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NETWORK ANALYSIS OF INTER-COUNTRY EXPORT PATTERNS IN THE EU: IMPLICATIONS FOR SMALL STATES[1]

Abstract. *We employ a network analysis approach to study inter-country export patterns of EU member states. We employ three weighted centrality measures to analyse the importance of individual member states in the network. We focus specifically on so-called small states and their structural importance in the network. By employing weighted generalised blockmodeling, we identify five specific blocks of countries. Network visualisations further show a strong core-periphery structure in our network, as well as two specific groups of countries with higher relative intra-group trade (called cliques in network analysis). Our results offer important implications for the theory of export patterns of small states and show that small states do not necessarily focus their exports more on neighbouring markets compared to large states.*

Keywords: *network analysis, export patterns, European Union member states, weighted centrality measures, weighted generalised blockmodeling, export patterns of small states*

Introduction

The application of network analysis – a methodological field originating in sociometry of the early 20th century (Freeman, 2004) – is still believed to be relatively new in the economics and business literature (Jackson, 2008; Goyal, 2011) despite the netisation of economics (Fulik, 2001) and talk of a network economy (Barabasi, 2003).

Here, we would like to point out to the clear distinction between the metaphoric use of network terminology (Alajoutsijärvi, Eriksson and

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[1] *The authors would especially like to thank Peter V. Marsden (Harvard University) and Anuška Ferligoj (University of Ljubljana) for their comments and suggestions on how to improve the paper.*

Tikkanen, 2001), the cognitive-linguistic framework of network concepts (Smith-Doerr and Powell, 2005), the philosophical discourse related to the paradigmatic status of network theory (Borgatti and Foster, 2003), and the methodology of (social) network analysis. With respect to this diversity, Smith-Doerr and Powell (2005: 379) emphasise how one is never 'quite sure whether networks are a metaphor, a method, or a theory'. In any case, the issue of networks and their analysis has become much more complex than simply looking at networks as puzzle-solving prisms, explaining socio-economic interaction (Kilduff, Tsai and Hanke, 2006; Podolny, 2001). The use of network analysis also marks a long overdue departure of economics and business analysis from atomised individualism (Kahneman, 1994) towards interaction and embeddedness of economic behaviour.

The goal of this paper is to analyse the inter-county EU export patterns with appropriate network methodology, and particularly to shed light on the importance of so-called small states within this network. In addressing the latter, our key research question was: Are all small states the same / equally important (from a structural point of view) within the inter-country EU export network?

We use two specific types of methodological approaches in this paper: weighted centrality measures and weighted generalised blockmodeling. The three weighted centrality measures – degree centrality, closeness centrality and betweenness centrality – were proposed by Opsahl, Agneessens and Skvoretz (2009). Weighted generalised blockmodeling was developed by Žiberna (2007) and should be seen as an extension to traditional binary generalised blockmodeling of network data. Both of these methodological approaches represent fairly recent analytical advancements in network analysis and have not been previously employed in the international economics and business literature. We also focus in our analysis on the link between country size and export pattern diversification, following the work of Krugman (1980), Melitz (2003), Melitz and Ottaviano (2008), and Aakerman and Forslid (2007). In this regard, we provide an empirical contribution to the research on trade patterns of small states in an EU-27 inter-country network context.[2] The use of weighted centrality scores also sheds new light on the relative and unique importance of individual EU member states within the

[2] *Liou and Ding (2002) point to an absence of a consistent criterion for differentiating between small and large states. Population size seems to be the most widely employed criterion (Read, 2001). Having said this, the population cut-off values for small states range from 20 million proposed by UNIDO (1979) to 1.5 million used by the Commonwealth Secretariat (Commonwealth Advisory Group, 1997). In this paper, the small state population threshold is set at 5 million, as proposed by Collier & Dollar (1999); Looney, (1988); Jalan (1982). While Udovič & Svetličič (2007) note that the threshold value for small states is most frequently set in the literature at 10 million inhabitants, this value was set in the analysis of small states in a world-wide context. In our opinion, a 5 million inhabitant cut-off value is more appropriate for the EU-27 context.*

intra-EU export network. With regard to the importance of small states, we test two underlying research hypotheses: (1) small states tend to geographically concentrate their exports more on neighbouring countries; and (2) all EU small states occupy the same type of structural position in the intra-EU export network.

We approach the concept of networks and the field of network analysis from the perspective of a methodological approach, rather than a paradigm (Jackson, 2008). Due to its focus on actor interaction and relationships, rather than actor attributes, network analysis and theory is one of the few areas in social sciences that are not reductionist *per se*, and can be applied to a variety of levels of analysis in a society. This may range from small groups to entire global systems (Kadushin, 2004), including world trade patterns (Wasserman & Faust, 1994). In fact, despite the novelty of network analysis in the international economics and business literature, the earliest attempts of visualising and analysing international trade patterns date back to *The Network of World Trade* (League of Nations, 1942), followed by Hilgerdt's (1943) *The Case for Multinational Trade*.

Within the international economics literature, the issue of trade patterns has represented one of the central themes of economic analysis since the 1970s (Bowen, Hollander and Viaene, 1998). However, the analysis of trade patterns in this area has mainly involved the use of gravity and econometric modeling. Both focus on actor attributes and as methodologies assume independency of observations. More recently, however, the trade patterns stream of research within international economics has also seen a gradual employment of network analysis, which has enabled an extension of the traditional markets and hierarchies models (Williamson, 1975; Powell, 1990) to address issues of networks vs markets in international trade (Rauch, 1999), trade relationships as trade networks (see Fagiolo, Reyes and Schiavo, 2007 for an overview), strategic production factor trade flows – such as copper (e.g. Tong and Lifset, 2007), consumption network externalities and consumption patterns (e.g. Janeba, 2007), equity and foreign investment patterns (e.g. Portes and Rey, 2005), evolutionary processes of complex international networks (e.g. Liu et al., 2007), as well as the impact of trade agreements on international trade (e.g. Reyes, Wooster and Shirrel, 2009). Recently, the work by Hidalgo et al. (2007) and Hidalgo and Hausmann (2009) on export product spaces of countries, by Hidalgo and Hausmann (2008) on economic development, and the so-called Lego theory on the link between foreign trade, country capabilities and economic development has also gained much attention in the network-oriented international economics literature and broader.

This paper contributes to a growing research stream of analysing economic phenomena using network analysis. It analyses the inter-country per capita export data of EU member states for the year 2008 as *weighted* (valued) network data. We have decided to use data for 2008 because this was the last year before a huge economic downturn across most EU markets caused by the global economic and financial crisis. It has also impacted new member states, and smaller states in particular, which could bias our results.

The introduction is followed by a short theoretical overview of trade patterns in the international economics and international business literature, as well as the specifics of trade patterns of small states. In this section, we also outline our two research hypotheses. Next, we present an overview of methodological issues related to the analysis of inter-country trade patterns and the nature of analysing network data. Particular attention was paid to weighted network data and the corresponding centrality measures. This is followed by an overview of key results related to three kinds of weighted centrality measures, results from visual inspection of our network, and the optimal solution from weighted generalised blockmodeling. The paper concludes with a discussion of results and their implications; particularly with regard to export patterns of small states.

Short theoretical overview

Given the methodological focus of our paper, this section discusses only few of the most relevant issues related to the study and determinants of trade patterns in the international business and economics literature.

The interest of economics in foreign trade patterns goes back to the founding fathers of international economics in the early 19th century (Smith, 1776/1952; Ricardo, 1817/1955). The starting point of contemporary research on country trade patterns can be related to the Heckscher-Ohlin Endowment theory (Salvatore, 2011), upgraded by Stolper and Samuelson in 1941. This theory has been tested several times, however the 'devastating test' of its applicability was provided by Leontief (1954), whose results have never been totally rejected (Neary, 2004: 1; Rogowsky, 1987/2005: 390; Gandolfo, 1998: 86). After WWII, the world market structure faced immense changes (Udovič and Svetličič, 2007), which led to changing patterns of trade (Rogowsky, 1987/2005: 397–399) underlined by liberalisation (Goldstein, 1988/2005: 187), oligopolisation (Knickerbocker, 1973) and monopolisation of markets (Buckley and Casson, 1976). These trends were spearheaded by product differentiation (e.g. abandoning the presumption of homogenous commodities) (Penrose, 1958; Hymer, 1960; Krugman, 1980) and technology advancement (Linder, 1961; Posner, 1961; Vernon, 1966), and segmented the practice of international trade in two theoretical perspectives: international economics and international business. Table 1 provides an overview of the key authors related to the study of internationalisation in the context of trade patterns.

Table 1: KEY AUTHORS AND THEORETICAL APPROACHES RELATED TO INTERNATIONALISATION AND (DETERMINANTS OF) TRADE PATTERNS

	Key authors	Sources of internationalisation
International business approaches to internationalisation	Penrose (1958), Hymer (1960), Hymer (1968), Vernon (1966); Williamson (1975)	firm's sources (firm-specific factors)
	Knickerbocker (1973); Rugman (1975; 1979)	market characteristics (oligopolisation); market-specific factors (risk aversion)
	Aliber (1971)	financial motives (e.g. exchange rate)
	Uppsala/Scandinavian model (Johanson & Vahlne, 1977; Luostarinen, 1979)	firm-market-specific characteristics (step-by-step internationalisation)
	Kojima (1973; 1978)	country-specific characteristics (macroeconomic environment)
	Ozawa (1992)	production factors characteristics (advantages)
	Dunning (1981; 1988; 1993)	different sources (from firm- to market-specific) for internationalisation
International economics approaches to internationalisation	Lancaster (1979); Lancaster & Helpman (1981); Krugman (1979); Krugman (1980);	product differentiation (as source of internationalisation)
	Markusen (1981; 1984); Ethier (1982); Eaton-Kierzkowsky (1984)	market structure (increasing returns, differentiation, competition, monopoly)
	Grossman and Helpman (1991)	market structure (allowing innovations and differentiations of intermediate products)
	Helpman & Krugman (1984, 1985); Brainard (1993); Ethier (1986); Markusen & Venables (1995, 1996); Markusen & Ethier (1996); Markusen (1999); Markusen & Maskus (1999); Markusen (2002); Helpman, Melitz & Yeaple (2003); Head & Ries (2003); Razin, Rubinstein & Sadka (2003); Bloningen (2005); Aizenman & Noy (2005); Helpman (2006); Razin & Sadka (2007)	internationalisation through FDI (firm-specific factors, market-specific factors, pull and push determinants)

Source: Own classification on the basis of Udovič (2004), Dunning (2003) and Svetličič (1996). Note: All references within this table available upon request to the authors.

However, it was not only in the field of international economics and business that new trade patterns tried to find root, but they also tried to find new ground in the theory of international political economy, which dealt mostly with the institutional approach of internationalisation and trade patterns (Krasner, 1976/2005; Strange, 1995; Gowa and Mansfield, 1993; Mansfield et al., 2000/2005). The first authors after WWII were mainly devoted to the liberal approach and its consequences (Baldwin, 1995: 339). Soon after the resurrection of European economies in the 1960s and the accelerated pace of European integration, researchers analysed trade patterns from different new points of view, as for example:

- within the integration processes and regional trade arrangements (Ohmae, 1995; Vernon, 1990; Lawrence, 1995);
- globalisation activities and (economic) sovereignty (Scholte, 2005; Frankel, 2000; Svetličič, 2004; Kuttner, 1990);
- position of transition states in the world economy (Svetličič and Rojec, 2003); and
- relations in the states-firms-markets triangle (Strange, 1992/1995; Stopford and Henley, 1991).

The contemporary international community is a complex phenomenon, with correspondingly complex country trade patterns, which cannot be simply explained using the traditional endowment perspective, nor analysed with methodologies that assume independent units of analysis. Therefore, the key approach in studying international economics and business characteristics is to start from a clear theoretical and substantive approach, and analyse the phenomenon from various points of view, incorporating interdisciplinarity in both theory and analyses. Our research represents an interdisciplinary cross-section between international political economy, international business and network analysis. It analyses the export patterns within EU-27 as a regional integration, and with a special emphasis on export relations among different regions of the EU (North vs South, East vs West), different sizes of countries (small vs large) and sub-regional intensities of exports within the EU.[3]

With regard to the literature on trade patterns of small states, most of the existing literature and empirical evidence claim that small states tend to geographically concentrate their exports towards a few countries (Briguglio et al., 2009; Udovič and Svetličič, 2007; Udovič and Rašković, 2010). Furthermore, a small domestic market and weaker Porter's national diamond force companies to internationalise earlier and have different sources of competitive advantage (Rašković, 2014). According to Williams et al. (2014: 127), small states 'face dual constraints of relatively weak institutions and a narrow resource base'. Thus, based on these issues and the implications from the so-called Scandinavian stepwise theory of internationalisation, one could expect that:

[3] *For a more comprehensive review of the literature on export patterns of small states, see Rašković et al. (2012).*

Research hypothesis 1: *Small states tend to geographically concentrate their exports more on a few neighbouring countries compared to other types of states.*

Similarly, small EU states are also believed to be more dependent on a few large traditional EU export markets (Udovič and Rašković, 2010). This is particularly the case because the majority of small EU states are actually less developed new EU member states from Eastern Europe for which large markets like Germany, France and Italy have historically played the role of most important export markets (Inotai, 2013). Thus, one can also expect that:

Research hypothesis 2: *Small states will have similar structural positions within the inter-country EU export network.*

Methodology[4]

In a comprehensive review of research methodologies in the international business field published in the International Business Review by Yang, Wang and Su (2006), the authors show how 60.9% of the reviewed international business studies in the 1992–2003 period published in the six leading international business journals are based on single-country samples and 88.9% on samples from large Western markets. In addition, most of the studies employ a fairly traditional structural equation or regression modeling.

Operationalisation of a weighted network

A network can most simply be defined as a graph with some additional information about the vertices (units of observation) and the ties (links) between them; or mathematically as (Wasserman & Faust, 1994):

- a set of vertices (actors): $U = \{u_1, u_2, ..., u_n\}$;
- a set of ties (relationships) between vertices: $R = \{r_1, r_2, ..., r_m\}$;
- and where a network can be operationalised as: $N = (U, R)$.

[4] *This section of the paper assumes the reader to be familiar with the basics of network analysis and Graph theory. Readers not familiar with these areas are advised to consult Wasserman & Faust (1994): Social Network Analysis: Methods and Applications for a general overview of network analysis, and Doreian, Batagelj and Ferligoj (2005): Generalized blockmodeling for an overview of generalised blockmodeling.*

Extending this perspective to a *weighted network*, it can be operationalised mathematically as (Wasserman & Faust, 1994):

- a real-valued *n x n* adjacency matrix *w*, where w_{ij} corresponds to the (possibly weighted and/or directed) tie between *i* and *j*
- where in case of the directed network $w_{ij} \neq w_{ji}$ (and $w_{ij} = w_{ji}$ for the undirected network)
- and where a weighted network can be operationalised simply as: $N = (U, W)$.

Weighted centrality measures

As outlined by Opsahl, Agneessens and Skvoretz (2009: 245), centrality 'has been a key issue in network analysis'. However, the original measures of centrality, as proposed by Freeman (1978),[5] have long had the limitation of being 'only designed for binary data'. Table 2 provides the description and operationalisation of the three weighted centrality measures employed in our analysis.

Table 2: DESCRIPTION AND OPERATIONALISATION OF THE EMPLOYED WEIGHTED CENTRALITY MEASURES

Centrality measure	Description	Weighted centrality measure operationalisation	Comment
Degree	The number of vertices to which a particular focal vertex is connected (Freeman, 1978).	$C_D^{w\alpha}(i) = k_i \times \left(\frac{s_i}{k_i}\right)^{\alpha} = k_i^{(1-\alpha)} \times s$ Where: i corresponds to the focal vertex; *j* corresponds to all other vertices; *N* corresponds to the total number of network vertices; *x* corresponds to the adjacency matrix; *w* corresponds to the weighted adjacency matrix; and α corresponds to the positive tuning parameter (in our analysis $\alpha = 1$).	This weighted centrality measure corresponds to the number of ties *ki* to other vertices from a given focal vertex, multiplied by the average *weight* of ties over these vertices, and adjusted by a *tuning parameter* (Opsahl, Agneessens & Skvoretz, 2009).

[5] *Degree centrality, closeness centrality, and betweenness centrality.*

Centrality measure	Description	Weighted centrality measure operationalisation	Comment
Closeness	Inverse sum of geodesic (shortest path) distances to all remaining vertices from a particular vertex (Opsahl, Agneessens & Skvoretz, 2009).	$C_C^{w\alpha}(i) = \left[\sum_j^N d^{w\alpha}(i,j)\right]^{-1}$	Opsahl, Agneessens & Skvoretz (2009, p. 247) summarise Freeman's (1978) concepts of *closeness and betweenness* centrality as being based on the *identification and length of shortest paths* among network vertices. In the case of weighted networks, the following formula is used to calculate geodesic distance: $d^{w\alpha}(i,j) = \min\left(\frac{1}{(w_{ih})^\alpha} + \ldots + \frac{1}{(w_{hj})^\alpha}\right)$
Betweenness	Degree of unique geodesic distances, where one focal vertex lies on the geodesic distance between two other nodes, and is able to 'control' the flow (Opsahl, Agneessens & Skvoretz, 2009).	$C_B^{w\alpha}(i) = \frac{g_{jk}^{w\alpha}(i)}{g_{jk}^{w\alpha}}$ Where: g_{jk} corresponds to the number binary geodesic distances between two vertices; and g_{jk} *(i)* is the total number of g_{jk} through vertex *i*	

Source: Opsahl, Agneessens and Skvoretz (2009).

Outline of the weighted generalised blockmodeling approach

One goal of blockmodeling is to reduce a large incoherent network to a smaller comprehensible and simply interpretable structure (Batagelj, Ferligoj and Doreian, 2004). The concept of generalised blockmodeling was presented by Doreian, Batagelj and Ferligoj (2005) for binary data, and recently developed for valued networks by Žiberna (2007 and 2008). In generalised blockmodeling, the local optimisation algorithm directly searches for the best-fitting partition based on a selected type of equivalence or block types. We decided to use structural equivalence[6], where units are structurally equivalent if they are connected in exactly the same way to the same neighbours (Lorrain and White, 1971).

Following Žiberna's (2007) step-by-step approach to generalised blockmodeling of weighted network data, we first applied homogeneity blockmodeling. It searches for homogeneity within blocks with two possible measures of variability, namely the *sum of square deviations from the mean* and the *sum of absolute deviations from the median*. This led us to

[6] *A formal definition of structural equivalence is presented in Doreian, Batagelj and Ferligoj (2005: 172), and Žiberna (2009).*

the appropriate partition and image matrix for estimating the *m* parameter. The *m* parameter corresponds to the minimal value that characterises a tie between units as important. In the case of structural equivalence, the distribution of cell values and the means of complete blocks should be examined. This procedure provides an interval estimate of possible *m* values (see Figure 5 in the Appendix). General guidelines for determining the possible *m* values are as follows: (1) if the distribution of cell values is bimodal, the best suitable value for parameter *m* is between both modes, and (2) if the distribution is unimodal, the parameter *m* should be around the mode. Despite of these guidelines, the final selection of the best *m* is somewhat arbitrary. Žiberna (2007: 114) himself emphasises that 'the best way to determine the parameter *m* is prior knowledge, which can tell us how strong a tie should be to be considered strong or relevant'. In the last stage, a valued network with all the ranges of *m* values was produced, and the best partition of EU-27 countries was selected, based on suitability to ideal blocks and possibility of a logical interpretation.

Results

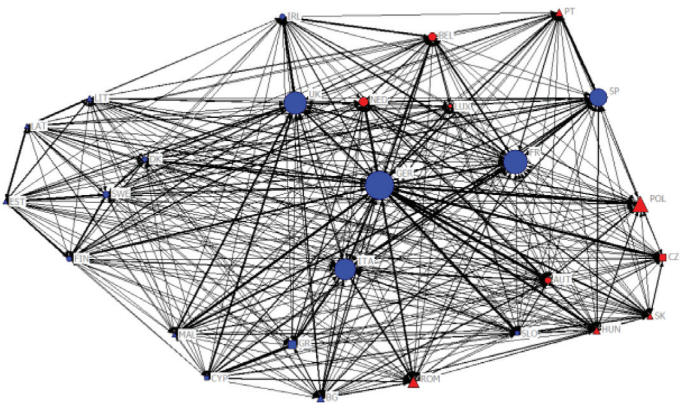
The presented results first start with a pair of network visualisations produced in NetDraw within the social network analysis package UCINET VI. This is followed by an overview of the three weighted centrality measures calculated in the *tnet* (Opsahl, 2009) application within the statistical package *R*, and further by a weighted generalised blockmodel in *R*, applying Žiberna's (2007) approach to weighted generalised blockmodeling. The final weighted network visualisation at the end of the results section was produced in the social network analysis package *Pajek* (Batagelj and Mrvar, 2011).

Initial network visualisations

Figure 1 displays the initial network visualisation of weighted country-by-country per capita export data, where the tie strength represents the percentage of exports from country *i* to country *j*, relative to the total exports of country *i* to EU countries in 2008. On the other hand, Figure 2 represents only ties over 3.85%[7] in total EU-27 exports. This threshold is set on the assumption of equal distribution of exports among all 26 (*N-1*) EU countries, from the perspective of the country in focus.

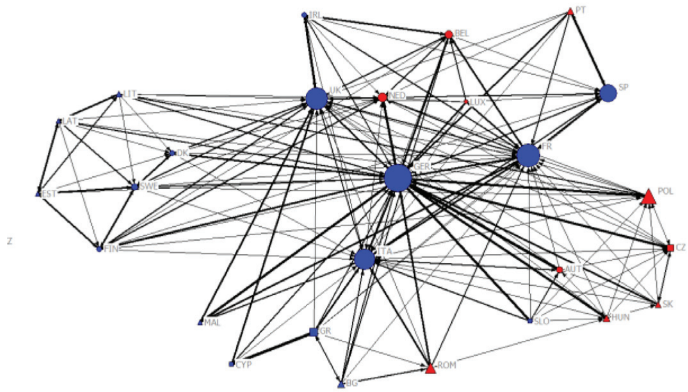
[7] *3.85 = 100/26*

Figure 1: INITIAL VISUALISATION OF THE WEIGHTED COUNTRY-BY-COUNTRY EU-27 EXPORT DATA



Source: Eurostat, 2010.

Figure 2: VISUALISATION WITH TIE THRESHOLD VALUE 3.85 PER CENT



Source: Eurostat, 2010.

In both figures vertex size (of a country) corresponds to population size. Vertex shape corresponds to the level of economic development, measured as the percentage of the average EU-27 GDP per capita.[8] Vertex colour corresponds to the overall share of exports of a given country within the EU, relative to its total exports in 2008.[9] As can be seen from the network

8 Countries were grouped into 3 development categories: (1) up to 79% of the average EU-27 GDP per capita (triangular shape); (2) 80–100% of the average EU-27 GDP per capita (square shape), and (3) above 100% of the average EU-27 GDP per capita (round shape).

9 Above or below 70% of total country exports tied to the EU-27.

visualisation in Figure 2, with the tie cut-off value at 3.85% of total exports, we can observe a core-periphery structure, where the four biggest European markets (Germany, France, the UK and Italy) represent the core, while most of the other countries represent its periphery. In addition, we can also see a set of very distinct Girvan-Newman-type[10] of country subgroups, namely the Scandinavian-Baltic group and the Benelux group.

Weighted network centrality measures

Table 3 displays the calculated weighted *degree*, *closeness* and *betweenness* centrality scores for each country, based on per capita exports. In terms of degree centrality of the weighted network, Luxemburg has the highest weighted per capita export degree centrality, followed by Belgium and the Netherlands. This implies that this group of Benelux countries has the highest level of per capita exports within the EU-27 network. On the other hand, Cyprus has the lowest weighted degree centrality. Furthermore, the average per capita exports of small states are higher (μ = 7,987; σ = 10,226) than those of medium-sized and large states (μ = 6,872; σ = 6,138).[11]

Looking at weighted closeness centrality[12] scores for each country, we in general see two distinct subgroups of countries. The first group of countries, led by Luxemburg (2.82), Denmark (2.47), Belgium (2.46) and Sweden (2.41), have high weighted closeness centrality scores, implying short geodesic (shortest-path) distances to other EU countries. These can thus be seen as key inter-EU trading countries. The second group, with lower closeness centrality scores, implying long geodesic distances to other EU countries, is represented by less developed and geographically more isolated countries, namely Cyprus (1.06), Greece (1.22) and Bulgaria (1.28). Comparing the weighted *degree* and *closeness centrality* scores for Denmark and Sweden, they have much lower weighted degree centrality (cumulative exports to EU countries), but are more closely (directly) linked to other EU countries.

[10] *The Girvan-Newman community detection algorithm in social network analysis refers to a group (community) of countries which have very strong inter-community connections; e.g. a very dense subgroup of inter-exporting countries (Wasserman and Faust, 1994).*

[11] *Initial data was given in EUR 1000, thus a mean of 7,987 corresponds to an average per capita export of a small EU-27 country of almost EUR 8 million.*

[12] *Contrary to weighted degree centrality, the scores for weighted closeness and betweenness centralities cannot be directly meaningfully interpreted, since they are based on calculated geodesic (shortest-path) distances. Their interpretative power thus lies in relative country comparisons.*

Table 3: WEIGHTED CENTRALITY MEASURES OF PER CAPITA INTER-COUNTRY EU-27 EXPORTS AND NORMALISED DISTRIBUTION OF EXPORTS TO NEIGHBOURING COUNTRIES IN 2008 (IN EUR 1000)

Country	DC*	CC**	BC	Exports to neighbouring markets***
Austria (S)	10,700	2.27	92	11.6%
Belgium (M)	23,118	2.46	98	15.2%
Bulgaria (M)	1,190	1.28	0	14.4%
Cyprus (S)	753	1.06	0	38.4%
Czech Republic (M)	8,147	2.18	23	15.0%
Denmark (M)	10,047	2.47	25	15.6%
Estonia (S)	4.402	2.28	73	15.1%
Finland (M)	6,912	2.40	104	11.0%
France (L)	4,140	1.96	11	10.2%
Germany (L)	7,560	2.19	386	5.2%
Greece (M)	1,004	1.22	27	14.6%
Hungary (M)	5,743	2.12	1	5.2%
Ireland (S)	12,184	2.38	0	38.6%
Italy (L)	3,634	1.85	0	7.2%
Latvia (S)	2,076	1.65	0	13.7%
Lithuania (S)	2,880	1.81	1	11.0%
Luxemburg (S)	31,539	2.82	0	14.2%
Malta (S)	2,205	2.29	0	11.7%
Netherlands (M)	20,842	2.45	198	15.2%
Poland (L)	2,363	1.83	0	11.2%
Portugal (M)	2,521	1.68	0	18.1%
Romania (L)	1,103	1.39	0	6.6%
Slovakia (M)	7,644	2.15	1	9.7%
Slovenia (S)	7,860	2.18	0	11.2%
Spain (L)	2,895	1.70	25	20.0%
Sweden (M)	8,109	2.41	100	6.7%
UK (L)	2,897	1.81	46	12.4%

Source: Eurostat, 2010; own calculations.

Notes: S = small, M = medium-sized, L = large; DC = degree centrality, CC = closeness centrality, BC = betweenness centrality. * Data in EUR 1000. ** Multiplied by 100 for easier comparison. *** Normalised share of per capita exports to neighbouring markets, where the total share of exports to the neighbouring markets was divided by the number of neighbouring EU countries for each state. For island states like Ireland or Malta, neighbouring markets were assumed to be the markets in a radius of up to 1000 kilometres.

In terms of the three employed weighted centrality measures, the weighted betweenness centrality scores for each country most obviously convey the relative importance of a particular EU country in terms of the share of geodesic distances which pass through a given country. While Germany (386), as the EU's economic engine, obviously has the highest share of geodesic distances, followed by the Netherlands (198), Estonia with a weighted betweenness centrality score of 73 may be seen as an important trading interface between the developed Scandinavian north, and the European economic core.

With regard to the normalised share of exports to neighbouring EU countries, we can see that, apart from Cyprus and Ireland, which are huge recipients of FDI, most other countries have quite comparable normalised shares of exports to their neighbouring EU countries. This also holds important implications for small states in international trade, since it shows that small states do not *per se* export more to their neighbouring EU countries, but that this may be to a greater extent a consequence of their geographical position and the number of neighbouring EU countries.

A generalised weighted blockmodel

Within the first step of our blockmodeling approach, we first focused on determining the most suitable number of country subgroups (clusters). For this purpose we performed both hierarchical clustering (Ward's method) on the original weighted per capita export data, as well as the interactive-split CONCOR partitioning procedure in UCINET VI, based on dichotomisation of exporting ties, using the 3.85% threshold for the share of exports of a particular country:

$$r_{ij} \begin{Bmatrix} 1,\ \textit{if} > 3.85\ \textit{per cent of exports} \\ 0,\ \textit{otherwise} \end{Bmatrix}$$

The results of the two clustering approaches were complemented by existing theory and descriptive data on inter-country EU trade patterns to establish the existence of five-country clusters. The CONCOR interactive-split partitioning procedure produced a goodness-of-fit result of 0.55, which is satisfactory according to recommendations by Wasserman & Faust (1994).

In the next step, homogeneity blockmodeling was applied in accordance with Žiberna's (2007) procedure. Based on the selected structural equivalence, the obtained image matrix and partitions, the mean of the complete block was calculated (see Figure 5 in the Appendix), and an interval estimate[13] of the *m* parameter was obtained. The final *m* parameter value was arbitrarily set based on supporting knowledge, since 'the best way to determine the parameter m is prior knowledge, which can tell us how strong a tie should be to be considered strong or relevant' (Žiberna, 2007: 114). With this in mind, *m = 500,000* for per capita exports was chosen as the most appropriate value.

[13] *Please refer to Figure 5 in the Appendix for a discussion of our interval estimate for the m parameter.*

In the last step, the valued blockmodeling was performed based on the specified number of country clusters or blocks (five) and on the selected *m* parameter (500,000). In this regard, Figure 3 displays the best partition, according to suitability to ideal blocks and the possibility of a logical and substantive interpretation, where the value in each cell should be multiplied by 100,000 to show the exact per capita export flow from country *i* to country *j*.

As can be seen from the corresponding weighted blockmodel in Figure 3, the first partition of countries includes the Central and Eastern European (CEE) clique with Austria as its hub. This clique is also closely connected to the main economic engines of Europe, which are shown in the third partition. The average per capita pair-wise country export flow in the first partition is 5.54, as shown in Figure 1, and corresponds to EUR 554,400 per capita.[14] Particularly interesting is the second partition, which includes Estonia, Ireland and Luxemburg. All of the three countries are small states with high weighted closeness and betweenness centrality scores. They are open economies with high levels of inbound FDI, and were also severely hit by the current economic and financial crisis. They have a very low pair-wise average per capita export among themselves (only 0.463 or EUR 46,300), but a very high pair-wise average per capita export with both the third partition of European economic engines and Poland (828.3 or EUR 828,300) and the fourth partition of Benelux and Scandinavian countries (561.3 or EUR 561,300). The fifth partition corresponds to the EU South, as along with Lithuania and Latvia, which seem to significantly differ from Estonia in terms of export patterns, due to their level of economic development and level of FDI.

Complementing the weighted blockmodel in Figure 3, Table 4 displays the average pair-wise per capita country exports for each block of countries.

Table 4: AVERAGE PAIR-WISE PER CAPITA EXPORTS FOR EACH COUNTRY BLOCK (IN EUR)

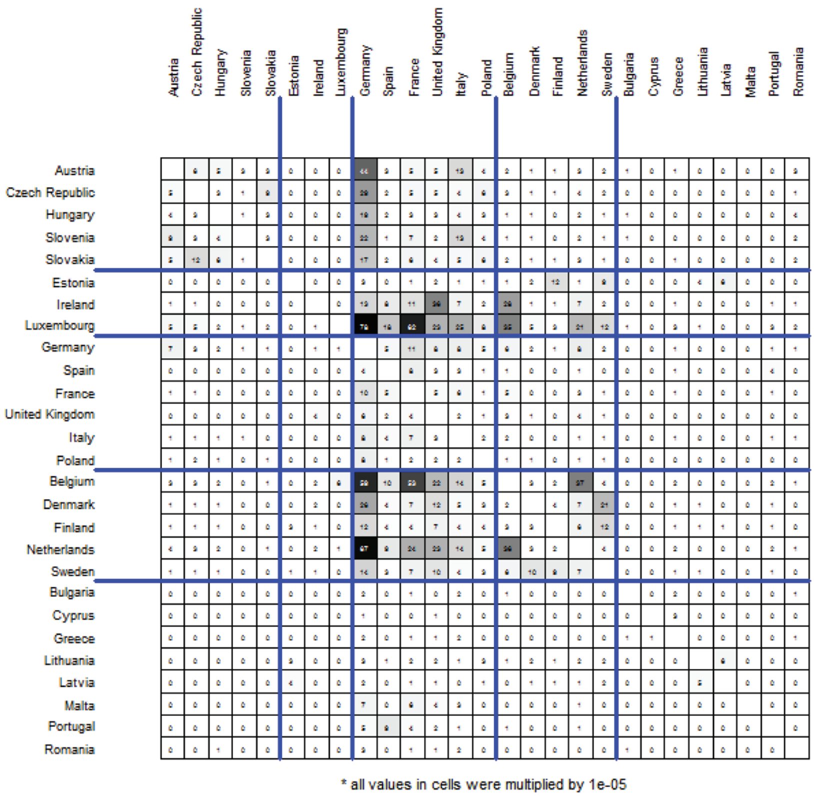
Block/Block	1	2	3	4	5
1	554,400*	25,800	699,400*	140,300	35,900
2	72,700	46,300	828,300*	561,300*	35,400
3	102,500	80,300	541,000*	196,600	27,600
4	115,400	205,500	1,215,800*	1,137,600*	36,400
5	23,500	88,800	222,400	81,700	46,800

Source: Own analysis in R; data from Eurostat (2010).
*Complete blocks, with country pair-wise export flows over the *m* parameter value of EUR 500,000 per capita.

[14] *Since the values in the blockmodel were multiplied by 0.01 for easier visualisation purposes, and the original data was in EUR 1000.*

In terms of the specific relationships between the individual country blocks, we can see that the CEE partition is closely interconnected, as well as connected to the main European economic engines and Poland. The second partition (Estonia, Ireland and Luxemburg) is not very interconnected, but closely connected to both the main European economic engines and Poland (partition three), and the Benelux-Scandinavian group (mostly Estonia, as can be seen from its high betweenness centrality score). In turn, the Benelux-Scandinavian group is almost as equally interconnected, as it is connected to the main European economic engines and Poland in terms of its per capita exports.

Figure 3: A WEIGHTED GENERALISED BLOCKMODEL, BASED ON 5 CLUSTERS AND M = 500,000[15] PER CAPITA EXPORTS



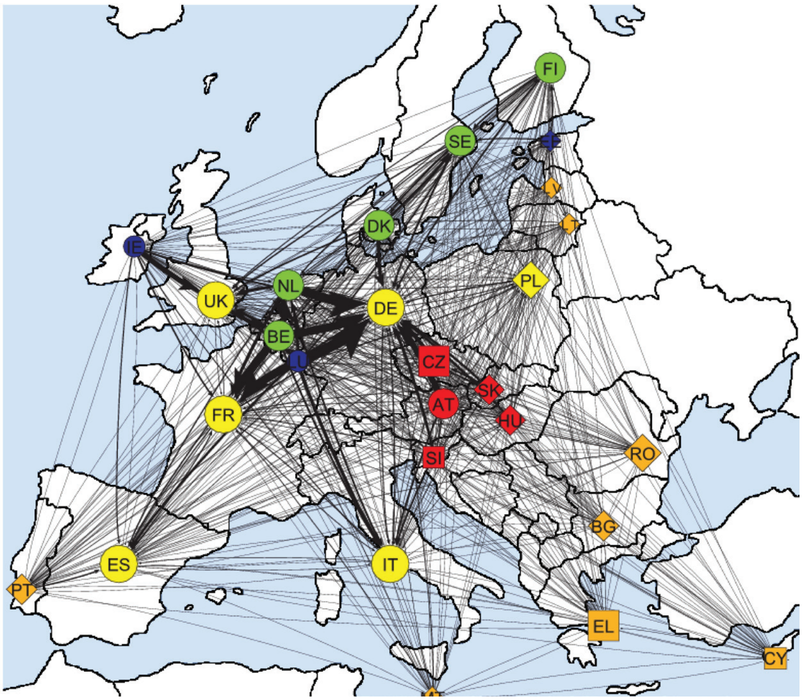
Source: Own analysis in R; data from Eurostat (2010).
Note: *Country block 1*: Austria, Czech Republic, Hungary, Slovenia, Slovakia; *Country block 2*: Estonia, Ireland, Luxemburg; *Country block 3*: Germany, Spain, France, UK, Italy; *Country block 4*: Belgium, Denmark, Finland, Netherlands, Sweden; *Country block 5*: Bulgaria, Cyprus, Greece, Lithuania, Latvia, Malta, Portugal, Romania.

[15] *Since the original Eurostat data was in EUR 1,000.*

Complementing the results from our weighted blockmodeling procedure, Figure 4 displays the final visualisation of our EU-27 per capita export inter-country network. Country colour in the visualisation corresponds to the five obtained country subgroups, vertex shape corresponds to the different levels of economic development relative to the EU average GDP per capita[16] and vertex size corresponds to the size of the country in terms of population.

The visualisation in Figure 4 complements our observations about the EU-27 inter-country export network, and shows a strong core-periphery structure with two corresponding cliques and a specific subgroup of three small states. With regard to this group, Ireland is strongly linked to the UK, Estonia to Finland, and Luxemburg to several key economic engines of Europe (Germany, France, Belgium and the Netherlands). This is the reason why they showed relatively low interconnections among themselves.

Figure 4: FINAL VISUALISATION OF THE EU-27 WEIGHTED PER CAPITA EXPORT INTER-COUNTRY NETWORK WITH CORRESPONDING VERTEX (COUNTRY) ATTRIBUTES



Source: Pajek software; data from Eurostat, 2010.

[16] *The round vertex shape indicates a higher GDP per capita than the EU-27 average; the square vertex shape marks countries with a GDP per capita between 80 and 99.9% of the EU-27 average; and the rhomboid vertex shape countries with a GDP per capita below 80% of the EU-27 average.*

Taking into consideration the country attributes, we can see that more economically developed countries have higher levels of inter- and intra-group trade (e.g. the main economic engines and Poland, and Benelux-Scandinavia). In addition to this, the most economically developed countries within regional cliques (e.g. CEE) usually represent strong hubs (e.g. Austria within CEE).

Discussion and concluding remarks

The purpose of our paper was to explore the various patterns and structures of inter-country exports of EU member states. In this regard, we employed two relatively new network analysis approaches for analysing weighted networks, which have not yet been used in the international economics and business literature. These two approaches – weighted centrality measures and weighted generalised blockmodeling – were complemented by an elaborate visualisation of inter-country per capita export flows of EU member states in the *Pajek* tool. The results show a clear core-periphery structure, which is not very surprising. In addition, two Girvan-Newman-type cliques highlight the importance of strong regional interconnections, while the results of weighted betweenness centrality shed light on the relative importance of specific states, regardless of their size or economic development. In particular, the high weighted centrality score for Estonia calls for further research on the determinants (e.g. FDI) of its position within the inter-country trade network, and the corresponding results for the country.

With regard to the perspective of small states, the normalised shares of exports to neighbouring markets (based on the number of neighbouring markets) indicate that, apart from very specific small states (e.g. Luxemburg, Ireland, Cyprus), which have strong financial sectors, other small states do not *per se* concentrate their exports more on neighbouring markets compared to other countries. However, one should note here that this observation is only made for the intra-EU network, and further analyses would be needed to test this finding on other non-EU small states.

Furthermore, the partitioning of our weighted generalised blockmodel and the specific export relationships within and between individual country blocks also show that small states cannot be simply treated as a collective whole with regard to their trade patterns and focus.

While the final weighted network visualisation in Figure 4 calls for a deeper analysis of the underlying country attributes, we would once again like to point out that network analysis is focused on relations and not on the actors' attributes. Having said this, the two outlined network approaches can be (and should be) upgraded using traditional international business and economics analytical tools, particularly structural equation modeling, gravity modeling, regression modeling and multi-level linear hierarchical modeling. We hope the interdisciplinary use between these tools will provide the field with better and more comprehensive conclusions, accompanied by powerful visualisation offered by the field of network analysis.

Finally, we acknowledge that we have analysed only inter-country EU export flows for one single year (2008). In future research, it would make sense to compare various time periods (e.g. 2008, 2010 as the peak of the crisis, and 2014), as well as to analyse, for example, export flows in terms of added value, since a large degree of inter-country EU trade can in fact be processing trade. This may be particularly true among new and less developed EU member states.

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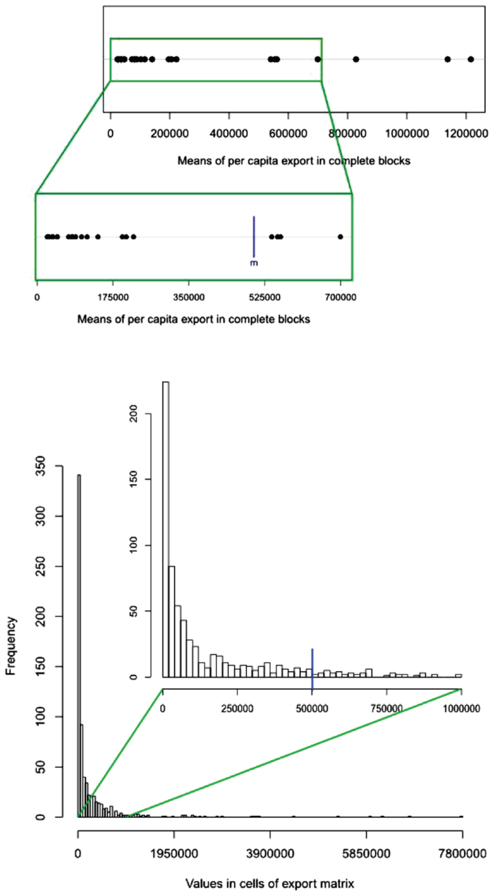
Appendix

Figure 5 provides the results from our homogeneity blockmodeling, and shows the distribution of per capita export means in complete blocks. Based on the corresponding distribution of means, an interval estimate of the *m* parameter was obtained for valued blockmodeling.

Figure 5: DISTRIBUTION OF PER CAPITA EXPORT MEANS IN COMPLETE BLOCKS WITHIN HOMOGENEITY BLOCKMODELING



Based on the recommendations by Žiberna (2007) and the corresponding distribution of per capita export means, the *m* parameter should be on the interval [222,500; 540,000]; because this is the largest gap between the means. We chose 500,000 based on the most suitable interpretative power of our results and the robustness of the solution.