



Analysing International Student Mobility Flows in Higher Education: A Comparative Study on European Countries

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Accepted: 26 January 2020 / Published online: 1 February 2020
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Abstract

The analysis of the factors pulling and pushing students in a foreign country to complete their higher education is key for the implementation of university policies aimed at increasing the number of credits gained by students abroad and hence the degree of internationalisation of institutions. Consistent with previous studies, the present contribution examines the roles played by countries in the Erasmus student mobility flows by considering a joint strategy of analysis based on social network analysis and exploratory data analysis. First, data on Erasmus student exchanges among countries are gathered at macro-level from the European Union Open Data Portal and network data structures are analysed. Second, educational indicators from the Eurostat website are collected to describe the investments in higher education. The main findings suggest the presence of a core-periphery configuration in the student mobility network with few central countries in which the economic benefits and the investments in education seem to act as key elements for university attractiveness.

Keywords Directed and weighted network · Erasmus student mobility · European open data · Social network analysis

1 Introduction

The increasing number of foreign students in higher education has made international student flows an important research topic to describe how countries interact and communicate each other.

The European Union (EU) has developed several mobility programmes to promote the exchange of cultural, professional and personal experiences within its confines. The most famous programme is the European Region Action Scheme for the Mobility of University Student (Erasmus), the aim of which is to encourage and support the academic mobility of students, professors and academic staff in higher education within EU countries. Each year,

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thanks to Erasmus agreements, the universities (*home institutions*) offer the opportunities to make months-long exchange visits to partner universities (*host institutions*). Since its creation in 1987, participation in the Erasmus programme has increased from 3000 participants in 1987 to 272,497 in 2013–2014, and within the new Erasmus programme for the period 2014–2020, the so-called *Erasmus+*, the number of participants has increased to 796,761 for Key Action 1 in 2017.

Within this scenario, the present contribution aims at studying and identifying the main characteristics of the Erasmus student mobility flows in European countries in six academic years, from 2008–2009 to 2013–2014. The analysis of the Erasmus phenomenon is done using a joint analysis strategy, combining the instruments of social network analysis and exploratory data analysis.

The data under study are gathered from the EU Open Data Portal, and network data structures are defined to analyse and describe relationships among actors. Educational indicators are collected from the Eurostat website to describe the investments of European countries in higher education in the period under analysis and better clarify the role of each country in the internationalization process of higher education system.

When dealing with social networks, the data consist of a set of actors linked by one or more kinds of relationships. Different topics can be studied according to the types of actors involved in the network and the types of ties linking them. In this study the actors (i.e. nodes) are the countries, and the links represent the number of students involved in the mobility exchange. Ties among them can then be defined according to the direction and/or the presence or absence of link weights. In particular, a directed weighted network is defined when the direction of the connections is relevant together with weights attached to ties. Hence, temporal, directed, weighted are built considering students' flows (outgoing and incoming) among countries.

The paper is organized as follows. Section 2 introduces a review of related works. Section 3 describes the methodological approach for exploring mobility data and country indicators along with the main research questions. Section 4 introduces and describes the data. Section 5 reports the main findings of the study. The paper ends with suggestions for future lines of research (Sect. 6).

2 Review of Related Literature

International student mobility, particularly Erasmus mobility, is considered an important instrument for the Europeanisation of EU member states, since it contributes to the development of the European dimension and of intercultural competencies, which are essential for economic development in a globalized world.

The benefits of participating in a study-abroad programme during university are reported in several contributions. Studying abroad contributes to the growth of students' abilities, language competencies and intercultural skills. Moreover, these students seem to work in higher-status employment sectors, they are more likely to have international jobs, and they are also less likely to remain unemployed after graduation (González et al. 2001; King and Ruiz-Gelices 2003; Teichler 2004; Norris and Gillespie 2009; Pary and Waldinger 2011; Ballatore and Ferede 2013; Natek and Lesjak 2013; Amendola and Restaino 2017). Apart from personal benefits, other aspects, such as shared European cultural values and integration, have received attention in the literature (Rodríguez et al. 2011; Mitchell 2012; Souto-Otero et al. 2013; Böttcher et al. 2016; Shields 2019). To capture the structural features and patterns of

student mobility across countries, the network concept has gained wide acceptance (Chen and Barnett 2000; Chadee and Naidoo 2009; Jiang 2014). Erasmus student mobility, indeed, can be described as a network between higher education institutions, the nodes being the universities/countries involved in the exchange and the links the number of students going abroad. Hence, the social network analysis approach (Wasserman and Faust 1994) has been applied in several studies at the international level to better understand the complexity of students' mobility flows between countries by identifying feeder and storer actors, that is, good importers and good exporters (Chen and Barnett 2000; Jiang 2014; Barnett et al. 2016; Macrander 2017; Kondakci et al. 2018); by analysing the directions and the intensity of this phenomenon (Derszi et al. 2011; Shields 2013; Breznik and Ragozini 2015; Breznik and Dakovic 2016; Barnett et al. 2016; Breznik 2017); and by capturing the structural features and the patterns of student mobility across different countries investigating the factors pulling and pushing students to complete their higher education abroad (Breznik et al. 2013; Barnett et al. 2016).

The following points summarize some of the main results discussed in the literature describing the international students exchange programme with a network approach:

- The international student network has changed significantly over the past 20 years (Barnett and Wu 1995). While the United States and some developed Western countries have remained at the center of the network, Asian and Middle Eastern countries have become more central, while African countries remain more peripheral in the network. These changes reflect not only the hierarchical structure of the hegemonic powers in the modern world system, but also economic changes over this time period.
- The network of collaboration generated by the Erasmus student mobilities can be analysed with a simple model to reproduce the observed characteristics and topological and weighted features (Derszi et al. 2011). Student exchange agreements are made by professors through their personal professional contacts. Therefore, the Erasmus student mobility network could indirectly describe the collaboration network of academic staff working in European universities.
- Three groups of countries are revealed in the Erasmus student network (Breznik et al. 2013): good importers and exporters, good importers, and good exporters only. The first group is dominated by Mediterranean countries (except for Germany). The second group contains Northern European countries, such as Denmark, the United Kingdom, Ireland, Finland and Sweden. The third group includes countries of Continental Europe, such as Belgium, the Netherlands and Austria, and two additional Western European countries: Czech Republic and Poland.
- The antecedents of the mobility structure of international students at the macro-level are ascertained by considering the physical distance between capitals, common borders and common languages shared by countries (Barnett et al. 2016).
- The patterns and dynamics of international student mobility revealed that international student mobility is not only an issue of the economically developed, politically stable, and academically advanced Western countries, but also a concern for countries with different economic, political, and academic characteristics (Kondakci et al. 2018).

3 Methodological Approach

As underlined in Sect. 2, a social network analysis (SNA) perspective offers useful tools for capturing and analysing the structural characteristics and the patterns of students' mobility flows.

Erasmus mobility can be described as a network in which countries represent the nodes (\mathcal{N}) and student exchanges between countries define the links (\mathcal{L}) between them. The number of students involved in this exchange represents the weight (\mathcal{V}) of each link. Thus, the weighted directed graph $\mathbf{G}_v(\mathcal{N}, \mathcal{L}, \mathcal{V})$ describing the network consists of the following: a set of nodes, $\mathcal{N} = n_1, n_2, \dots, n_g$, a set of lines (or arcs), $\mathcal{L} = l_1, l_2, \dots, l_L$, and a set of values, $\mathcal{V} = v_1, v_2, \dots, v_L$, attached to the links. The corresponding adjacency matrix \mathbf{A} is both directed with a link from the origin country to the destination country and weighted with elements $a_{ij} = 0$ if country $i \in \mathcal{N}$ does not send a link to country $j \in \mathcal{N}$ and $a_{ij} > 0$ otherwise.

The use of SNA methods in the Erasmus mobility framework becomes a key strategy to achieve a comprehensive understanding of student flows among countries. Apart from the description of the interactions among the network's members, the general aims are to identify countries that play central roles and to discover the presence of a particular configuration of the whole network structure.

To acquire this information, different network centrality measures can be adopted to recognize countries with dominant positions into the network (Freeman 1979). Among them, the hub (HUB) and authority (AUT) centrality scores (Kleinberg 1999) are here computed to identify which countries are good exporters and/or good importers in the student mobility flow. By definition, a country has a high authority score if it is linked by many different hubs. A good authority is a country that is pointed to by many good countries, that is, *good importer*. A country is a hub if it points to many other countries. A good hub is one that points to many good authorities, that is, *good exporter*. A country can play both roles, being an authority and a hub.¹

Given the adjacency matrix \mathbf{A} , the algorithm to compute hub and authority scores for each country consists of an iterative procedure providing a rank for all the countries involved in a network. The algorithm (Kleinberg 1999) maintains and updates numerical weights for each country. Thus, for each country, negative authority hub weights are not computed. These weights are normalised so that their squares sum to 1 and countries with larger values are the better authorities and hubs, respectively.

Kleinberg's algorithm solution for authority and hub scores converges to the dominant eigenvector of the cross-product of matrix \mathbf{A} with its transpose \mathbf{A}^T :

$$\begin{aligned} \text{AUT} &\Rightarrow \mathbf{A}^T \times \mathbf{A} \\ \text{HUB} &\Rightarrow \mathbf{A} \times \mathbf{A}^T. \end{aligned}$$

Furthermore, when the interest is analysing the tendency of countries to exchange students with countries similar to themselves, a network measure, called the $E - I$ index (Krackhardt and Stern 1988), can capture the presence of homophily behaviours among countries

¹ Note that, in the following analyses, we report the main findings by using absolute values in the Erasmus student mobility networks. The results obtained after performing the procedure for the normalisation of the link weights proposed in the related literature (Breznik et al. 2013; Breznik and Ragozini 2015) have shown similar results in terms of countries' ranking position.

according to additional information. Given a partition of a network into a number of mutually exclusive groups, this index represents the number of ties external to the group minus the number of ties that are internal to the group divided by the total number of ties:

$$E - I \text{ index} = \frac{E - I}{E + I}$$

with E is the number of external links and I the number of internal links. The $E - I$ index ranges from -1 , when all links are internal to the partitions (homophily behaviour), to $+1$, when all links are external to the partitions (heterophily behaviour). $E - I = 0$ when links are balanced into internal and external ties.

By considering the aggregation of countries in macro-areas as attribute data, the index allows defining countries' behaviours regarding student mobility. In particular, a European macro-area shows a *heterophily behaviour* if student flows take place within countries belonging to different European macro-areas, and a *homophily behaviour* if students move within countries belonging to the same macro-area.

In addition, to discover the whole network configuration for Erasmus student mobility, a type of clustering for network data (*blockmodeling*) (Lorrain and White 1971; Batagelj and Ferligoj 2000) is considered, aiming at grouping actors according to equivalence concepts and reducing the network to a simpler graph in which connections within and between clusters of equivalent actors are displayed.

Two approaches can be pursued in blockmodeling analysis (Batagelj et al. 1992; Doreian et al. 2005). In the *indirect approach*, network data are first transformed into a compatible (dis)similarity matrix, such as considering Euclidean distance between pairs of nodes, and then an appropriate clustering criterion function (e.g. the Ward clustering method) is adopted to identify the number of clusters. In the *direct approach*, instead, the adjacency matrix is directly analysed and the number of clusters are decided either inductively or deductively by setting theoretical and context-specific considerations. The approach to deal with weighted network data are also discussed in the literature (Žiberna 2007, 2008).

In the following, for analysing the Erasmus student mobility network configuration, an indirect blockmodeling approach is adopted.

Finally, the network results are enriched by considering exploratory data analysis methods (i.e. principal component analysis and hierarchical clustering) applied to both higher educational indicators and network measures to reveal connections between the roles played by countries in the student mobility network and their investments in education as a key element of institution's attractiveness.

3.1 Research Questions

Equipped with these theoretical and methodological frameworks, the present contribution aims at answering the following research questions:

1. The number of students exchanges between EU countries is growing faster over the time, revealing a high sensibility to the internationalisation process in tertiary higher education [**RQ1**] (Sect. 5.1).
2. The countries in the Erasmus student mobility can be classified as good exporters or good importers or both, as in other previous works [**RQ2**] (Sect. 5.2).

3. European macro-areas present a higher propensity to share students by countries in different geographical areas, showing a heterophily behaviour in activating new international links [RQ3] (Sect. 5.3).
4. The pattern of Erasmus student mobility across countries resembles the typical style observed in the literature. In particular, the core-periphery structure appears as the most emerging underlying mechanism to explain student mobility, consisting of *core countries* that are densely interconnected and connected to peripheral countries, and *peripheral countries* that are not densely interconnected among them. Furthermore, the characteristics of the incoming-outgoing flows of Erasmus students between European countries is affected by the attractiveness of universities at country level measured by several indicators related to the investments in higher education [RQ4] (Sect. 5.4).

4 Data Collection

The data on Erasmus student mobility flows are downloaded from the official European Commission website on Erasmus-Statistics.² The period under analysis consists of six academic years from 2008–2009 to 2013–2014. Two types of Erasmus mobility of students enrolled at higher education institutions are analysed: the *Student Mobility for Studies* (SMS), which enables students to spend study periods in other countries, and the *Student Mobility for Placement* (SMP), which enables students to spend placement periods (traineeship or internship) in enterprises or organizations in other countries. In both cases, the period abroad can last from 3 to 12 months.

The information available in the datasets are the following:

- the IDs of sending and hosting Erasmus Partners;
- the name of sending and hosting Erasmus Partners;
- the sending and hosting countries;
- the students' genders;
- the subject area codes;
- the types of mobility (SMS or SMP);
- the levels of study (first cycle, second cycle, third cycle and short cycle); and
- the duration of mobility in months.

In addition, to inspect the attractiveness of universities, several indicators downloaded from the Eurostat website and related to specific features of the Tertiary Education System are added as further information in the analysis (Table 1).

To better explain international mobility flows, the aggregation of European countries in five macro-areas (Northern Europe, Western Europe, Eastern Europe, Central Europe and Southern Europe) is considered in the analysis.

² For details see <https://data.europa.eu/euodp/en/data/publisher/eac>.

Table 1 List of indicators downloaded from the Eurostat website

Index	Label
Enrolment in tertiary education	I1
Expenditure on tertiary as a percentage of government expenditure on education	I2
Net flow ratio of internationally mobile students (inbound - outbound)	I3
School age population, tertiary education	I4
Government expenditure on education as a percentage of Gross Domestic Product (GDP)	I5
Gross enrolment ratio, tertiary	I6
Graduates from tertiary education	I7
Expenditure on education as a percentage of total government expenditure	I8
Government expenditure on tertiary education as a percentage of Gross Domestic Product (GDP)	I9
Teachers in tertiary education programmes	I10
Inbound mobility rate	I11
Expenditure on tertiary as a percentage of total government expenditure	I12
Total outbound internationally mobile tertiary students studying abroad	I13
Total inbound internationally mobile students	I14
Outbound mobility ratio	I15
Gross outbound enrolment ratio	I16

Table 2 Distribution of Erasmus students mobility between 2008–2009 and 2013–2014

Year	Total number of exchanges	#. of exchanges		Average duration (in month)	
		SMS	SMP	SMS	SMP
2008–2009	198,523	168,193	30,330	6.4	< 3
2009–2010	213,266	177,705	35,561	6.4	4.2
2010–2011	231,408	190,495	40,913	6.4	4.3
2011–2012	252,827	204,744	48,083	6.3	4.3
2012–2013	268,143	212,522	55,621	6.2	4.7
2013–2014	272,497	212,208	60,289	6.2	4.4

Our elaboration is based on *Erasmus Facts, Figures and Trends*, for the years considered. The report is available on the official European Commission website on Erasmus-Statistics

5 Data Analysis and Findings

Table 2 shows the distribution of Erasmus students for SMS and SMP. An increasing trend in the total number of exchanges and in the mobility for studies is observed expect for the last year 2013–2014 where the mobility for studies registered a moderate decrease of -0.14% on the previous year. The mobility for placement increased steadily from 2008–2009 to 2013–2014, doubling the number of students involved. The average length of stay is quite stable, expect for SMP, which registered an increase in 2009–2010.

To study the temporal changes and the networks' characteristics that occurred in the six academic years under analysis, 12 weighted directed adjacency matrices are defined. Each matrix describes the students flows among countries involved in the Erasmus programme

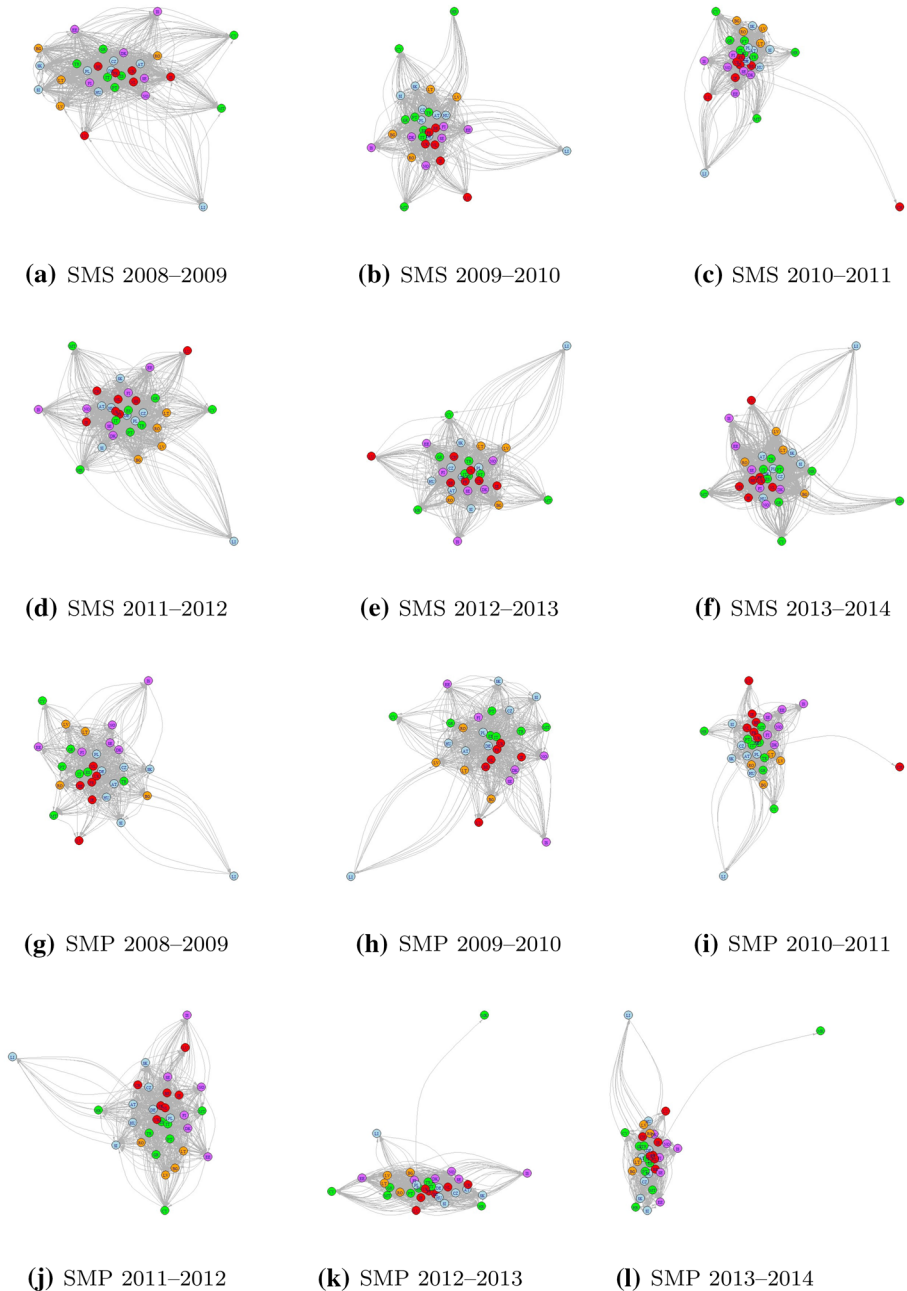


Fig. 1 Graphical visualisation of Erasmus student mobility networks for studies (SMS) and for placement (SMP) according to European macro-areas' aggregation of countries, from 2008–2009 to 2013–2014. Node colour: red = Western Europe, orange = Eastern Europe, light blue = Central Europe, green = Southern Europe, and violet = Northern Europe. (Color figure online)

Table 3 Number of countries involved in the Erasmus student mobility networks for studies (SMS) and for placement (SMP) from 2008–2009 to 2013–2014

Academic year	SMS			SMP		
	Country	# Links	# Students	Country	# Links	# Students
2008–2009	31	807	168,193	31	646	30,330
2009–2010	32	823	177,705	31	690	35,561
2010–2011	33	839	190,495	33	705	40,913
2011–2012	33	919	204,744	33	796	48,083
2012–2013	33	910	211,995	34	833	55,552
2013–2014	34	928	212,208	34	841	60,289

for each academic year. In the following, the main findings obtained according to the four research questions described above are reported.

5.1 Trend of Erasmus Student Mobility

Figure 1 display the network visualisations of the 12 weighted adjacency matrices, showing the increasing relationships among countries for the SMS and SMP networks over the time. The graph visualisations are enriched by colouring the nodes according to European macro-areas' aggregation.

The structure of the temporal networks shows a little increase in terms of involved countries and links among them. Specifically, the number of nodes for the SMS and SMP networks increases from 31 countries in 2008–2009 to 34 countries in 2013–2014, and the number of links goes up from 807 links in 2008–2009 to 928 links in 2013–2014 in the SMS network and from 646 links in 2008–2009 to 841 links in 2013–2014 for the SMP network (Table 3).

As underlined in Sect. 4, the Erasmus mobility networks have mainly changed in terms of number of students involved in the programme, representing the weights of the links between pairs of countries. In general, the number of students who joined the Erasmus programme increased. A remarkable difference between the two networks is observed. The number of students who moved for study is greater than the number of students who moved for placement. In particular, it goes up from 168,193 in 2008–2009 to 212,208 in 2013–2014 for the SMS network (+ 26.2%) and from 30,330 in 2008–2009 to 60,289 in 2013–2014 for the SMP (+ 98.8%).

5.2 A Ranking of European Countries

The evolution of the two Erasmus networks in terms of incoming and outgoing students in each European country is explored through the variation (%) between the first and the last year for the SMS and SMP. Tables 4 and 5 show, respectively, the number of outgoing and incoming students for the first and last years under analysis (the first four columns), and the variation (in %) between the two time periods (2008–2009 and 2013–2014) (the fifth and sixth columns, respectively) for each country. In general, the percentage of variation is almost always positive, indicating an increase in the number of students involved in the Erasmus programme.

Table 4 Number of incoming and outgoing students in the Erasmus student mobility for studies (SMS) and hub and authority scores for all countries for 2008–2009 and 2013–2014

Country	2008–2009		2013–2014		% Variation		2008–2009		2013–2014	
	Outgoing	Incoming	Outgoing	Incoming	Outgoing	Incoming	Hub	Auth	Hub	Auth
AT	4053	4039	4556	4934	12.41	22.16	0.16	0.10	0.14	0.12
BE	5041	5283	6247	6402	23.92	21.18	0.23	0.15	0.22	0.20
BG	1283	393	1305	612	1.71	55.73	0.04	0.01	0.04	0.01
CH	–	–	2702	2611	–	–	–	–	0.10	0.08
CY	144	234	285	527	97.92	125.21	0.00	0.01	0.01	0.01
CZ	5440	3764	6193	5848	13.84	55.37	0.18	0.10	0.17	0.15
DE	23,407	17,722	29,983	22,809	28.09	28.70	1.00	0.47	1.00	0.60
DK	1648	5273	2581	4911	56.61	– 6.87	0.07	0.15	0.09	0.15
EE	551	591	716	1059	29.95	79.19	0.02	0.02	0.02	0.03
ES	24,399	28,175	30,621	30,275	25.50	7.45	0.81	1.00	0.87	1.00
FI	3436	6115	4339	6618	26.28	8.23	0.13	0.19	0.13	0.22
FR	23,560	20,955	26,921	24,057	14.27	14.80	1.00	0.63	0.86	0.74
GR	2737	1946	3456	1763	26.27	– 9.40	0.11	0.05	0.11	0.05
HR	–	–	1070	746	–	–	–	–	0.03	0.02
HU	3518	2205	3059	3967	–13.05	79.91	0.11	0.06	0.09	0.11
IE	1421	4061	2121	4821	49.26	18.71	0.07	0.17	0.08	0.18
IS	186	353	194	487	4.30	37.96	0.01	0.01	0.01	0.02
IT	17,754	15,530	21,889	16,872	23.29	8.64	0.92	0.50	0.88	0.55
LI	20	34	25	36	25.00	5.88	0.00	0.00	0.00	0.00
LT	2425	1117	2327	2082	– 4.04	86.39	0.06	0.03	0.06	0.05
LU	426	53	431	109	1.17	105.66	0.02	0.00	0.02	0.00
LV	1104	401	1367	976	23.82	143.39	0.03	0.01	0.03	0.03
MK	–	–	89	0	–	–	–	–	0.00	0.00
MT	142	355	151	480	6.34	35.21	0.00	0.01	0.00	0.01
NL	4902	6894	7231	8368	47.51	21.38	0.20	0.20	0.23	0.24
NO	1317	3041	1558	4226	18.30	38.97	0.05	0.11	0.05	0.15
PL	11,784	4528	11,384	10,593	– 3.39	133.94	0.41	0.13	0.35	0.32
PT	4834	5732	5325	9020	10.16	57.36	0.19	0.17	0.16	0.27
RO	3064	990	3683	1704	20.20	72.12	0.13	0.03	0.12	0.05
SE	2413	8206	3324	8874	37.75	8.14	0.10	0.29	0.11	0.31
SI	1132	991	1277	1677	12.81	69.22	0.04	0.02	0.03	0.04
SK	1703	787	2568	1247	50.79	58.45	0.05	0.02	0.06	0.03
TR	6920	2360	12,948	5843	87.11	147.58	0.20	0.07	0.33	0.19
UK	7429	16,065	10,282	17,654	38.40	9.89	0.36	0.61	0.43	0.63

AT Austria, BE Belgium, BG Bulgaria, CH Switzerland, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GR Greece, HR Croatia, HU Hungary, IE Ireland, IS Iceland, IT Italy, LI Liechtenstein, LT Lithuania, LU Luxembourg, LV Latvia, MK Macedonia, MT Malta, NL Netherlands, NO Norway, PL Poland, PT Portugal, RO Romania, SE Sweden, SI Slovenia, SK Slovakia, TR Turkey, UK United Kingdom

Table 5 Number of incoming and outgoing students in the Erasmus student mobility for placement (SMP) and hub and authority scores for all countries in 2008–2009 and 2013–2014

Country	2008–2009		2013–2014		% Variation		2008–2009		2013–2014	
	Outgoing	Incoming	Outgoing	Incoming	Outgoing	Incoming	Hub	Auth	Hub	Auth
AT	886	689	1237	1254	39.62	82.00	0.17	0.13	0.12	0.08
BE	904	1563	1507	2.919	66.70	86.76	0.18	0.28	0.12	0.32
BG	137	121	452	282	229.93	133.06	0.02	0.02	0.03	0.02
CH	–	–	334	1.624	–	–	–	–	0.03	0.16
CY	13	160	110	276	746.15	72.50	0.00	0.01	0.01	0.01
CZ	605	407	1317	1020	117.69	150.61	0.10	0.05	0.11	0.07
DE	4487	4210	6274	8155	39.83	93.71	0.87	0.60	0.52	0.61
DK	475	364	1129	868	137.68	138.46	0.07	0.06	0.09	0.06
EE	207	117	294	243	42.03	107.69	0.03	0.01	0.02	0.01
ES	3006	4997	6614	9002	120.03	80.15	0.48	1.00	0.50	0.81
FI	975	490	1230	661	26.15	34.90	0.16	0.07	0.10	0.05
FR	4723	3659	9838	5564	108.30	52.06	1.00	0.69	1.00	0.42
GR	292	903	1014	1241	247.26	37.43	0.05	0.07	0.08	0.06
HR	–	–	333	241	–	–	–	–	0.02	0.01
HU	539	271	966	797	79.22	194.10	0.08	0.04	0.07	0.04
IE	415	1090	851	1801	105.06	65.23	0.10	0.24	0.10	0.22
IS	12	61	43	187	258.33	206.56	0.00	0.01	0.00	0.01
IT	1622	1962	4442	3332	173.86	69.83	0.37	0.33	0.44	0.27
LI	2	13	5	32	150.00	146.15	0.00	0.00	0.00	0.00
LT	575	100	1096	385	90.61	285.00	0.06	0.01	0.06	0.02
LU	0	224	3	476	–	112.50	0.00	0.06	0.00	0.05
LV	358	79	818	255	128.49	222.78	0.04	0.01	0.04	0.02
MK	–	–	0	1	–	–	–	–	0.00	0.00
MT	9	261	79	1498	777.78	473.95	0.00	0.06	0.01	0.15
NL	2103	1187	3407	2.183	62.01	83.91	0.42	0.23	0.35	0.19
NO	93	361	108	580	16.13	60.66	0.01	0.06	0.01	0.04
PL	1618	395	4137	1100	155.69	178.48	0.26	0.06	0.33	0.09
PT	560	500	1632	1410	191.43	182.00	0.12	0.07	0.16	0.10
RO	680	216	2059	485	202.79	124.54	0.13	0.04	0.12	0.04
SE	270	634	396	1138	46.67	79.50	0.04	0.12	0.03	0.10
SI	176	87	515	234	192.61	168.97	0.03	0.01	0.04	0.01
SK	317	126	609	323	92.11	156.35	0.04	0.02	0.03	0.02
TR	874	298	2112	975	141.65	227.18	0.15	0.05	0.19	0.07
UK	3397	4785	5328	9747	56.84	103.70	0.74	0.97	0.47	1.00

AT Austria, BE Belgium, BG Bulgaria, CH Switzerland, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GR Greece, HR Croatia, HU Hungary, IE Ireland, IS Iceland, IT Italy, LI Liechtenstein, LT Lithuania, LU Luxembourg, LV Latvia, MK Macedonia, MT Malta, NL Netherlands, NO Norway, PL Poland, PT Portugal, RO Romania, SE Sweden, SI Slovenia, SK Slovakia, TR Turkey, UK United Kingdom

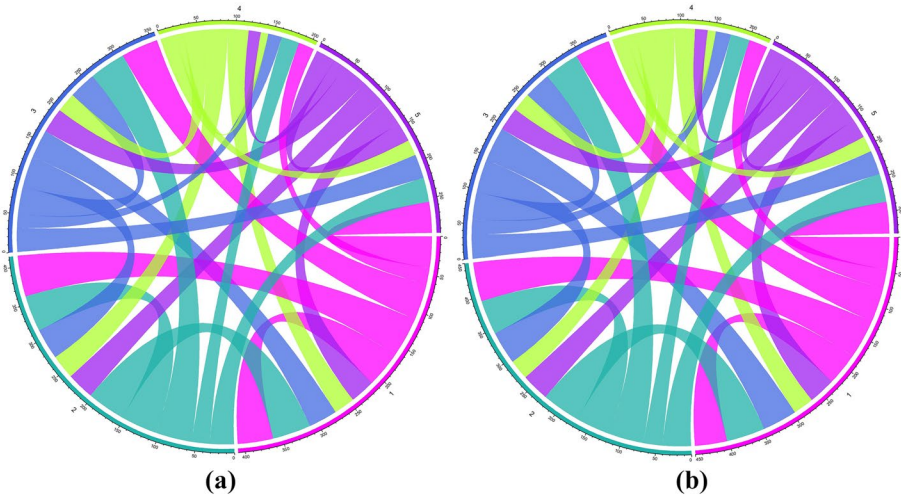


Fig. 2 Erasmus student mobility for studies (SMS) and for placement (SMP) according to European macro-areas' aggregation in 2013–2014. Region colour: fuchsia = Central Europe, green = Southern Europe, blue = Western Europe, yellow = Eastern Europe, purple = Northern Europe. (Color figure online)

By focusing the attention on the five countries where student mobility flows are a well-known phenomenon (Spain, France, Germany, Italy and the United Kingdom), for the SMS network, the number of incoming students is less than the number of the outgoing ones for France, Germany and Italy, while the opposite situation is observed in the United Kingdom and Spain. Moreover, for the year 2013–2014, Spain is the country with almost the same number of incoming and outgoing students.

Almost the same scenario occurs in the SMP network, even if students' flows are much lower. The United Kingdom and Spain show higher incoming than outgoing students, while the reverse is observed in France. Italy shows opposite behaviours in both years: in 2008–2009, incoming students are higher than the outgoing one and vice versa in 2013–2014. Instead, for Germany in 2008–2009, the number of incoming students is less than those outgoing and vice versa in 2013–2014.

By considering the results described above, countries are classified as *good exporters* or *good importers* by means of the *hub* and *authority* network centrality indices.³ Tables 4 and 5 show the hub and authority scores (the last four columns) for each country in the SMS and SMP networks defined for the years 2008–2009 and 2013–2014.

Looking at the authority scores of the SMS network, the best importing countries are Spain, France and the United Kingdom, since they occupy the top positions in the authorities' ranking; while Germany and France show the highest hub scores, taking up the top positions in the hubs' ranking. For almost all the years, Spain is both the best authority and the best hub country in the SMS network. In both rankings, Italy is always in the top five positions. In particular, it is in a better position in the hub scores rankings, showing a better exporting than importing behaviour in the SMS network.

³ Since no particular differences emerge in the ranking obtained by sorting countries according to the hub and authority scores computed for all years, the results are reported for the first and last academic years.

Regarding the SMP network, the rankings of countries by authority scores show that the best importing countries for Erasmus placement are the United Kingdom and Spain. At the same time, the best exporting countries are France and Germany, showing the highest hub scores. Italy has a marginal role in the SMP network, since it is between the fifth and the sixth positions.

5.3 Homophily Behaviour of European Macro-areas

A circlesize graph layout (chord diagrams) is drawn to show the student flows among European countries in 2013–2014 and to describe the propensity to share students in the SMS and SMP networks. Figure 2 describes the relationships among countries classified into five macro-areas (see Sect. 4), where the links between countries in the same European macro-areas and outside them are shown by different colours according to each country's propensity to in-group and out-group student exchanges.

The two graphs highlight the heterogeneity of the links between European macro-areas, as confirmed by the $E - I$ index. For both networks, the values at the whole network level are around 0.60, showing an heterophily behaviour of European macro-areas in sharing students from different geographical areas. These results are stable over time.

5.4 Towards a Core-Periphery Network Configuration and University Attractiveness

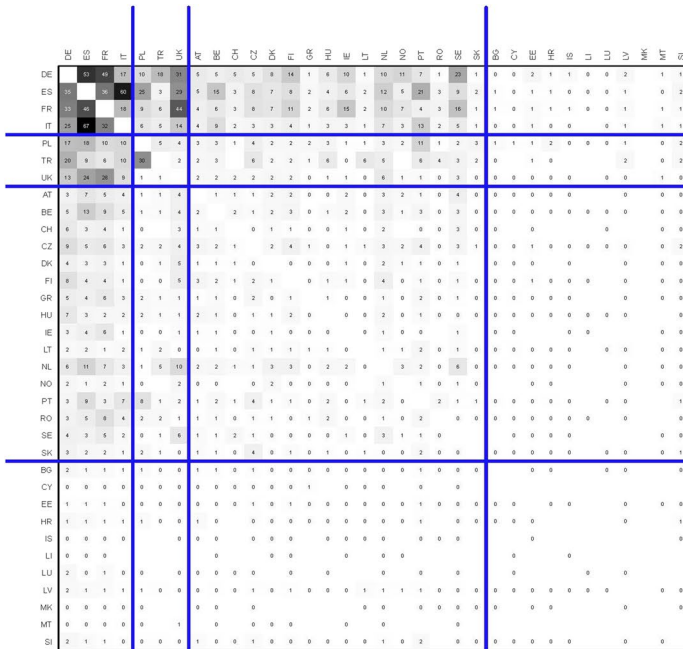
The definition of homogeneous groups of countries is carried out by performing an indirect blockmodeling approach on the SMS and SMP networks for 2013–2014.

For the SMS, a clear network partition into four groups is observed. Figure 3a shows the permuted adjacency matrix according to the derived partition, highlighting the presence of a core-periphery network configuration, characterized by the following:

- Two small, dense *core groups* of four countries (Germany, Spain, France and Italy) and three countries (Poland, Turkey and the United Kingdom) in which a relevant amount of students' exchanges appears within and between countries being in the all four groups.
- One *semi-peripheral group* composed of 16 countries that, on the one hand, share students in the Erasmus programme with the core countries and, on the other hand, have few ties with the other countries in the periphery.
- One sparse, unconnected *peripheral group* consisting mainly of 11 small countries characterized by a reduced experience in the Erasmus student programme.

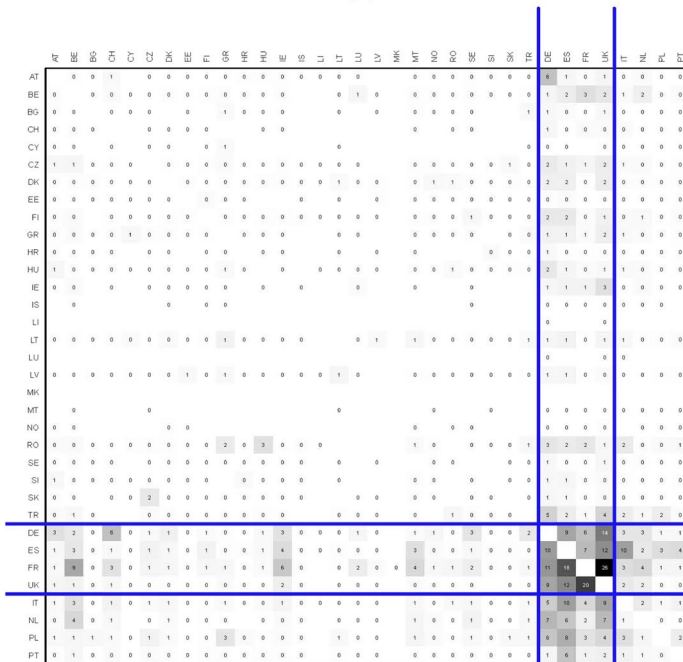
A different configuration is obtained for the SMP network in which a solution in three groups seems to better describe the relationships among countries for students placement exchange. The three groups' solution in Fig. 3b shows the presence of two small, dense *core groups* with four countries each (Germany, Spain, France and the United Kingdom in the first, and Italy, Poland, Portugal and the Netherlands in the second) that share several connections within and between clusters; on the other hand, one *semi-peripheral group* is composed of countries that mainly exchanges students for placement with the two core countries and with few links among internal countries.

To better describe the core-periphery network configuration, principal component analysis (PCA) and hierarchical clustering are performed for SMS and SMP networks considering the hub and authority scores and the indicators of the Tertiary Education



* all values in cells were multiplied by 0.01

(a)



* all values in cells were multiplied by 0.01

(b)

Fig. 3 Permutated adjacency matrices of Erasmus student mobility for studies (SMS) and for placement (SMP) according to the derived partitions

System (as listed in Table 1) as input variables. These analyses are useful for linking international students' mobility and the attractiveness of universities measured by means of some educational indicators related to the investments in higher education. Section 4 contains the list of indicators.

The first and second principal components explain the 62.78% of the total variance for the SMS and the 61.73% for the SMP. Looking at the indicators correlated with the first two axes, this first one is characterized by the roles of countries (central or periphery) in the Erasmus mobility networks and the indicators related to people working and studying in higher education institutions. In particular, on the right side of the first axis, there are the countries with a central role in both networks and with a higher number of people involved in the education system (students and professors), while on the left side contains those with peripheral roles and few people involved in education. The second axis is then characterized by the indicators that measure the expenditures on education: the countries with higher investments at the top, the countries with lower investments at the bottom.

Based on the PCA results, an agglomerative hierarchical clustering is performed using the Ward's criterion to identify the presence of homogeneous clusters of countries involved in the two networks.

It is possible to identify *three clusters* in both cases (see Fig. 4), confirming the previous classification obtained by performing the indirect blockmodeling approach. The 34 countries joining the Erasmus programme for studies and for placement are grouped as follows:

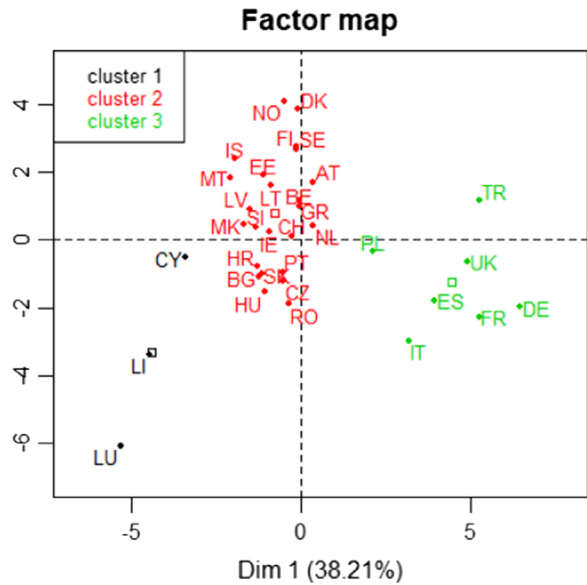
- *cluster 1* (7 countries): Germany, Spain, France, Italy, Poland, Turkey and the United Kingdom;
- *cluster 2* (24 countries): Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, Greece, Croatia, Hungary, Ireland, Iceland, Lithuania, Latvia, Macedonia, Malta, the Netherlands, Norway, Portugal, Romania, Sweden, Slovenia, Slovakia and Switzerland;
- *cluster 3* (3 countries): Cyprus, Liechtenstein and Luxembourg.

The countries in *cluster 1* are the most central ones in the SMS and SMP networks, with the highest hub and authority scores. This cluster comprises the first participating countries in the programme, i.e., the long runner countries, Poland marking the eastward expansion of the Erasmus programme by joining it in 1998 marking and Turkey entering the programme in 2004. These two last countries are called short runners.

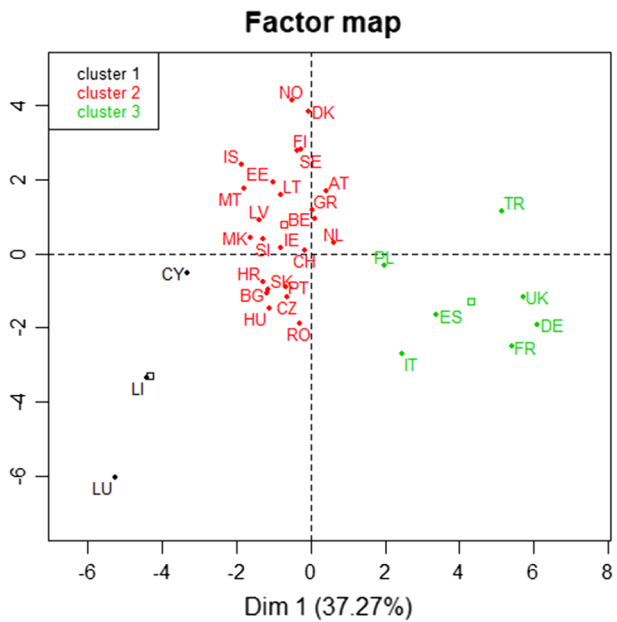
Cluster 3 merges the less central countries in the networks, showing the lowest hub and authority scores. These are small countries that did not participate in the initial phase of the Erasmus programme, except for Luxembourg.

All the countries in *cluster 2* are further grouped to highlight more homogenous partitions. In particular, cluster 2 has been split into three partitions. The first comprises Northern long runner countries (Denmark, Finland, Iceland, Norway and Sweden) with one short runner country (Malta) that joined the programme in 2000. These countries also have hub and authority scores closest to 0. The second partition includes long runner countries (Austria, Belgium, the Netherlands, Greece and Ireland) with some Eastern countries (Estonia, Lithuania, Latvia and Slovenia) and Macedonia, which joined the programme in 2014. In the third partition, there are the Eastern short runner countries, (Czech Republic, Hungary, Romania, Slovakia and Bulgaria) with one Western long runner country (Portugal) and Croatia, which joined the programme in 2009.

Fig. 4 Factorial map of the first two principal components on educational indicators in Erasmus student mobility for studies (SMS) and for placement (SMP). Nodes are coloured according to the three clusters' solutions



(a) SMS 2013–14



(b) SMP 2013–14

6 Conclusion

The present contribution focused on the analysis of the Erasmus student mobility flows to examine the roles played by European countries in the internationalisation process

that characterizes universities. The data were downloaded from the EU Open Data Portal and were related to the characteristics of student mobility for study and placement. Thanks to a joint strategy of analysis based on main instruments of social network analysis (SNA) and exploratory data analysis, it was possible to answer the four research questions.

The main results of the analysis can be synthesized as follows:

- The number of students exchanges between EU countries has been growing faster over time.
- Few countries, especially those in the Mediterranean area (Spain, Italy, France and Germany), were classified as good exporters and/or good importers.
- A higher propensity to share students from different European macro-areas was found. In more detail, students are willing to go to countries in European macro-areas different than their home countries.
- A core-periphery network configuration seems to emerge consisting of a few big countries with consistent investments in higher education that share students among them and with peripheral countries, on the one hand, and many small, peripheral countries characterized by recent experiences in Erasmus programme with promising investments, on the other.
- The incoming-outgoing flows of Erasmus student mobility between European countries are related to the investment in higher education when it is considered an indicator of countries' attractiveness.

As future research proposal, since the present contribution adopted an indirect blockmodeling approach primarily as an exploratory tool, a direct approach could be adopted to further investigate the network structure by setting up ideal configurations on the basis of theoretical hypotheses. A deeper investigation of the relationship between network dynamics and country attractiveness is required. Several socio-economic indicators should be collected to describe the geographical distribution of hosting and sending countries, to examine each country's position in the Erasmus student mobility network and to study the underlying mechanisms by applying statistical modeling. Moreover, we will investigate whether there exist some differences in network dynamics in terms of subject area, gender and level of study. Finally, a further sensitivity analysis of the stability of the obtained results could be of interest according to the various normalisation criteria proposed in the literature (Batagelj et al. 2014) to consider the number of students that are actually studying in the years analysed by filtering the effect of countries with larger student populations with respect to small countries who seem to share a reduced number of units in the Erasmus student mobility flows.

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