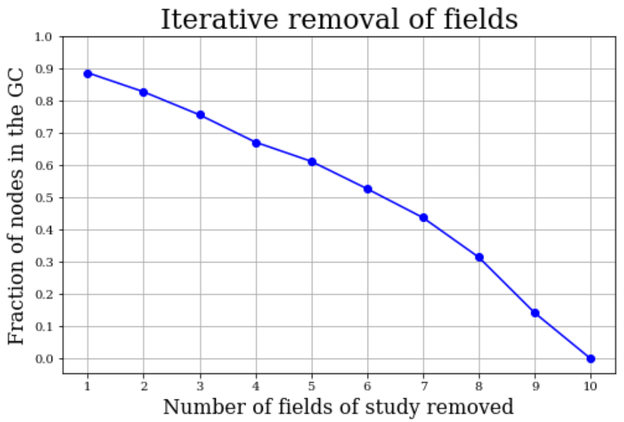
01

Adding, one after another, the edges from the different fields, maximising the fraction of nodes in the GC.

02

Removing edges from the different fields, minimising the fraction of nodes in the GC, similarly to robustness.



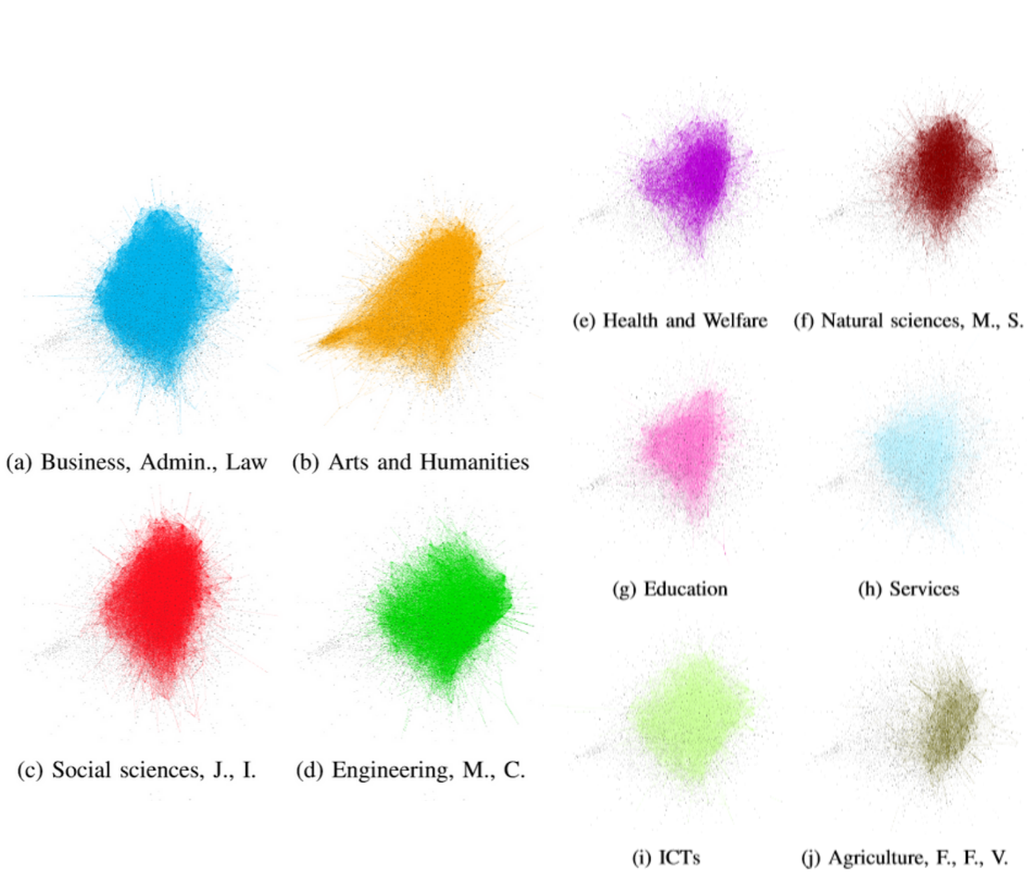



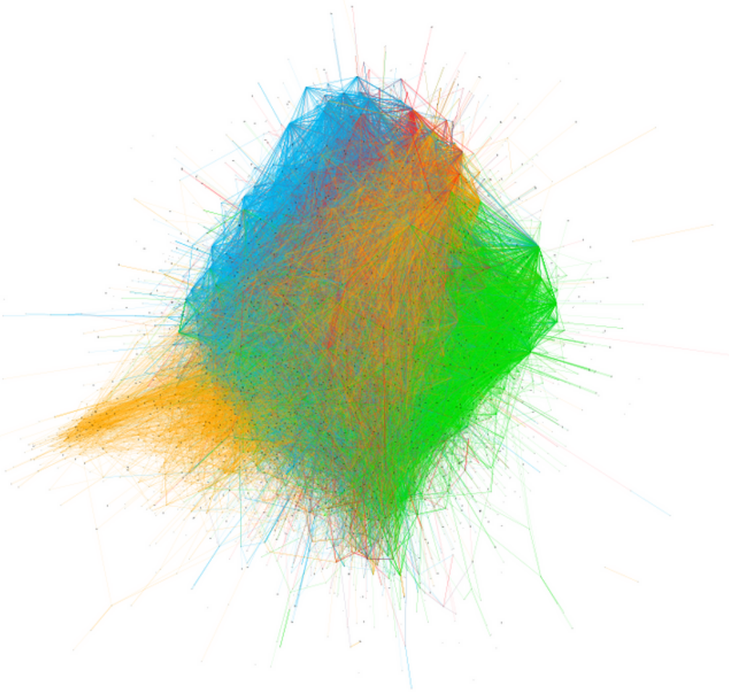

## Single field network

| Field of study considered | Percentage in GC |
|---|---|
| Arts and Humanities | 54.10% |
| Business, Admin. and Law | 53.10% |
| Social sciences, J. and I. | 47.09% |
| Engineering, M. and C. | 46.11% |
| Natural sciences, M. and S. | 34.15% |
| ICTs | 33.68% |
| Services | 33.03% |
| Education | 30.48% |
| Health and Welfare | 26.41% |
| Agriculture, F., F. and V. | 14.20% |

The institutions are (almost) completely connected by the exchanges in the fields of education they offer.

# Multilayer network



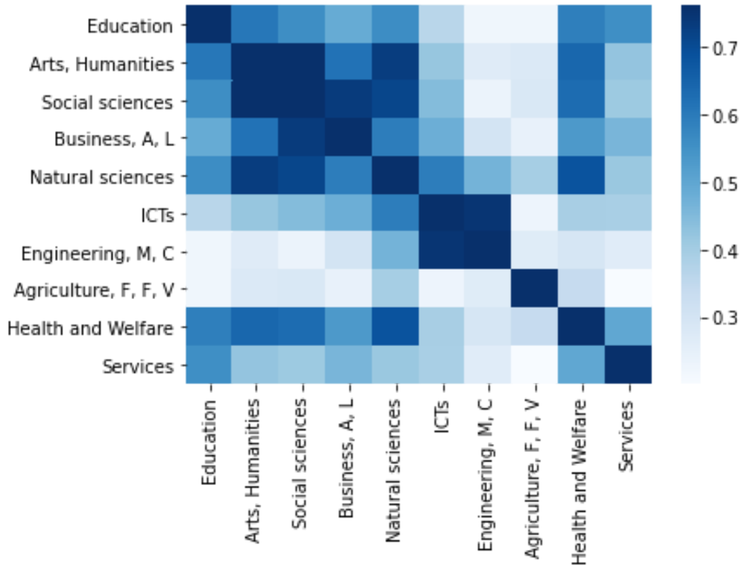



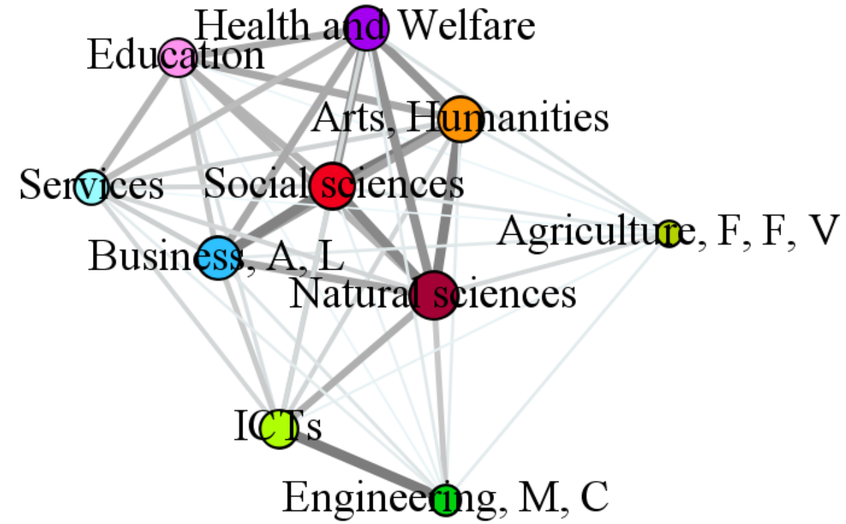
Multilayer network: *a collection of networks with the same nodes, but different edges, in this case with one layer for each one of the fields of study.*

# Layer interdependence

We can measure the interdependence between fields of education using the **Pearson's correlation coefficient** between the degree sequences of each pair of layers.

$$r_{\alpha,\beta} = \frac{\langle k_i^{[\alpha]} k_i^{[\beta]} \rangle - \langle k_i^{[\alpha]} \rangle \langle k_i^{[\beta]} \rangle}{\sigma_{k^{[\alpha]}} \sigma_{k^{[\beta]}}}$$



# Answers to research questions

## 01

What are the most relevant fields of study?

- ”Business, Administration and Law” (**26.55**%);
- ”Arts and Humanities” (**21.05**%);
- ”Engineering, Manufacturing and Construction” (**15.10**%);
- ”Social sciences, Journalism and Information” (**14.75**%).

## 02

Are there any significant changes over the years?

No significant change, except an overall increase.

## 03

Is there an increase in mobility for some faculties?

From the year 2014 to 2019 there has been an increase in mobility for each of the faculties.

(SOUTO-OTERO (2008)

**Social-cultural or economic reasons?**

## 04

Are the institutes with greater mobility those who offer the greatest number of fields of study?

We can therefore deduce that certainly having a broader educational offer leads to being a more **popular choice** of student mobility, but institutions with a wide number of choices **are not necessarily the only ones important in the network.**

## 05

Which field of study appears to be more ”central” than others?

*"The average of the PageRank authority increases as the number of fields of study offered increases"*

So we can deduce that as the number of courses offered increases, the centrality of the institution considered increases (in average).

## 06

Are there overlaps between the different areas or are some more independent than others?

By the analysis of robustness we observed that most of the fields of study **overlap each other without being mutually exclusive**.

The only exception is the disciplines of the ”Arts and Humanities” category.

# 08.
# COMMUNITIES

# Research questions

How are countries divided in communities? 01

How are institutions divided in communities? 02

Is there a reason behind the composition of institutions communities? 03

# Country Communities

**1**

1. Italy
2. Austria
3. Czechia
4. Denmark
5. Germany
6. Spain
7. Finland
8. Hungary
9. Poland
10. UK
11. Switzerland

**2**

1. Estonia
2. Serbia
3. Ukraine
4. Bosnia and Herzegovina
5. Montenegro
6. Moldova
7. Bulgaria
8. Belarus
9. Greece
10. Croatia
11. Portugal
12. Romania
13. Ireland
14. Iceland
15. Liechtenstein
16. Luxembourg
17. Latvia
18. North Macedonia
19. Malta
20. Norway
21. Turkey
22. Solvenia
23. Slovakia

**3**

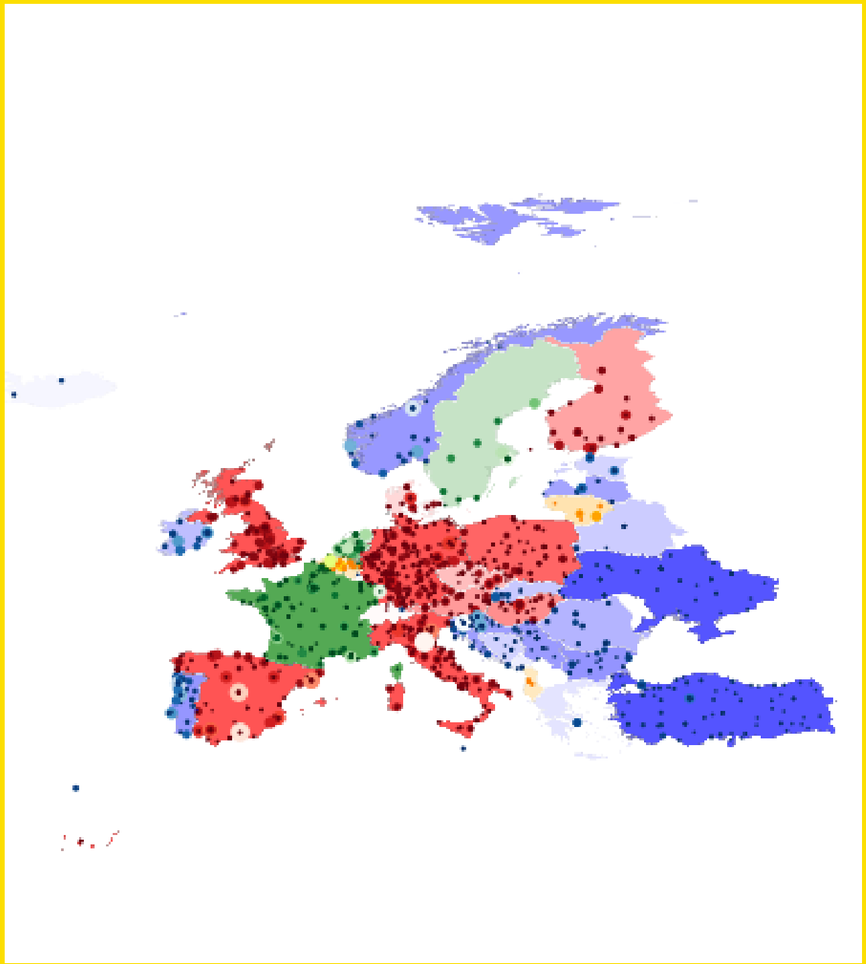
1. France
2. Netherlands
3. Sweden

**4**

1. Belgium
2. Albania
3. Lithuania

# Graphic visualization

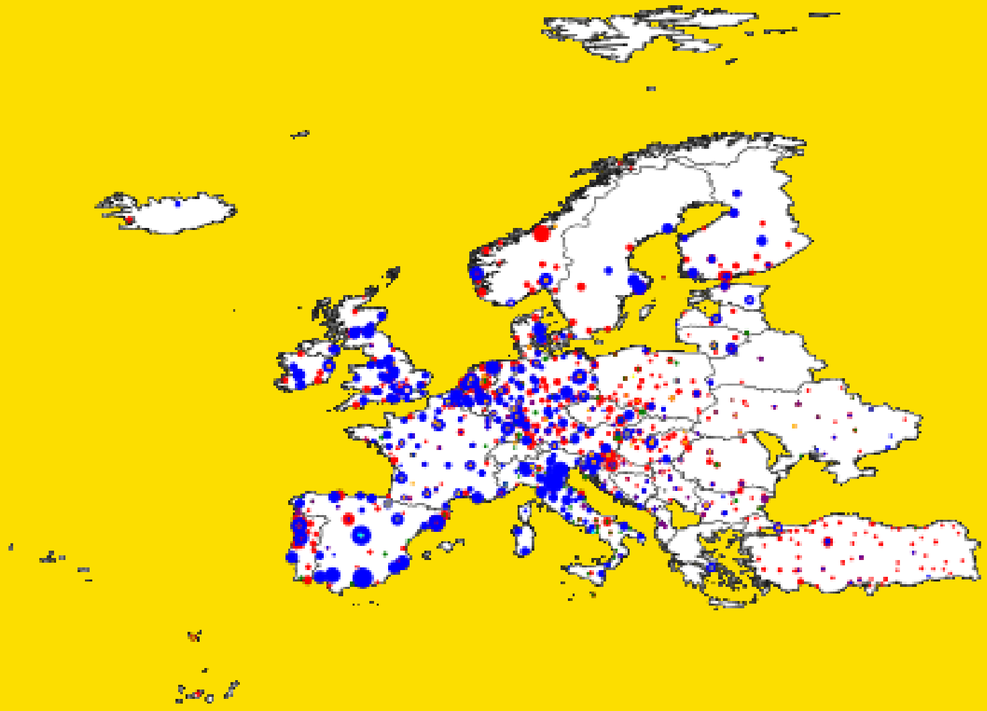
## Authorities



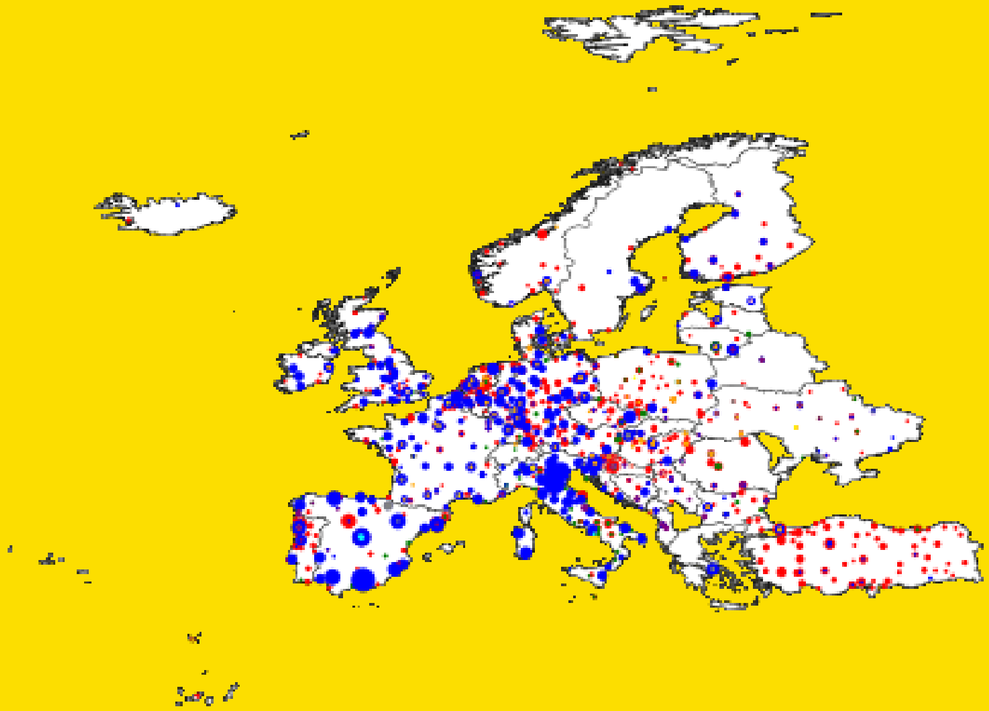
## Hubs

# Institutions Communities

## Authorities

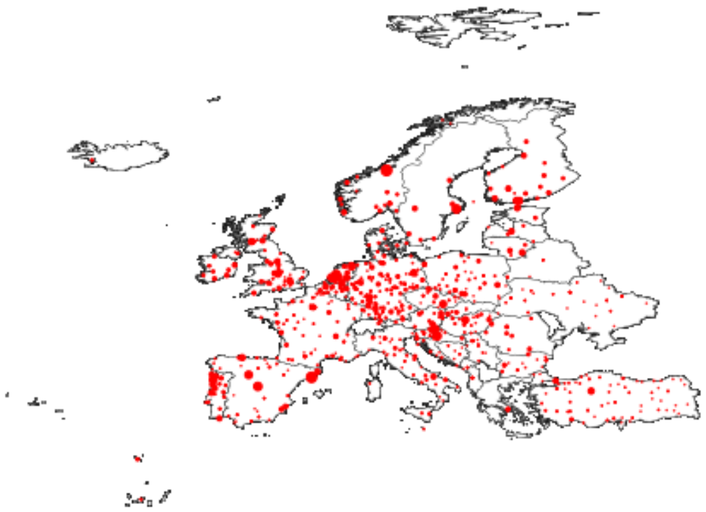


## Hubs

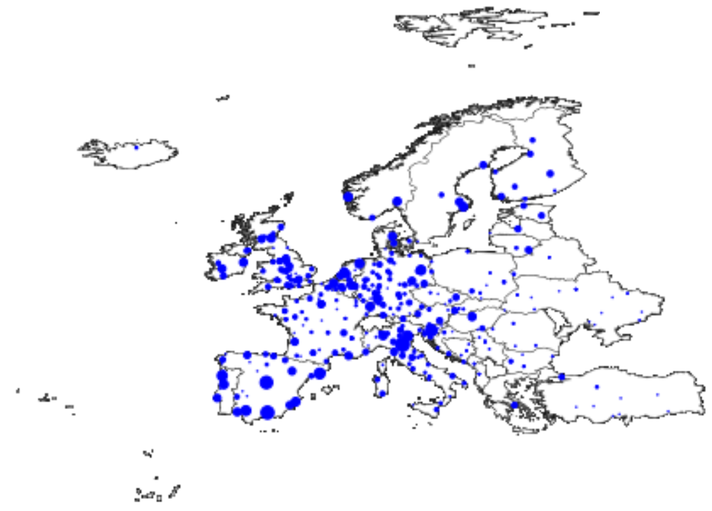


In both figures are represented all the biggest communities. Since the most visible are only the biggest two (red and blue), this means that these two communities contains the majority of Authorities and Hubs in the network.

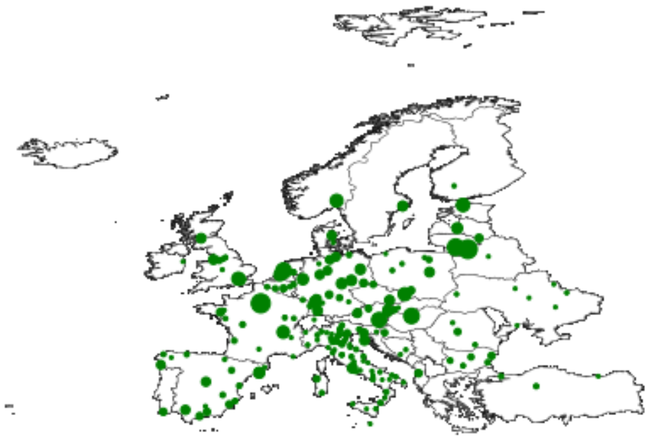
1



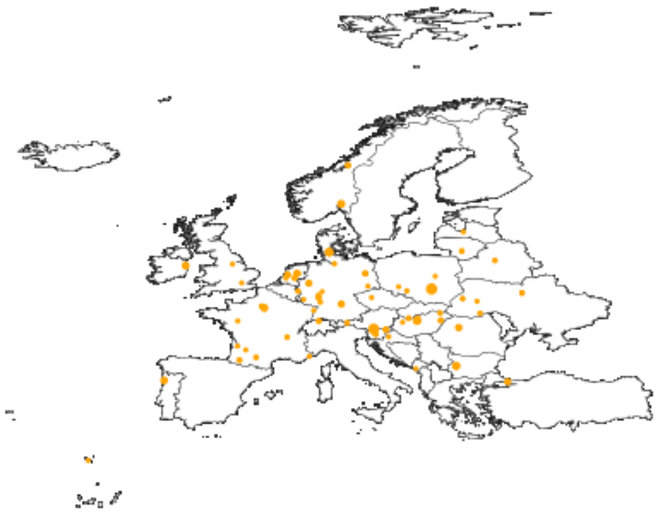
2



3

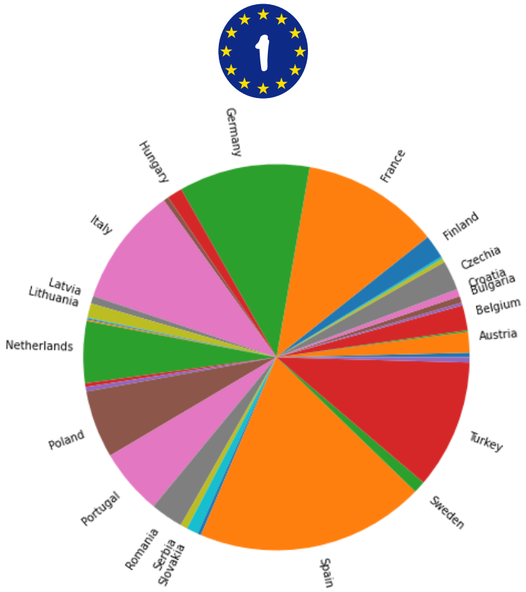


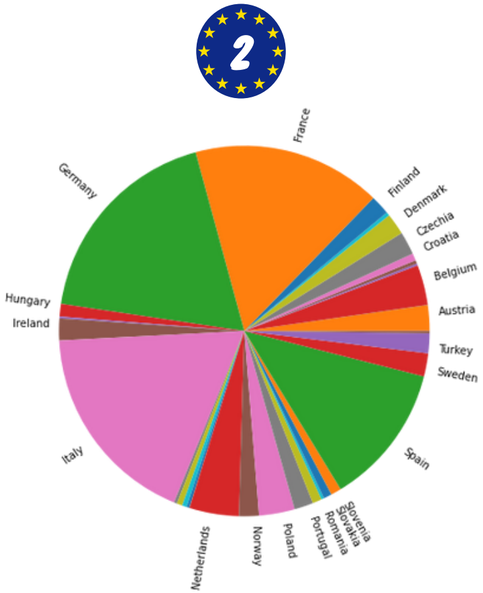
4

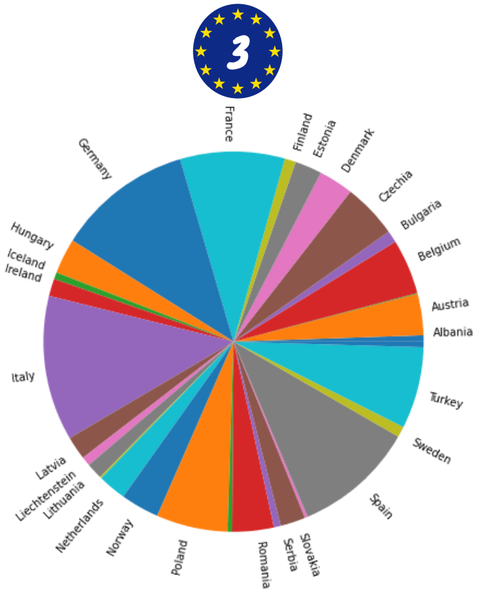


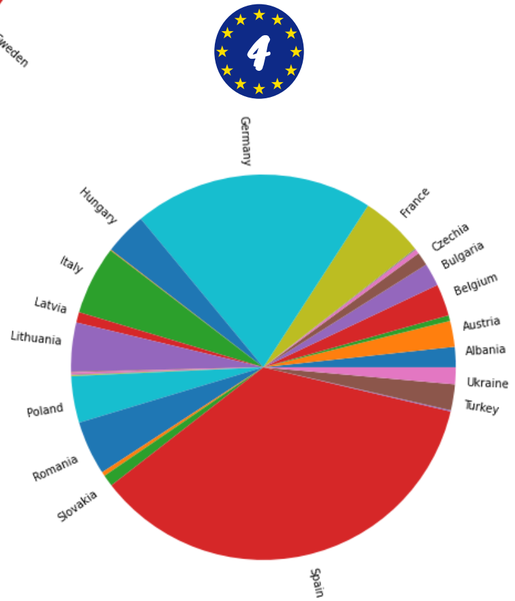
**Community 5** is not geographically represented because of inconsistencies between Erasmus dataset and geographical dataset were too many in this case.

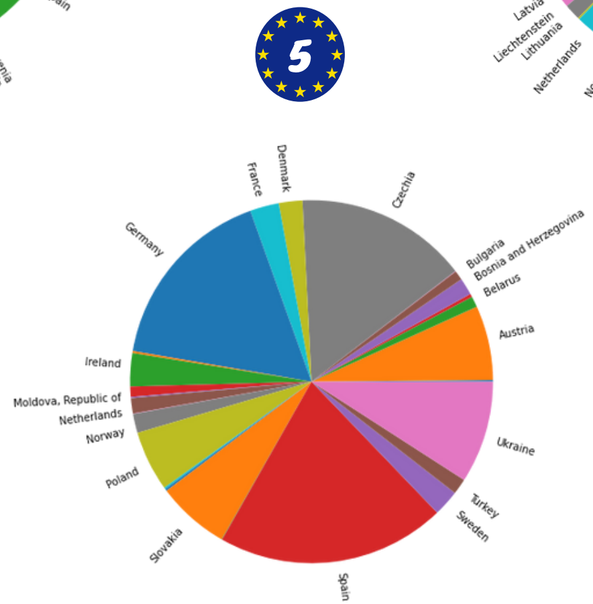
# Could belonging country influence communities?



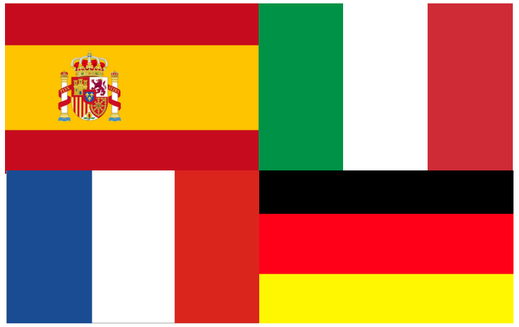



# Results

Communities 1, 2 and 3 have really similar and various composition so we think that they have not been influenced by belonging country or language.

Germany and Spain have a really big participation in community 4 so they might have influenced this community with their connections.



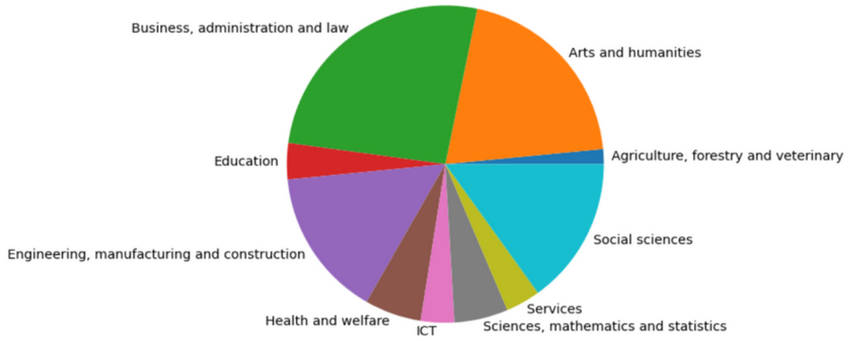
Spain, Italy, Germany and France have relevant and similar participation in almost every community, but especially in community 1, 2 and 3.

Community 5 in addition to the big participations of Germany and Spain (together again), is the only one with big participations of Czechia and Ukraine and in general this community has a bigger participation of eastern Europe countries so this could be a common feature.

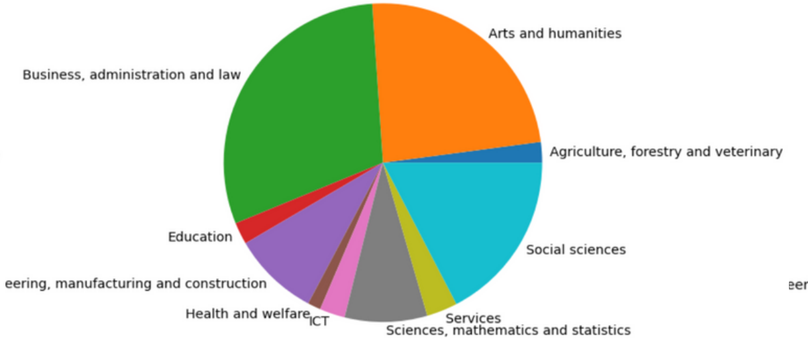
In conclusion although significant links between countries in a community can be found, the majority of countries is split between all communities, the relevant exceptions that might have slightly influenced the communities are: **Italy**, **Spain**, **France**, **Germany** which have a strong influence in almost every community, and **eastern Europe countries**.

# Could fields of study influence communities?

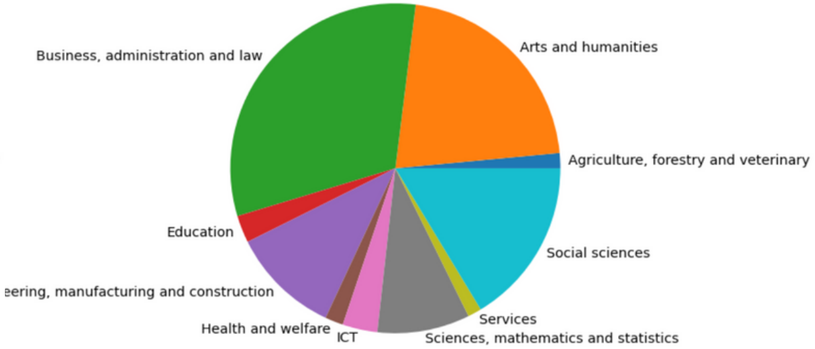
1



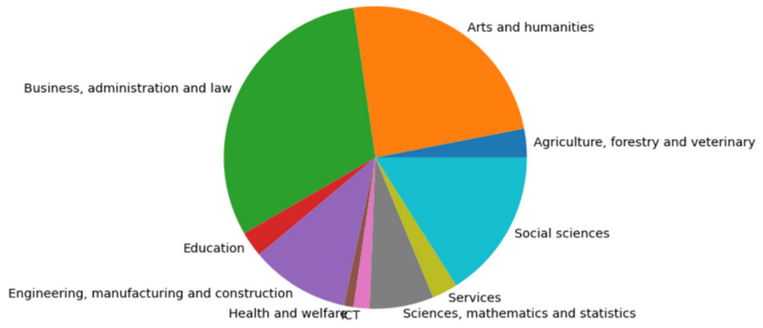

2



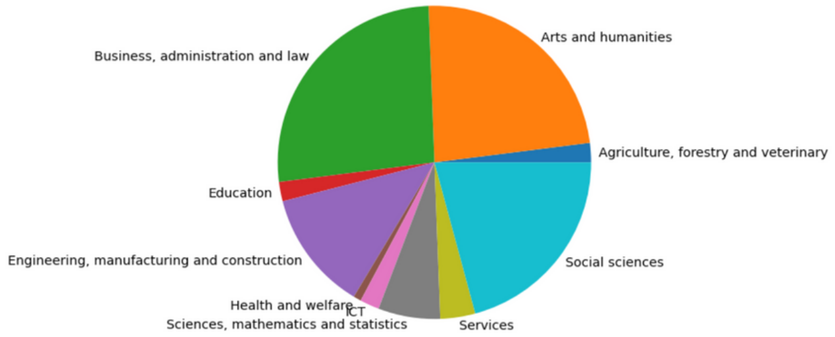

3




4




5



# Answers to research questions

How are countries divided in communities?

01

In community 1 most countries have  important institutions with possibility of study in English, while community 2 contains mostly eastern Europe countries.
On the other hand community 3 and 4 do not seem really meaningful communities.

How are institutions divided in communities?

02

From the two maps of institutions communities since the most visible are only the biggest two (red and blue), this means that these two communities contains the majority of Authorities and Hubs in the network. Furthermore they seem to be distrubuted all over Europe.

Is there a reason behind the composition of institutions communities?

03

Although significant links between countries in a community can be found, the majority of institutions belonging from the same country is split between all communities. And from the previous charts is clear that fields of study do not influence community compositions.

# 09.
# CONCLUSIONS

# 2014 2019

Spain Germany
France Italy
UK Turkey

Valencia
Granada
Bologna

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

SAPIENZA
UNIVERSITÀ DI ROMA

UNIVERSITÀ
DEGLI STUDI
DI PADOVA

”Business, Administration Law”

”Arts and Humanities”

The subdivision in community of the European institutions is not influenced by fields of study or languages.

More similarities than differences

# References:


[1] Charu C Aggarwal. An introduction to social network data analytics. In Social network data analytics, pages 1–15. Springer, 2011.

[2] Philip G Altbach. Impact and adjustment: Foreign students in comparative perspective. Higher Education, 21(3):305–323, 1991.

[3] Albert-Laszl ´ o Barab ´ asi. Network science. ´ Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 371(1987):20120375, 2013

[4] George A Barnett, Moosung Lee, Ke Jiang, and Han Woo Park. The flow of international students from a macro perspective: a network analysis. Compare: A Journal of Comparative and International Education, 46(4):533–559, 2016.

[5] George A Barnett and Reggie Yingli Wu. The international student exchange network: 1970 & 1989. Higher Education, 30(4):353–368, 1995.

[6] Michel Beine, Romain Noel, and Lionel Ragot. Determinants of the ¨ international mobility of students. Economics of Education review, 41:40–54, 2014.

[7] G. Bianconi and A. L. Barabasi. Competition and multiscaling ´ in evolving networks. EPL (Europhysics Letters), 54(4):436–442, May 2001.

[8] Kristijan Breznik and Goran akovic. Erasmus student mobility ´ flows-the national-level social network analysis of slovenia. International Journal of Innovation and Learning, 20(2):124–137, 2016.

[9] Kristijan Breznik and Vesna Skrbinjek. Erasmus student mobility flows. European Journal of Education, 55(1):105–117, 2020.

[10] Sergey Brin and Lawrence Page. The anatomy of a large-scale hypertextual web search engine. Computer networks and ISDN systems, 30(1-7):107–117, 1998.

[11] Tse-Mei Chen and George A Barnett. Research on international student flows from a macro perspective: A network analysis of 1985, 1989 and 1995. Higher education, 39(4):435–453, 2000.

[12] European Commission. Erasmus mobility statistics 2014 - 2018 [data set]. Directorate-General for Education, Youth, Sport and Culture, 2020.

[13] European Commission, Sport Directorate-General for Education, Youth, and Culture. Erasmus+ annual report 2020 : statistical annex. 2021.

[14] Caterina De Bacco, Eleanor A. Power, Daniel B. Larremore, and Cristopher Moore. Community detection, link prediction, and layer interdependence in multilayer networks. Phys. Rev. E, 95:042317, Apr 2017.

[15] Amparo de la Loma. The european higher education area in 2012: Bologna process implementation report. Revista Espanola ˜ de Educacion Comparada ´ , (20):422, 2012.

[16] Commissione europea and dello sport e della cultura Direzione generale dell'Istruzione, della gioventu. ` ECTS Guida per l'utente 2015. Ufficio delle pubblicazioni, 2017.

[17] Laszlo Gadar, Zsolt T Kosztyan, and Janos Abonyi. The settlement structure is reflected in personal investments: Distance-dependent network modularity-based measurement of regional attractiveness. Complexity, 2018, 2018.

[18] Carlos Rodr´ıguez Gonzalez, Ricardo Bustillo Mesanza, and Petr ´ Mariel. The determinants of international student mobility flows: an empirical study on the erasmus programme. Higher education, 62(4):413–430, 2011.

[19] Angelika Grabher, Petra Wejwar, Martin Unger, and Berta Terzieva. Student mobility in the ehea: Underrepresentation in student credit mobility and imbalanced degree mobility; study commissioned by the austrian ministry of science (bmwf). 2014.

[20] Xueying Han, Galen Stocking, Matthew A Gebbie, and Richard P Appelbaum. Will they stay or will they go? international graduate students and their decisions to stay or leave the us upon graduation. PloS one, 10(3):e0118183, 2015.

[21] Jon M Kleinberg et al. Authoritative sources in a hyperlinked environment. In SODA, volume 98, pages 668–677. Citeseer, 1998.

[22] Jane Knight. Student mobility and internationalization: Trends and tribulations. Research in Comparative and International Education, 7(1):20–33, 2012.

[23] Yasar Kondakci, Svenja Bedenlier, and Olaf Zawacki-Richter. Social network analysis of international student mobility: uncovering the rise of regional hubs. Higher Education, 75(3):517–535, 2018.

[24] Findlay A. Stewart E. Lowell, B.L. Brain strain: Optimising highly skilled migration from developing countries. Asylum and Migration Working Paper Series, (3), 2004.

[25] Ashley Macrander. Fractal inequality: A social network analysis of global and regional international student mobility. Research in Comparative and International Education, 12(2):243–268, 2017.

[26] Dolores Messer and Stefan C Wolter. Are student exchange programs worth it? Higher education, 54(5):647–663, 2007.

[27] Vincenzo Nicosia and Vito Latora. Measuring and modeling correlations in multiplex networks. Physical Review E, 92(3), Sep 2015.

[28] Manuel Souto Otero. The socio-economic background of erasmus students: A trend towards wider inclusion? International review of education, 54(2):135–154, 2008.

[29] Justin JW Powell and Claudia Finger. The bologna process's model of mobility in europe: the relationship of its spatial and social 33 dimensions. European Educational Research Journal, 12(2):270–285, 2013.

[30] W.W. Powell. Neither market nor hierarchy: Network forms of organization. Research in Organizational Behavior, (12):295–336, 1990.

[31] Neil G Ruiz. The geography of foreign students in us higher education: Origins and destinations. Report, Global Cities Initiative, 2014.

[32] Robin Shields. Globalization and international student mobility: A network analysis. Comparative Education Review, 57(4):609–636, 2013.

[33] Robin Shields. Following the leader? network models of "worldclass" universities on twitter. Higher Education, 71(2):253–268, 2016.

[34] Ulrich Teichler. Internationalisation of higher education: European experiences. Asia Pacific education review, 10(1):93–106, 2009.

[35] Noel M Tichy, Michael L Tushman, and Charles Fombrun. Social network analysis for organizations. Academy of management review, 4(4):507–519, 1979.

[36] Zeynep Ugurlu. Social network analysis of the farabi exchange program: Student mobility. Eurasian journal of educational research, 16(65):313–334, 2016.

[37] Eva Maria Vogtle and Michael Windzio. Networks of international ¨ student mobility: enlargement and consolidation of the european transnational education space? Higher Education, 72(6):723–741, 2016.

# Erasmus+ study mobility team!

**MARTINA CAVALLANTI**

Communication strategies

**ANNA GIAMBARDA**

Communication strategies

**RACHELE REGINA**

Communication strategies

**ANNA STELLA**

Modern Languages for Communication and International Cooperation

**FILIPPO BRAGATO**

ICT for Internet and Multimedia

**TOMMASO LOTTA**

ICT for Internet and Multimedia

**GIANMARIA VENTURA**

ICT for Internet and Multimedia

**NICOLA DAL BELLO**

ICT for Internet and Multimedia

**GIOVANNI DONGHI**

Data Science

**ELIA DALLAPELLEGRINA**

Computer Engineering


THANKS FOR YOUR
ATTENTION!