Institutional network of engineering students in the Erasmus programme

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ABSTRACT: The Erasmus programme is synonymous with academic mobility in Europe. It has supported over three million student exchanges between over 5,000 higher education (HE) institutions. Engineering education represents a powerful force in the Erasmus as HE engineering institutions represent 37% of all HE institutions in this process. In this study, the author has analysed the mobility of engineering students. The focus was mainly at the institutional level rather than the country level. With the use of some standard statistical methods and some advanced ones, such as social network analysis, the author identified the more significant HE engineering institutions. The institutional network of engineering student exchanges consists of 1,943 HE engineering institutions and 29,711 direct links between them. Spanish HE institutions were recognised as those with the highest mobility of engineering students. Among institutions, the Polytechnic Universities in Valencia and Barcelona were at the top followed by the Technical University of Madrid. Turkey was recognised as a rapidly developing country in terms of student exchanges.

Keywords: Erasmus, student mobility, engineering students

INTRODUCTION

The Erasmus Programme (European Region Action Scheme for the Mobility of University Students) was inaugurated in 1987 and has achieved its mission as it has facilitated student exchanges between European countries. It is one of the more popular and successful mobility programmes in the world, having already supported over three million participants from more than 5,000 higher education (HE) institutions across 33 European countries [1]. In this article, the author focused on 5th Erasmus phase (Erasmus-LLP 2007-2013 [2]). This phase was characterised by the global financial and economic crisis and by the implementation of the Bologna Process. The financial global and economic crisis might have had a negative effect on the student mobility process, but the Bologna process has had a positive impact. It expanded the geographical boundaries of student exchanges in the Erasmus mobility programme.

Nowadays, international student mobility plays an important role in higher educational processes. The Erasmus programme itself combines student mobility with institutional responsibility [3][4]. It promotes the development of students' personal skills and, as a consequence, it improves their employment prospects. Participants in the Erasmus programme often further reinforce their advantages over non-participating colleagues [5][6].

In order to expand further the scope and intensity of collaboration, Erasmus member institutions introduced a new mechanism for mutual recognition, called the European Credit Transfer and Accumulation System (ECTS). The ECTS system is one of the prominent factors of the Erasmus programme and was developed to facilitate student mobility and academic recognition.

Up to this point, the Erasmus programme has been analysed mostly at the country level (for instance by Breznik and Đaković [7], Valiulis [8] and Derszi et al [1]), with only rare exceptions [9]. Spain, Italy, France and Germany were recognised as countries with the most student exchanges (out-going and in-coming) [10].

In this article, the author analysed the mobility of engineering students inside the Erasmus mobility programme. This is not a new topic as a preliminary study of engineering education in the Erasmus was already carried out at the beginning of the process [11]. However, in this study the author focused mainly on the institutional level and less on the country level. With the use of some standard statistical methods, but also some advance ones, significant HE engineering institutions in the Erasmus student mobility procedure were identified.

RESEARCH METHODOLOGY

The micro data set on student mobility for the Erasmus programme contains the following information for each student exchange in the 5th Erasmus phase: sending and receiving HE institution; sending and receiving country; gender and age of student; type of mobility; and subject area. In the period between 2007 and 2013, over 1.3 million students and 5,198 HE institutions were involved in the Erasmus student exchange process. Among them, the author identified 1,943 HE institutions that participated in at least one engineering student exchange. Engineering student exchanges were considered to be exchanges that were classified under study area number 5 (engineering, manufacturing and construction) in the International Standard Classification of Education (ISCED) [12].

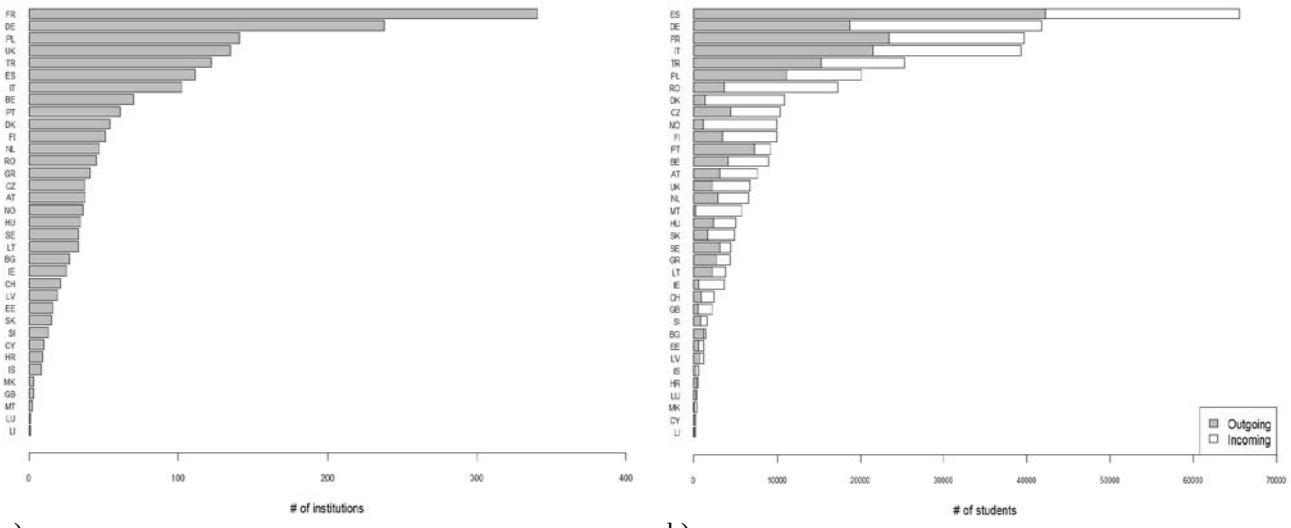
It seems natural to perceive Erasmus student mobility as a network of exchanges between HE institutions. For this reason, the author also analysed the data using (social) network analytic procedures. In general, a (social) network is defined as a set of actors and a relation or relations between them [13]. In this case, HE engineering institutions represent actors and student exchanges between HE engineering institutions define the relationship. The obtained network (the author will call it the institutional network), can be classified as a directed (with a link from home to host HE engineering institution) and weighted (a weight of the link between two HE engineering institutions is determined by the number of student exchanges) large network. Standard techniques to deal with networks (basic notions of a network, network centrality measures, etc) are described by, for instance, De Nooy et al [14]. The following paragraph has a more profound description of the network analytic method used in this article, the notion of *island*.

An advanced approach to explore a given (large) network refers to identifying and analysing its important parts. Using the notion of islands one can identify groups of nodes in a network that are more tightly connected as nodes outside the island. A node island of size [k,K] is defined as a weakly connected subnetwork with a number of nodes in the interval [k,K], such that the nodes inside the island have larger values of selected property p than their neighbours outside the island. Similarly, a line island of size [k,K] is a weakly connected subnetwork with a number of nodes in the interval [k,K], such that the links linking nodes of the island to their neighbours outside the island have weights *w* lower than the values of links of a maximal spanning tree inside the island [15].

Programmes for transforming data into a useful format and for producing networks were written in R [16]. R is a free software environment for statistical computing and was also applied for classical statistical analysis. For the analysis of networks the Pajek programme [17] was used.

RESULTS

In Figure 1a, the author presented a distribution of HE engineering institutions involved in the Erasmus process by country. Readers can observe that France is the country with the highest number of institutions by a convincing margin (over 300 HE engineering institutions in the Erasmus process). It is followed by Germany (clearly second with over 200 HE engineering institutions) and a group of 5 countries: Poland, United Kingdom, Turkey, Spain and Italy. All other countries have fewer than 100 HE engineering institutions involved in the process. Distribution of out-going and in-coming engineering mobility students by country can be found in Figure 1b. Spain is the country with the most students, moreover, the number of out-going students from Spain exceeds the number of all mobile students from the second placed Germany. Germany is closely followed by France and Italy. Significantly fewer students are mobile in Turkey, Poland, Romania, etc.



a) b)

Figure 1: a) distribution of HE engineering institutions by country; b) distribution of engineering mobility students by country.

An interesting observation can be made in Figure 1b, when examining the ratio between out-going and in-coming students per country. Spain, Turkey and Portugal are more student export oriented. On the other hand, Germany, Romania, Denmark and Norway are more import oriented.

The institutional network consists of 1,943 HE engineering institutions and 29,711 directed links between them. The network density is 0.008 and, therefore, it can be classified as a sparse network. The average degree of the node (a node represents an HE engineering institution) is 30.58, i.e. on average, each institution has slightly over 30 contacts (in- and out-going) with other institutions. The degree distribution of the entire institutional network in log-log scale is presented in Figure 2. One can observe that only three institutions have their degree over 500 (they share Erasmus contacts via student exchanges with over 500 HE engineering institutions). On the other hand, there are many engineering institutions with a low degree frequency. Generally speaking, the degree distribution lies on a straight line indicating scale-free property of the network [18]. This a well-known characteristic of many real-world type of networks.

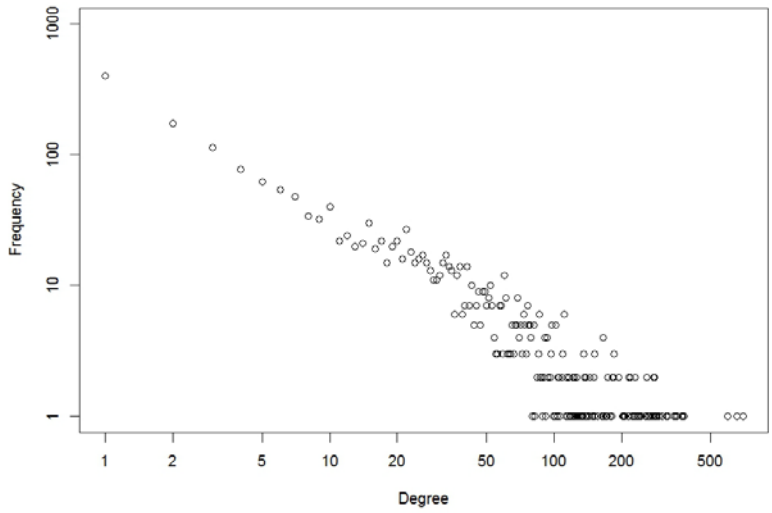


Figure 2: Degree distribution of institutional network.

By simple analysis of weighted links and actor degrees in the network, the author provided Table 1 that contains a list of HE engineering institutions in the Erasmus programme with the highest number of student exchanges. HE engineering institutions are ordered by the sum of in-coming students (in-students) and out-going students (Out-students). Among the 10 HE engineering institutions in Table 1, four are from Spain, two from Italy and one each from Sweden, Germany, the Czech Republic and Portugal. At the top of Table 1, one can find the Polytechnic University of Valencia, which exchanged 9,608 engineering students over the observed period. This institution is clearly the most popular choice for Erasmus mobility by international engineering students. It is also sending almost as many students to foreign HE engineering institutions (4,708 out-students). In the category of sending students, the Polytechnic University of Catalonia and the Technical University of Madrid are more successful than others by sending over 5,000 engineering students. An even more objective parameter is the ratio between in- and out-students calculated for each HE engineering institution. A higher ratio indicates that the HE engineering institution is recognised by foreign engineering students. On the other hand, a lower ratio should mean that the HE engineering institution is sending more students than receiving students. The highest ratio number between HE engineering institutions in Table 1 is by the Royal Institute of Technology from Stockholm (exactly 4.16). A significantly smaller, but also positive ratio, is demonstrated by the Technical University of Lisbon (1.50), the Czech Technical University in Prague (1.28), the Technical University of Munich (1.27) and the institution on the top of Table 1, the Polytechnic University of Valencia (1.04). The other six HE engineering institutions from Table 1 have ratios below 1.0, the lowest being the Technical University of Madrid (0.52) and University of Seville (0.59).

Table 1: Top 10 HE institutions regarding to the number of exchanged engineering students.

HE institution name	Code	In-students	Out-students	In-ties	Out-ties
Polytechnic University of Valencia	E VALENCI02	4,900	4,708	353	341
Polytechnic University of Catalonia	E BARCELO03	3,445	5,842	308	345
Technical University of Madrid	E MADRID05	2,720	5,185	276	318
Polytechnic University of Milan	I MILANO02	3,491	3,776	276	320
Polytechnic University of Turin	I TORINO02	2,089	2,592	186	168
Royal Institute of Technology Stockholm	S STOCKHO04	3,689	887	183	110
Technical University of Munich	D MUNCHEN02	2,313	1,827	204	177
Czech Technical University in Prague	CZ PRAHA10	2,252	1,754	202	173
Technical University of Lisbon	P LISBOA04	2,185	1,454	205	143
University of Seville	E SEVILLA01	1,270	2,154	126	153

The author continued the analysis by deleting all links in the network with weights lower than 141 (which is two-thirds of the highest weight). In other words, the author used a *line cut technique* and deleted all links with values below the 33rd percentile. All remaining links and institutions belonging to them are presented in Figure 3. Not surprisingly, many HE engineering institutions displayed in Figure 3 are also present in Table 1. Moreover, they share the links with the highest values. Only one institution from Table 1 is missing (the Technical University of Lisbon). However, the highest value on links in the institutional network is interestingly the one pointing from the Polytechnic University of Turin to the Athlone Institute of Technology in Dublin (with 211 students). The strongest and the most important links are in both ways weighted with more than 141 students (this is indicated as a both-way link between two HE engineering institutions in Figure 3). These link the following pairs of institutions: the Polytechnic University of Turin and the Polytechnic University of Catalonia; the Polytechnic University of Catalonia and the Polytechnic University of Milan; and the Polytechnic University of Milan and the Polytechnic University of Valencia.

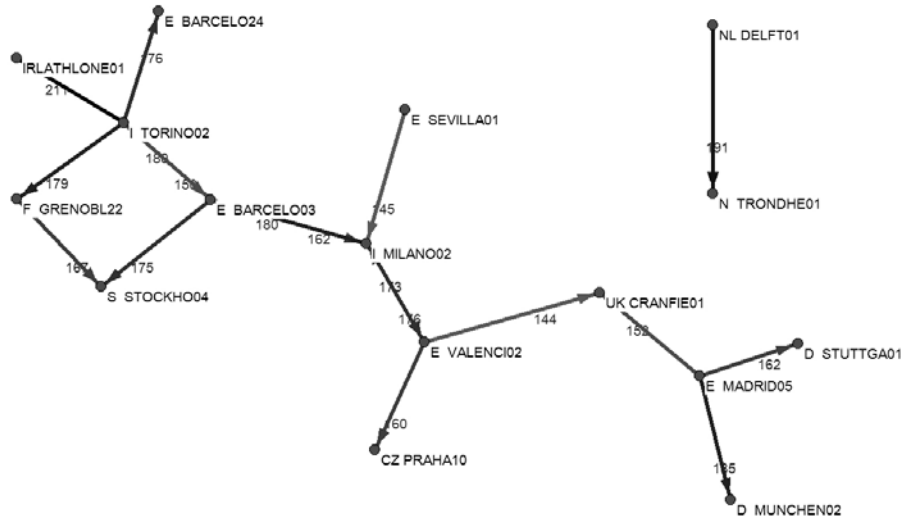


Figure 3: Remaining institutional network after deleting links with weights lower than 141.

In order to find denser parts of the institutional network the line island approach was used. This method is usually used when researchers would like to find not only already prominent groups of nodes, but also groups of nodes that can be potentially important in the future. Namely, line islands found with this method are at different heights. More importantly, nodes on each island are highly interconnected compared to other nodes outside of an island. The author chose three to be the bottom limit for the number of nodes on the island, as one did not want islands with only two institutions. For the upper limit, 30 was chosen as the maximum number of HE engineering institutions on an island. One finds 16 line islands of the size (3.30) in the institutional network and the author displayed them in Figure 4. The strength of links in Figure 4 is indicated by the grayscale intensity; darker links are stronger.

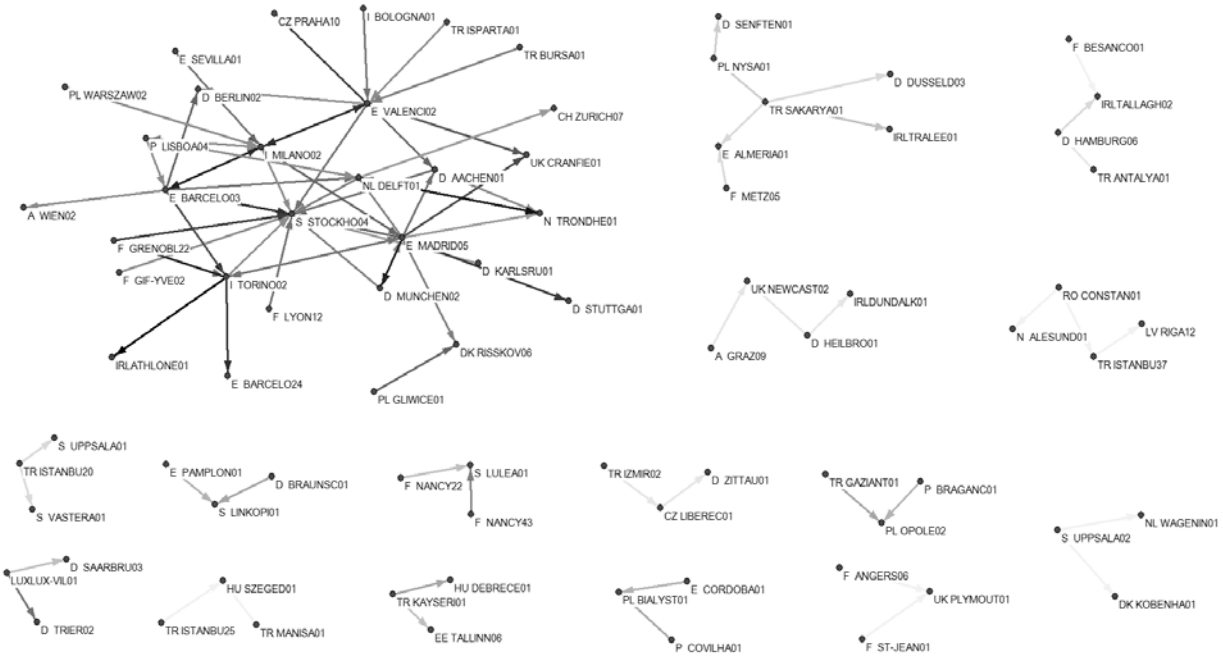


Figure 4: Line islands of size (3,30) of the institutional network.

In the top left part of Figure 4, the largest island with 28 HE engineering institutions can be seen. For the current analysis, this island is not very interesting as it includes all HE engineering institutions that were already discussed in Table 1 and even all institutions displayed in Figure 3. Moreover, already known HE engineering institutions play the main role on the largest island as they share higher number of links compared to other HE engineering institutions. Beside this main island, one can observe one island with seven HE engineering institutions, three islands with four HE engineering institutions and 11 islands with three HE engineering institutions. In the centre of the second largest island is the Sakarya University from Turkey. This HE institution exports Erasmus engineering students to Germany (University of Applied Sciences in Düsseldorf), Poland (University of Applied Sciences in Nysa), Ireland (Institute of Technology of Tralee) and Spain (University of Almeria).

Turkish HE engineering institutions (Akdeniz University in Antalya and Piri Reis University in Istanbul) can also be found on two of the three islands with four HE engineering institutions. Interesting findings are related to the smallest islands. Young and successful Sabanci University from Turkey exports Erasmus engineering students to Swedish HE engineering institutions (Uppsala University and Mälardalen University College in Västerås). Potentially strong collaboration between Turkish HE engineering institutions and institutions in different parts of Europe was observed. They exchanged engineering students with Northern Europe (Sweden), Central Europe (Germany, Ireland) and most frequently with Eastern Europe (Latvia, the Czech Republic, Poland and Hungary). Luleå University of Technology in Sweden is evidently very popular among French engineering students, particularly those from Nancy (National Polytechnic Institute of Lorraine and University of Lorraine). Turkish engineering students from Istanbul Aydin University and from Manisa Celal Bayar University are hosted at University of Szeged in Hungary, and engineering students from University of Luxembourg travel often to Germany (Saarland University of Applied Sciences and Engineering in Saarbrücken and University of Applied Sciences in Trier).

DISCUSSION AND CONCLUSIONS

Engineering education represents a powerful force as HE engineering institutions represent 37% of all HE in the Erasmus process. In accordance with previous studies on the Erasmus programme in general, Spanish HE institutions were recognised as the institutions with the highest mobility of engineering students. Spain exports significantly more student than it imports, and this is similar in neighbouring country Portugal. Scandinavian countries are extremely import oriented. It should be interesting to explore the reason for such a contrast. One of the main reasons can be EEA grants, the Norway Financial Mechanism that involves Norway, Iceland and Liechtenstein. Norway's Financial Mechanism is to some extent even more attractive and, especially, financially friendlier compared to the Erasmus programme. This can be the reason that Norwegian and other Scandinavian students rarely exploit the Erasmus mobility opportunities.

At the institutional level, Polytechnic Universities in Valencia and Barcelona were at the top followed by the Technical University of Madrid. Although most HE engineering institutions are from France, no French institution can be found among the top 10 HE institutions regarding the number of engineering students exchanged. In general, institutions with the highest student mobility collaborate very well among themselves. The author found the line island, which contained many top HE engineering institutions in terms of student exchanges. This shows that the core of student mobility in the study area of engineering is quite concentrated. One can even recognise the core-periphery characteristics of the model.

Further, the line island approach identifies locally important subnetworks at lower levels. The main advantage of this method is that it also detects emerging groups. Turkish HE engineering institutions are active and Turkey can be recognised as a rapidly developing country in terms of engineering student mobility. To be more specific, Turkey can be classified as an export oriented country in terms of mobility of engineering students. Turkey exports its engineering students across Europe, but the focus is mainly on Eastern Europe.

There are many ideas about future work on this topic. It should definitely include an analysis of the time component, i.e. the longitudinal type of research. The Erasmus programme also offers mobility to professors and supporting staff. It would be interesting to make comparisons between student-professor and student-staff mobility on both country and institutional levels.

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BIOGRAPHY

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