Relational Methodologies and Epistemology in Economics and Management Sciences

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Chapter 6
An International Trade Comparison of Two Supposedly Different Sectors:
An Investigation on Inter-Sectoral Diversity and Sectoral Trade Stability

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ABSTRACT

According to modern international economics, and especially evolutionary economic geography, a country industry characteristics influence the structure of its international trade. Following this view, this chapter moves from the following basic research issue: if two sectors are very different according to market, economic and technological aspects, should we expect that its corresponding international trade networks are as well markedly different? Aerospace and Common Earth Materials seem quite different in those respects, and thus, they are good candidates to explore that research issue. Its comparison allowed to evidence and discuss some methodological problems in applying social network analysis, and especially in using it to compare different networks. In particular, it is underlined the difficulty to handle valued networks when value variance is very high, and to combine three groups of indicators: simple, hierarchy focused, and strictly topological. The comparative analysis employed 32 indicators either at network or sub-network level, like for core-periphery analysis, which indicate clear and marked diversity only in terms of hierarchical degree and topological aspects. A first conclusion is that the two examined trade networks are following a similar path and, excepted for few indicators, they seem to be rather similar even at a deeper structural level. Hence, one (or more) of three implications can be drawn: 1) the global value networks corresponding to the two sectors are not so markedly different; 2) they are substantially different but such a diversity does not produce a significant difference in terms of international trade networks; 3) there are some methodological problems that prevent differences to be evidence and require a more refined and modified comparison. A second conclusion is that trade patterns of both sectors are rather unstable.

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INTRODUCTION

As discussed in the previous chapter (see Angelini & Biggiero), during the last 15 years social network analysis has been repeatedly applied to different aspects of international trade (Kali & Reyes, 2007; Kali *et al.*, 2007; Fagiolo *et al.*, 2009; Serrano & Boguñà, 2003; Serrano, 2007; Serrano *et al.*, 2007). This complex system is composed by thousands of different commodities, each with its specific characteristics and its specific trade network. Commodities are grouped into sectors, and depending on the level of aggregation hundreds or dozens or few sectors are generated. In the perspective of social network analysis each sector is represented by a trade network, with its peculiar topology and dynamics. The understanding of each sector/network is already rather complex, being international trade the result of the interplay of many (economic and non-economic) variables. For the whole world trade web is the outcome of summing up all commodities trade, though many excellent studies have worked at such an aggregate level, sectoral analysis and comparisons could substantially help deepening the analysis at sectoral level.

International trade studies (Bowen *et al.*, 2012; Ethier *et al.*, 1995; Feenstra, 2003; Feenstra & Taylor, 2010; Milberg and Winkler, 2013), and especially evolutionary economic geography (Boschma & Frenken, 2006; Boschma & Lambooy, 1999; Boschma & Martin, 2007; Essletzbichler & Rigby, 2007; Frenken & Boschma, 2007; Martin & Sunley, 2007) suggest that some of the major forces shaping trade patterns are industry structure, its degree of technological complexity, and the distribution of raw resources and competences. Though these are not the only variables, it is reasonable to expect that the trade networks of two sectors particularly different respect to these variables had to significantly differ. These considerations pushed us to choose two very different sectors – aerospace (AS) and common earth materials (CEM) - and then to check if their trade networks differ as well. Further, in order to make the analytical comparison more homogeneous and effective, we run the investigation during the same time span: 2002-2006.

Another theoretical perspective involved into this work is that of global value chain (Gereffi, 1999; Gereffi *et al.*, 2005; Humphrey, 1995; Humphrey & Schmitz, 2002; Milberg & Winkler, 2013), which expands the idea of domestic industrial domestic filière to that of global filière, where various kinds of production and distribution activities are realized not only by large multinational corporations but also by competitive small and medium enterprises, especially in high-tech industries. A further advancement on this research area is that globalization – mostly on the demand side - and localization – mostly on the supply side – can co-exist in a continuous restructuring of the global filière. In this evolutionary process, industrial clusters progressive opening to multinationals and its digitalization are playing a decisive role (Biggiero, 2002, 2006). AS is a paradigmatic example of this kind of evolution: an extremely high-tech and globalized industry that is structured into industrial clusters (Acha *et al.*, 2007; Alberti & Pizzurno, 2015; Alfonso-Gil, 2007; Beaudry, 2001; Biggiero & Angelini, 2015; Biggiero & Sammarra, 2010; Broekel & Boshma, 2011, 2012; Caroli, 2006; Cooke & Ehret, 2009; Eriksson, 2000; Giuri *et al.*, 2007; Jackson, 2004; Longhi, 2005; Lublinsky, 2003; Niosi & Zhegu, 2005; O'Sullivan, 2006; Sammarra & Biggiero, 2008; Smith & Ibrahim, 2006). In this perspective, a sectoral international trade is supposed to be strictly specific to its corresponding global value network, because the distribution of exchanges should be strongly conditioned by the distribution of clusters between countries, the inter-clusters exchange, and finally the localization of demand. Hence, these approaches emphasize *rationales to expect a high degree of diversity between international sectoral networks corresponding to different global value networks*.

Further, a theoretical perspective argues that there is a high level of similarity within a same international sectoral network in a longitudinal dimension. This aspect has been debated in international economics under the label of trade patterns stability and persistency (Crespo & Fontoura, 2007; Carter & Xianghong, 2004), which recently came to coincide with that of duration of trade (Besedes, 2008; Besedes & Prusa, 2006a, 2006b; Hess & Persson, 2011; Nitsch, 2009). According to this perspective, we had to expect a certain stability of AS and CEM trade patterns.

This study allows investigating on both issues: inter-sectoral diversity, due to supposed diversity in AS and CEM global value networks, and sectoral trade patterns stability. It will be shown that both expectations are not confirmed: i) besides a very different distribution of exchanges among countries, the two trade networks appear rather similar in terms of a very extensive comparison involving 32 indicators, articulated into general, hierarchy-focused, and strictly topological aspects; ii) besides a superficial stability, when employing a very specific indicator of trade pattern stability, during the five years of analysis both networks seem to change the distribution of the large majority of its exchanges. It will be deeply discussed that these two conclusions can be disputable depending on three things: 1) the weights assigned to each of the many indicators employed for the comparison; 2) the formal method of comparison, which here has been overlooked and replaced by a very plain and intuitive (but therefore, potentially fallacious) method; 3) the lack of analogous comparisons between other international sectoral trade networks, which could provide useful points of reference.

This work proceeds as follows: in the next methodological section are introduced and discussed many network indicators, some of which have been already employed in the previous chapter of this volume. In the following two sections a general outline of AS and CEM international trade network is shown. Then, in section five links distribution in the two networks is analyzed to check whether they are scale-free or small-world shaped. In section six its topologies are investigated in order to know whether they are more assortative or dis-assortative, and whether a core-periphery structure can be found. Finally, in the seventh section, the two networks are straightly compared by remodeling its topology after selecting only the common countries. Conclusions evidence contradictory results and suggest methodological improvements of this comparative approach for future studies.

METHODOLOGICAL ASPECTS

In this research we used two datasets supplied by UN COMTRADE[1] database:

- AS cross Country Export data of 91 nations from 2002 to 2006;
- CEM cross Country Export data of 121 nations from 2002 to 2006.

We could not going back before 2002, because lack of older reliable data, and we stopped at 2006, because the early signs of the current world economic crisis did not yet come. Data are not deflated because a widely accepted cross countries deflator for all the countries is hard to be found and even harder to combine with that of counterparts. On the other side, we did not want to use a single deflator because it would cause a strong distortion.

The two networks will be compared in terms of average degree centrality (Adc), density, hierarchical degree (H_k), and degree of reciprocity. For all these measures (and many of the following ones) have been defined and discussed by Angelini & Biggiero in the previous chapter, we address the reader to it. Here we have added to these very general indicators also the average bilateral trade value (AVBT). We have calculated also various measures of centralization, some of which - Freeman's (Dc CE(F)) and

Snijders' (Dc CE(S)) - have been also introduced in the previous chapter. Here we remind only that they substantially differ, and that the former – albeit the most used – could be rather distortive when applied to multi-centered networks, like the two that are here under investigation. Dc CE(F) failure becomes particularly dramatic for the valued networks whose values span over many orders of magnitude, like in our case. In fact, for Dc CE(F) is measured contrasting the highest centrality with all the others, it happens that, i) if single node's centrality variance is so high like in international trade (and particularly in AS), spanning on six orders of magnitude, ii) if the most connected nodes are also the nodes with the highest values of single exchanges, and (finally) iii) if there is not only one out-layer but rather a group of out-layers, then the contrast of *k-1* followers' centrality respect to the leader's centrality equals so much the index that the large number of the *n-k* remaining countries doesn't count any more. Because equalization means annulling centralization, then this latter drops down. Hence, when these three conditions hold, the researcher should remember that Freeman's centralization indexes can be misleading, and thus, they should be used very cautiously.

Node's betweenness centrality - Freeman's betweenness centrality, hereafter Bc-Fre - is defined as the fraction of geodesics passing for one node over all possible geodesics in the graph (Freeman, 1977, 1979), as introduced in chapter 5. It could be questioned whether Bc were an appropriate measure for international trade patterns, because it is doubtful that some good or services flows from one country to another passing through an intermediate country, like it were an information. This criticism could be shared in a backward theoretical perspective or if addressed to very high aggregation in sectoral definition or if the sector is very heterogeneous. But if we assume (as we do) modern theoretical views and the perspective of global value chain[2], then the idea that goods – and especially intermediate (industrial) goods – are passed alongside trade network paths through (manufacturing or just pure trading) countries is perfectly realistic. Further, the complex dynamics of modern value chains includes also double (bilateral) exchanges of the same good or good's components between two countries. In this perspective Bc-Fre makes sense even more.

For AS and CEM network size are enough large, we compared sectors also under the aspect of links distribution. In particular, we check whether they are shaped in a scale-free (SF) and/or small-world (SW) topology. A network topology is generally declared to be SF when Dc follows a power-law distribution, and Barabási & Albert (1999) demonstrated that the fraction . of nodes in many real networks having *x* connections to other nodes is represented by a power-law function . $P(x) = x^{-\alpha}$ for large values of *x* and with the scaling exponent α in the range between 2 and 4. Thus, the overall network connectivity is characterized by few highly connected nodes and a large number of nodes slightly connected. Consequently, the probability of finding a node with *x* links is a function of the number of links "scaled" for (the constant scaling parameter), on which the skeweness of the distribution depends.

The SW property is captured by the joint analysis of two indicators: Apl and Cl. Defining the geodesic distance as the shortest path among all possible paths we can calculate diameter and average path length (Apl). The former reports the longest geodesic distance in the graph while Apl is the average distance of all the geodesics connecting all the nodes. When the graph is not fully connected these measures are calculated on the largest component, but this is not the case of our networks, which are totally connected. The graph clustering coefficient (Cl) measures the extent to which the network displays clustering. This index consists in the average of the neighborhoods densities of all actors. If Apl is low relatively to its network size and if Cl is high, then a network is SW shaped.

Now, besides checking whether a network is SW shaped or not, what is important is to know how much it is, because the SW property is not on/off, but rather a question of "small-worldliness" (Lewis, 2009). In order to compare different networks through a scalar index is necessary to combine the two ingredients of Cl and Apl (see chapter 5 for details about these measures). The SW coefficient is obtained as follows: i) calculating the actual and the random value of Cl and Apl indexes, ii) dividing both indexes to obtain an index of relative Cl and relative Apl, iii) dividing relative Cl with relative Apl. According to different scholars[3], the threshold of 1 or 4 or 4.75 are proposed to decide whether a network is SW shaped.

For we gathered five years, we decided to compare the two networks also in terms of longitudinal similarity and persistency, the former referring to two adjacent years, while the latter referring to the permanence over the whole period. To run the similarity analysis in strict topological terms, we applied five different indicators[4]: Quadratic Assignment Procedure (QAP), QAP log2, Simple Matching (SM) through relational cross tabs, Jaccard coefficient (J), and Modified Jaccard coefficient (MJ). Persistency has a more restrictive meaning than similarity, because it requires that similarity crosses a given number of years. In other words, if the topology of 2002 and 2006 is similar at, let say 50%, it means that half links stay in the same position in both years. However, it does not imply that they remained in the same position during all the years. This more restrictive condition is just that of persistency that we calculated through the indexes used for similarity during all the 5 years as a "filter" to select only the links which never change.

AEROSPACE TRADE WEB

The aerospace (AS) sector includes the following sub-sectors, with their respective commodities: aircraft, spacecraft, and parts thereof[5]. According to a vast literature (Acha *et al.*, 2007; Alfonso-Gil, 2007; Eriksson; 2000; Giuri *et al.*, 2007; Niosi & Zhegu, 2005; O'Sullivan, 2006; Smith & Rogers, 2004) AS is a high-tech industry, characterized by complex final products (Hobday, 1998; Paoli & Prencipe, 1999; Prencipe, 1997, 2001). Production was historically concentrated into few countries, namely US, UK, I, FR, G, and NL. Basically, US and EU dominated demand and production, but more recently demand became more distributed, because many are the countries where local civil airlines or military equipment are placed. At the beginning of this century few other countries acquired a growing remarkable position, among which Brazil and China in a prominent position. Key-resources are technological and market knowledge, which are located mostly in production countries.

During the five years 2002-2006, AS world trade increased its high density of exchange (table 1). However, the growth rate of total trade value (48.9%) should not be ascribed to links increasing, which in fact grew only 14.7%, but rather to the increase of average exchange value (29.8%). Adc (average degree centrality) ranges from 24 links per country in 2002 up to 28 in 2006, with a growth rate obviously corresponding to that of total links (because size is fixed). AS trade pattern is definitely not hierarchical, if this property is measured with H_k, which looks at the degree of direct and indirect asymmetry (see chapter 5 and 7 for details about Krackhardt's hierarchy measures). However, as we will see below, things are different when looking at different aspects of structural hierarchy, because it is possible to distinguish a group of core and another of peripheral countries.

In 2006 In-Dc CE(F) (in-degree centralization, that is, imports centralization according to Freeman's index) is very much centralized in dichotomous terms (0.58), while not at all in absolute values (0.02), but again very much if values are taken in logarithmic scale (0.43). The former result is quite reason-

Table 1. AS network outline

	2002	2003	2004	2005	2006
Size	91	91	91	91	91
N. of links	2,224	2,259	2,426	2,562	2,551
Total trade (10^6)	104,923	102,359	113,355	123,670	156,238
AVBT (10^6)	47	45	47	48	61
Adc	30.11	31.20	32.83	34.55	35.32
H_k	0.14	0.12	0.09	0.02	0.04
Reciprocity	0.53	0.56	0.56	0.59	0.59
Density	0.27	0.28	0.3	0.31	0.31
In-Dc CE(F)	0.03	0.02	0.02	0.02	0.02
Out-Dc CE(F)	0.05	0.04	0.04	0.05	0.05
In-Dc CE(F) dic	0.55	0.61	0.60	0.62	0.58
Out-Dc CE(F) dic	0.73	0.72	0.70	0.69	0.70
In-Dc CE(F) log2	0.40	0.43	0.42	0.45	0.43
Out-Dc CE(F) log2	0.6	0.59	0.59	0.6	0.59
In-Dc CE(S)	0.39	0.39	0.40	0.41	0.40
Out-Dc CE(S)	0.58	0.58	0.58	0.57	0.58
Bc-Fre	0.15	0.19	0.17	0.17	0.14
Apl	1.72	1.73	1.72	1.7	1.7
Cl	0.5	0.52	0.53	0.55	0.53

Legend:
Size = number of nodes;
AVBT = average value of bilateral trade, which results from total trade divided by the number of actual exchanges;
Adc = average degree centrality;
H_k = hierarchical degree (degree of direct and indirect reciprocity);
Reciprocity = degree of direct reciprocity;
Density (dichotomized) = when the values of the links are not considered;
In-Dc CE(F) valued = Freeman's in-degree centralization with economic values;
Out-Dc CE(F) valued = Freeman's out-degree centralization with economic values;
In-Dc CE(F) log2 = Freeman's in-degree centralization with economic values. In this case we used the base-2 logarithm values;
Out-Dc CE(F) log2 = Freeman's out-degree centralization with economic values. In this case we used the base-2 logarithm values;
In-Dc CE(F) dic = Freeman's dichotomized in-degree centralization;
Out-Dc CE(F) dic = Freeman's dichotomized out-degree centralization;
In- Dc CE(S) = Snijders' *J* index of graph in-degrees heterogeneity
Out- Dc CE(S) = Snijders' *J* index of graph out-degrees heterogeneity
Bc-Fre = betweenness centralization;
Apl = average path length;
Cl = global clusterization index (clustering coefficient).

able in terms of AS industry studies (Acha *et al.*, 2007; Alfonso-Gil, 2007; Esposito, 2004; Giuri *et al.*, 2007), because production is rather concentrated in few countries, and thus, it is reasonable to expect that this picture is mirrored in international trade data. In fact, USA and France have an In-Dc centrality about double than the close followers, and the whole distribution is quite unbalanced, so that few countries have relatively high and most countries very much small degrees. And for centralization is a sort of concentration index, this result makes production and trade aspects reciprocally consistent. This picture will be confirmed later on also by other analyses, and particularly by the scale-free distribution of import and export shares. The “strange” result is that of centralization in terms of trade values. Apparently, one could expect that this expression had to emphasize centralization, but instead it is almost annulled. This can be explained looking closely at how this index is built and at the peculiarity of these valued data, as discussed in the previous (methodological) section.

This interpretation is confirmed by the fact that, if calculation is made in log2 terms of economic values, then In-Dc-CE(F) shoot up to 0.43, because the very high values of the *k* group is squeezed respect to the *n-k* followers, making their contrast of with leader’s centrality meaningful. If we define the *k* group as the early eight countries – USA, France, Germany, UK, Canada, Brazil, Italy, and Spain – we see that they import from almost all the others, and that they cover 19.8% of all In-degrees in dichotomous terms respect to 6.5% in terms of import share. Looking at the trend during the five years, we see that not very much changes excepted that dichotomous and log2 centralization increases a little bit. Snijders’ multi-centered index (Dc CE(S)) confirms a very high level of centralization, aligned with that of Freeman’s index applied to log2 values and remarkably lower than that applied to absolute values.

Export shows a picture very similar to import centralization: an extremely high (0.7) level in dichotomous terms, which slightly decreases to 0.59 in logarithmic terms, and then crashes to 0.05 in economic values. Anyway, this latter is two and a half times that of import centralization, and in fact the eight leader countries cover 24.5% of total out-degrees, corresponding to 11.7% of export share. The interpretation is strictly aligned with that provided above for In-Dc centralization. Here, there is a slight reduction during the five years. In conclusion, grounding the analysis especially on dichotomous and log2 terms and with the methodological caveats discussed above, *AS international trade results extremely centralized either in imports or in exports*, but much more (about 12 points) in exports than in imports, even though the latter are increasing and the former decreasing.

Despite such concentration of direct centrality, the intermediating power, which is expressed by Bc-Fre, is quite small. This is due to two different factors: i) it doesn’t consider the values of the exchanges, but only their existence and orientation; ii) in the network more than a couple of big hubs exist. Likely, they are the few components of core countries (see below). Apl is quite low (1.7), confirming the existence of hubs that permit to connect all the network with short paths. The coefficient of global Cl is very high, telling us that a country’s partners tend usually to exchange each others, especially among core countries.

COMMON EARTH MATERIALS RADE WEB

The CEM sector concerns the following sub-sectors, with their respective commodities[6]: salt, Sulphur, earth, stone, plaster, lime, and cement. It should be noted that in this sector all fossil fuels, as oil, gas, coal, etc., and other energy fuels, like uranium, are excluded. As well, metallic minerals are excluded too. Unfortunately, there are no studies on this sector (at least at aggregate level), neither at international nor at national levels. However, on an intuitive base it is possible to advance some reasonable conjectures. Its technological development– at least in many (most?) sub-sectors could vary a lot across different countries, and its key-resources are raw materials, which indeed are (presumably) quite uniformly distributed worldwide, at least for many of its sub-sectors. Demand and supply could be evenly distributed between countries, with a major level of demand in highly developed and developing countries. Of course, international trade depends not only on domestic demand but also on domestic production. Unfortunately, lacking these data, our reasoning is purely conjectural.

During 2002-2006 CEM world trade increased its density of exchange (table 2) from 25 up to 29%, which indeed are values similar to AS. Conversely, being rather evenly geographically distributed over 30 countries more than AS[7], its total trade value, is only a small share (16% in 2006) than that of AS,

Table 2. CEM network outline

	2002	2003	2004	2005	2006
Size	121	121	121	121	121
N. of links	3,643	3,775	3,972	4,181	4,274
Total trade (10^6)	14,742	16,604	19,11	21,477	24,677
AVBT (10^6)	4	4	5	5	6
Adc	30.11	31.20	32.83	34.55	35.32
H_k	0.12	0.15	0.08	0.06	0.06
Reciprocity	0.48	0.5	0.5	0.52	0.51
Density	0.251	0.26	0.274	0.288	0.294
In-Dc CE(F)	0.02	0.02	0.02	0.03	0.03
Out-Dc CE(F)	0.02	0.01	0.02	0.02	0.02
In-Dc CE(F) dic	0.43	0.44	0.47	0.53	0.48
Out-Dc CE(F) dic	0.68	0.67	0.66	0.61	0.64
In-Dc CE(F) log2	0.29	0.29	0.31	0.34	0.31
Out-Dc CE(F) log2	0.46	0.45	0.45	0.43	0.45
In-Dc CE(S)	0.33	0.34	0.34	0.36	0.36
Out-Dc CE(S)	0.55	0.56	0.56	0.55	0.55
Bc-Fre	0.09	0.08	0.1	0.1	0.08
Apl	1.79	1.77	1.77	1.74	1.73
Cl	0.47	0.48	0.49	0.5	0.5

Legend:
Size = number of nodes;
AVBT = average value of bilateral trade, which results from total trade divided by the number of actual exchanges;
Adc = average degree centrality;
H_k = hierarchical degree (degree of direct and indirect reciprocity);
Reciprocity = degree of direct reciprocity;
Density (dichotomized) = when the values of the links are not considered;
In-Dc CE(F) valued = Freeman's in-degree centralization with economic values;
Out-Dc CE(F) valued = Freeman's out-degree centralization with economic values;
In-Dc CE(F) log2 = Freeman's in-degree centralization with economic values. In this case we used the base-2 logarithm values;
Out-Dc CE(F) log2 = Freeman's out-degree centralization with economic values. In this case we used the base-2 logarithm values;
In-Dc CE(F) dic = Freeman's dichotomized in-degree centralization;
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Out- Dc CE(S) = Snijders' *J* index of graph out-degrees heterogeneity
Bc-Fre = betweenness centralization;
Apl = average path length;
Cl = global clusterization index (clustering coefficient).

and the average value of bilateral trade less than 10% (average trade value is 204 million US$ respect to the 1717 million US$ in AS). However, during the five years CEM total trade value grew by 67.4%, much more than the 49% of AS, as well the absolute number of links, and hence network connectivity, increased of 17.3% respect to the 14.7% of AS. Adc varies between 30 in 2002 and 35 in 2006 links per country, higher than AS and also with a higher growth rate. Analogously to AS, in dyadic terms this network is definitely not hierarchical, either directly or indirectly.

Looking at the Freeman's index, in 2006 imports are very centralized in dichotomous terms, even though 10 points less than in AS (0.48 respect to 0.58), while in economic values it is almost the same (0.02). In logarithmic terms it is very centralized too (0.31), even though 12 points lower than AS. Here, five – USA, Germany, Canada, France, and Spain - out of the AS eight leader countries do coincide, and China enters the group. The same comments made for AS to explain the discrepancy between the three measures - dichotomous, log2 and economic values – hold here too. Trend analysis show that there is a slight increasing (about 10%) of centralization during the five years. Analogously to imports, export centralization mimics that of AS, as well with lower values: dichotomous is 0.64 instead of 0.7, logarithmic is 0.45 instead of 0.59, and in absolute values 0.02 instead of 0.05. Here, early eight countries cover 11.4% of all exports, and 11.8% of imports. During the five years export centralization reduces a little bit (between 1.5 and 5.9%, in log2 and dichotomous terms, respectively). As it happens in AS too, the multi-centered index confirms a very high level of centralization, but lower than that of Freeman's index, and slightly higher when this latter is applied to log2 values. In sum, *CEM international trade is also very much centralized like AS, but remarkably less*. Moreover, again mimicking AS, such a centralization is much more in exports than in imports, even though the former is reducing while the latter increasing. Thus, hubs seem to count more in exports than in imports. Apl is the same of AS, indicating that, because of the major size, some hub permits to connect all the network in less than two steps. Analogously to AS, this trade pattern is remarkably clusterized, and growing over time, likely due – in both sectors – to an evenly density increasing.

TOPOLOGICAL SIMILARITY

After describing general synthetic indicators, a step further in analyzing structural changes during the five years can be done by contrasting each pair of years through topological correlation of values and pure (dichotomous) topological overlapping. This analysis is run through QAP correlation, SM, J, and MJ (see the methodological section). Looking at AS, QAP matrix (table 3) correlates in- and out-flows, taking an economic value approach. It shows an almost full positive value (average 0.94), especially between contiguous years. This is probably due to the very high values of single bilateral trades, which statistically "squeeze" differences in a narrow range. In fact, when considering the base-2 logarithm (table 4), mean correlation index decreases considerably (0.83). However, it still keeps very high, indicating that also medium-small bilateral trades are similar among the five years.

When considering "pure" topological similarity in terms of present or absent links (table 5), that is with the SM index, results do not change very much (89%). This likely depends on the large number of *potential but not actual* bilateral trades, because "missing links" are about 69% (the complement to 100% of density). Hence, as discussed into the methodological section of the previous chapter (see Angelini & Biggiero), in order to take into account this factor, we have calculated a second type of similarity matrix cleaning for absent bilateral exchanges, i.e. we analyzed stability only respect to existing links

Table 3. AS QAP correlation matrix

	2002	2003	2004	2005	2006
2002	1.00				
2003	0.96	1.00			
2004	0.94	0.96	1.00		
2005	0.94	0.95	0.95	1.00	
2006	0.92	0.92	0.91	0.97	1.00

Table 4. AS QAP correlation matrix in log2

	2002	2003	2004	2005	2006
2002	1.00				
2003	0.84	1.00			
2004	0.83	0.85	1.00		
2005	0.80	0.83	0.86	1.00	
2006	0.80	0.81	0.83	0.85	1.00

between each couple of years (table 6 and 7). Reminding the difference between Jaccard coefficient and its modified version, we see that, once selecting only actual links, yearly similarity drops down to 68%, 21 points lower than SM. Further, when considering the modified version, similarity index crashes to 24, that is 65 points less than in SM. Therefore, considering only the actual exchanges without their economic values, *AS world trade changed yearly very much* (more than 75%).

QAP correlation matrix (table 8) shows strong and positive correlation values (0.95), especially between contiguous years, aligned with what has been observed in AS trade. When considering base-2 logarithm (table 9), mean correlation index decreases to 0.87, again in a similar way of AS, but with 4 points more, meaning that there are more exchanges of lower values.

Looking at pure topological similarity in terms of present or absent links (table 10), results do not change substantially and, with an average value of 0.91, CEM shows a degree of similarity higher than AS. Again, there is the same role played by missing links, which here count even more, likely due to the fact that the 30 countries more than AS size are all peripherals, and hence scarcely connected, as showed by the lower density. To grasp this aspect, Jaccard coefficient (table 11) is 71%, and its modified version

Table 5. AS Simple Matching matrix 2002-2006

	2002	2003	2004	2005	2006
2002	1.00				
2003	0.90	1.00			
2004	0.89	0.90	1.00		
2005	0.88	0.89	0.90	1.00	
2006	0.88	0.88	0.89	0.90	1.00

Table 6. AS Jaccard coefficient

	2002	2003	2004	2005	2006
2002					
2003	0.70				
2004	0.68	0.71			
2005	0.66	0.68	0.73		
2006	0.65	0.66	0.69	0.72	

Table 7. AS Modified Jaccard coefficient

	2002	2003	2004	2005	2006
2002					
2003	0.22				
2004	0.22	0.23			
2005	0.22	0.23	0.25		
2006	0.22	0.22	0.24	0.25	

Table 8. CEM QAP correlation matrix

	2002	2003	2004	2005	2006
2002	1.00				
2003	0.96	1.00			
2004	0.94	0.98	1.00		
2005	0.93	0.97	0.98	1.00	
2006	0.89	0.92	0.93	0.96	1.00

Table 9. QAP correlation matrix in log2

	2002	2003	2004	2005	2006
2002	1.00				
2003	0.89	1.00			
2004	0.87	0.89	1.00		
2005	0.85	0.87	0.90	1.00	
2006	0.83	0.85	0.86	0.89	1.00

Table 10. CEM Simple Matching matrix

	2002	2003	2004	2005	2006
2002	1.00				
2003	0.92	1.00			
2004	0.91	0.92	1.00		
2005	0.90	0.91	0.92	1.00	
2006	0.88	0.89	0.90	0.91	1.00

Table 11. CEM Jaccard coefficient

	2002	2003	2004	2005	2006
2002					
2003	0.74				
2004	0.71	0.74			
2005	0.68	0.71	0.75		
2006	0.65	0.68	0.70	0.74	

(table 12) 23%: hence, as we saw in AS, when appropriately taking into account missed links *CEM trade patterns change dramatically every year* (about 77% of links). Moreover, when selecting only those exchanges that persisted during all the years, in AS only 1590 links - corresponding to 19.4% - remain, and in CEM only 2742 links (18.9%). In sum, *under a seeming stability, both sectors experienced an extreme variability of trade patterns*.

SCALE-FREE AND SMALL-WORLD PROPERTIES

As can be seen from the four following figures, in 2006 both networks have a SF distribution of import and export share, with excellent fitness values of the estimated functions.

Besides the SF, both networks show also the SW property (table 13), and noticeably with very narrow values (all within the second decimal). Hence, *both networks are either SF or SW*.

Table 12. CEM Modified Jaccard coefficient

	2002	2003	2004	2005	2006
2002					
2003	0.22				
2004	0.22	0.23			
2005	0.22	0.23	0.24		
2006	0.22	0.22	0.23	0.25	

Figure 1.

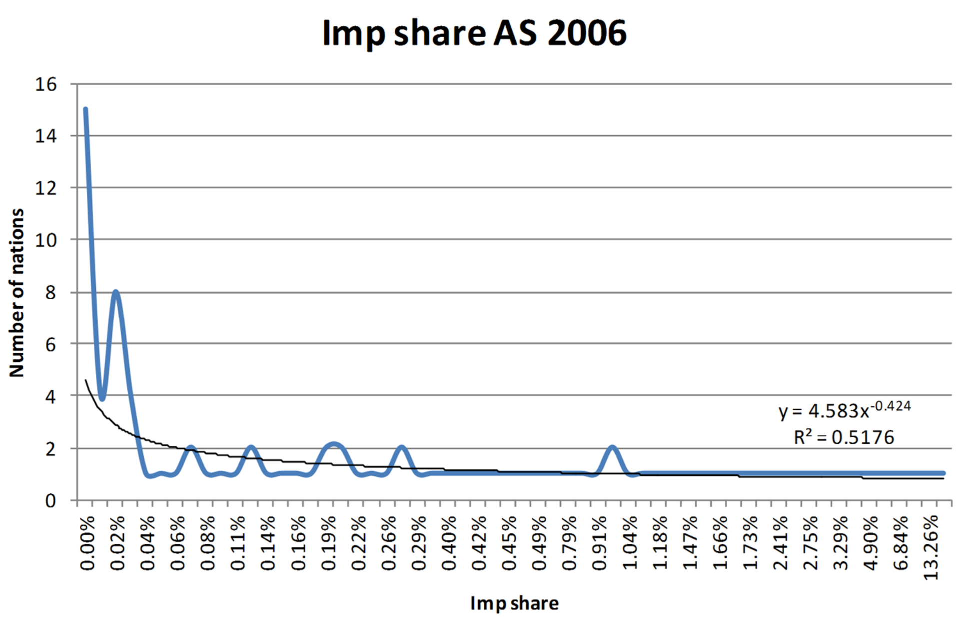

Figure 2.

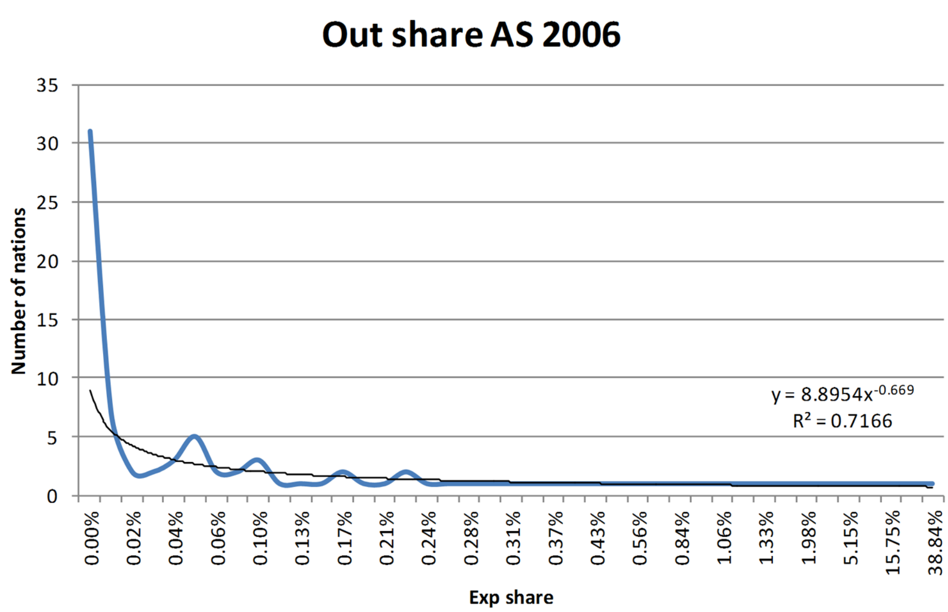

Figure 3.

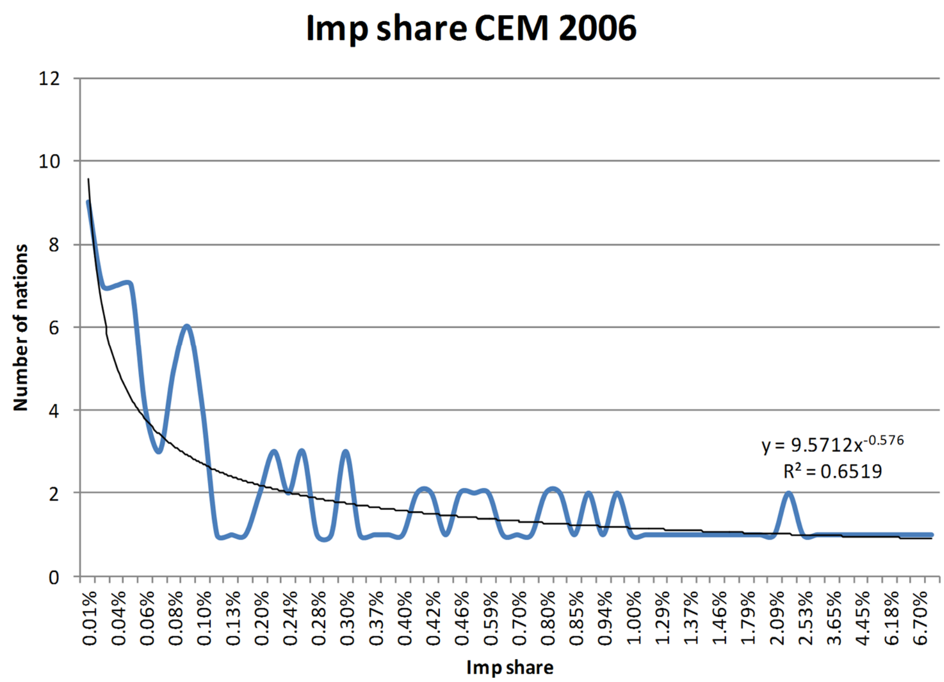

Figure 4.

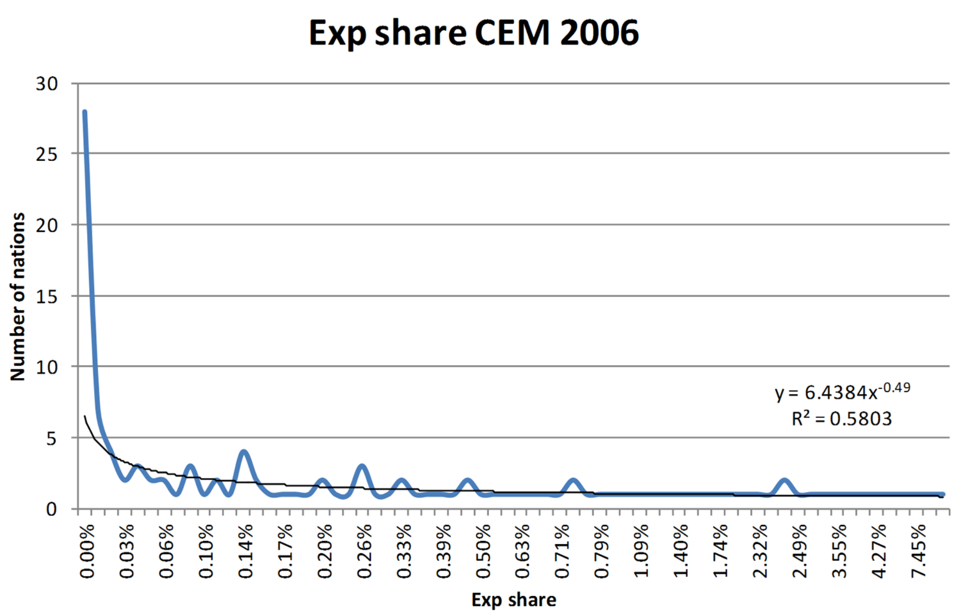

Table 13.

Small World coefficients								
	Density	Cl Actual	Cl Random	Apl Actual	Apl Random	Cl ratio	Apl ratio	Q
AS 2002	0.27	0.29	0.11	1.72	1.73	2.68	1.00	2.69
AS 2003	0.28	0.31	0.12	1.73	1.73	2.67	1.00	2.66
AS 2004	0.30	0.32	0.12	1.72	1.70	2.57	1.01	2.54
AS 2005	0.31	0.33	0.13	1.70	1.69	2.49	1.01	2.47
AS 2006	0.31	0.32	0.13	1.70	1.69	2.40	1.01	2.38
CEM 2002	0.25	0.27	0.10	1.79	1.75	2.71	1.02	2.65
CEM 2003	0.26	0.28	0.11	1.77	1.74	2.68	1.02	2.64
CEM 2004	0.27	0.29	0.11	1.77	1.73	2.60	1.03	2.53
CEM 2005	0.29	0.30	0.12	1.74	1.71	2.50	1.02	2.46
CEM 2006	0.29	0.29	0.12	1.73	1.71	2.38	1.01	2.36

Legend: Q = Cl ratio/Apl ratio

ASSORTATIVITY AND CORE-PERIPHERY ANALYSIS

Both networks are a little bit dis-assortative (table 14): in dichotomized terms AS is more dis-assortative than CEM, meaning that highly centralized countries tend to exchange more with low than with high centralized countries, and vice versa. This characteristic lowers substantially in valued terms, where AS becomes almost neutral (0.11), while CEM shows a weak preference (0.16) for dis-assortativity. These differences between dichotomous and valued terms can be explained with the fact that exchanges between highly centralized countries count much more than the ones between highly and lowly centralized countries. Further, CEM lower average value of single bilateral trade respect to AS explains also why dis-assortativity reduction is much higher for AS than for CEM, so much that, in valued terms, CEM becomes more dis-assortative than AS.

AS core-periphery analysis shows interesting outcomes, with good levels of fitness (table 15), thus dividing in a very reliable way the two sub-networks. In dichotomous terms, core varies between 43

Table 14.

Relation	Network	Assortativity
Dichotomized	AS 2002	-0.349
	AS 2006	-0.364
	CEM 2002	-0.234
	CEM 2006	-0.245
Valued	AS 2002	-0.114
	AS 2006	-0.109
	CEM 2002	-0.155
	CEM 2006	-0.158

Table 15.

AS Core-Periphery									
	Core			Periphery			Total Avg. Density*	size	fitness
	N. Countries	% Countries	Density intra core*	N. Countries	% Countries	Density intra periphery*			
2002	7	0.08	726	84	0.92	1	13	91	0.5
2002 log2	37	0.41	15.90	54	0.59	0.71	4.92	91	0.765
2002 dic	44	0.48	0.70	47	0.52	0.03	0.27	91	0.711
2003	7	0.08	644	84	0.92	2	12	91	0.457
2003 log2	40	0.44	15.57	51	0.56	0.54	5.10	91	0.758
2003 dic	45	0.49	0.70	46	0.51	0.02	0.28	91	0.707
2004	7	0.08	118	84	0.92	1	14	91	0.54
2004 log2	41	0.45	16.04	50	0.55	0.55	5.41	91	0.77
2004 dic	43	0.47	0.78	48	0.53	0.03	0.30	91	0.766
2005	8	0.09	662	83	0.91	2	15	91	0.46
2005 log2	40	0.44	16.84	51	0.56	0.75	5.70	91	0.789
2005 dic	45	0.49	0.77	46	0.51	0.04	0.31	91	0.752
2006	9	0.10	1.003	82	0.90	1	19	91	0.453
2006 log2	40	0.44	16.62	51	0.56	0.57	5.80	91	0.783
2006 dic	43	0.47	0.78	48	0.53	0.03	0.31	91	0.773

* values should be multiplied per 10^6

and 45 countries, depending on the year. The corresponding density ranges between 70 and 78%, with a fitness level systematically higher than 0.7. If we examine data in value terms, core shrinks to only 7-9 countries, with a density that in 2002 accounts 57 times and in 2006 53 times the average of the whole network. If we squeeze the highest values through log2 expression, then core enlarges about 5 times, meaning that as soon average exchange values are more balanced, more than half peripheral countries enter the core. Hence, *AS is characterized by a strong, elitist, and well defined core*.

Periphery has a very low density: about 3% in dichotomous terms and one tenth (respect to the average exchange value of the whole network) in valued terms. Thus, *peripheral countries almost do not trade each other*. Conversely, and confirming the slightly prevalent dis-assortativity, a lot of exchanges occur from core to peripheral countries (table 16), scoring an inner density that ranges from 27% in 2002 to 33% in 2006. A remarkable number of exchanges occurs also from peripheral to core countries, with an inner density ranging from 14% in 2002 to 18% in 2006. Interestingly, from a dynamic perspective 2002-

Table 16.

Density matrix of core-periphery						
	AS					
2002	**valued**		**dichotomized**		**log2**	
	Core	Periphery	Core	Periphery	Core	Periphery
Core	726,453,312,000	70,823,912,000	0.702	0.270	15.854	5.639
Periphery	38,374,520,000	1,383,281,875	0.135	0.026	2.979	0.707
2003	**valued**		**dichotomized**		**log2**	
	Core	Periphery	Core	Periphery	Core	Periphery
Core	644,313,408,000	70,628,472,000	0.697	0.265	15.568	5.049
Periphery	36,367,736,000	1,704,541,000	0.138	0.021	2.850	0.535
2004	**valued**		**dichotomized**		**log2**	
	Core	Periphery	Core	Periphery	Core	Periphery
Core	1,182,167,424,000	65,928,988,000	0.775	0.301	16.035	5.333
Periphery	26,202,686,000	1,315,606,125	0.160	0.033	2.799	0.553
2005	**valued**		**dichotomized**		**log2**	
	Core	Periphery	Core	Periphery	Core	Periphery
Core	662,198,464,000	72,257,768,000	0.772	0.291	16.844	5.735
Periphery	40,455,004,000	1,644,901,625	0.172	0.036	3.339	0.751
2006	**valued**		**dichotomized**		**log2**	
	Core	Periphery	Core	Periphery	Core	Periphery
Core	1,002,873,984,000	81,918,752,000	0.782	0.332	16.620	6.221
Periphery	21,299,336,000	1,080,088,500	0.183	0.033	3.633	0.565
	CEM					
2006	**valued**			**2005**	**log2**	
	Core	Periphery			Core	Periphery
Core	3,788,178,750	156,294,391		Core	15.065	5.793
Periphery	49,599,488	36,846,027		Periphery	2.909	1.016

2006, while periphery density does not change, core density grows 8 points, and core-to-periphery and periphery-to-core 5 points. If we further add that core slightly increases its size of two countries, it seems clear that *during the five years core relevance increased while that of periphery decreased*, as expected for its ancillary role even in global industry structure. Core dominance is well evidenced even in table 17, showing that in 2006 the 9 core countries – just 10% of all countries – cover 46% of all economic exchanges, and in spite of very marginal imports from periphery (10%), core countries export 39%[8].

Unfortunately, this (categorical) core-periphery algorithm applied by UCINET (Borgatti & Everett, 1999) worked very bad on CEM data (table 18) because, excepted for a couple of applications, fitness was far lower than 10%. Hence, we limit our interpretation to those two: the analysis of 2005 in terms of log2 and that of 2006 in dichotomous terms. Both show a core of about 50 countries, which means 40% of the whole size: in dichotomous terms core density is two and half times that of the whole network

Table 17.

Proportional shares of the core-periphery four combinations						
	Shares of the four sub-networks				Size share	
	c-c	c-p	p-p	p-c	core	periphery
AS valued 2006	0.46	0.39	0.05	0.10	0.1	0.9
AS dichotomous 2006	0.55	0.27	0.03	0.15	0.47	0.53
CEM dichotomous 2006	0.49	0.29	0.07	0.16	0.44	0.56
CEM log2 2005^	0.88	0.08	0.04	0.02	0.4	0.6

^ these data express the logarithmic in absolute values and then calculate the shares

Table 18.

CEM Core-Periphery									
	Core			Periphery			Total Avg. Density*	size	
	N. Countries	% Countries	Density intra core*	N. Countries	% Countries	Density intra periphery			fitness
2002	65	54	3	56	46	32598	1	121	
2002 log2	110	91	4.99	11	9	0.62	4.25	121	
2002 dic	113	93	0.28	8	7	0.02	0.25	121	0.039
2003	76	63	3	45	37	10867	1	121	0.077
2003 log2	111	92	5.15	10	8	0.34	4.44	121	0.05
2003 dic	119	98	0.27	2	2	0.00	0.26	121	0.007
2004	85	70	3	36	30	13659	1	121	0.054
2004 log2	111	92	5.35	10	8	0.39	4.63	121	0.051
2004 dic	118	98	0.29	3	2	0.00	0.27	121	0.013
2005	114	94	2	7	6	10	2	121	0.006
2005 log2	48	40	15.10	73	60	1.01	4.80	121	0.744
2005 dic	118	98	0.30	3	2	0.00	0.29	121	0.014
2006	80	66	4	41	34	36846	2	121	0.069
2006 log2	105	87	6.21	16	13	0.60	4.91	121	0.093
2006 dic	53	44	0.75	68	56	0.06	0.29	121	0.713

* values should be multiplied per 10^6

average, while periphery is very sparse (6%). Looking at the shares of the four sub-networks in terms of 2005 log2 economic values – and then expressing these logarithmic in absolute values – we see that this large core absorbs 88% of all exchanged values. In short, from these fragmented data we can say that *in CEM trade a strict core cannot be found*, and that, to the extent it can be found, in economic terms periphery is almost superfluous.

A STRAIGHT COMPARISON

There are 89 countries common to the two networks, because two are only in AS and 30 only in CEM. These latter countries are totally irrelevant from an economic perspective, and also very marginal from a topological perspective. They are the countries responsible for the high volatility of exchanges, as witnessed by the small inter-year stability measured by the Modified Jaccard coefficient. Therefore, it is very interesting to directly contrast the two networks (table 19), which now (having the same nodes) can be straightly compared also in pure topological terms.

As concerning the general indexes, while most of them remain unchanged, we can note that CEM hierarchical degree lowers, equaling that of AS. Clearly, a certain hierarchical power is exerted especially over the 30 marginal countries. Further, density jumps from 29 up to 40%, just because (as we

Table 19.

	AS 2006	CEM 2006	AS-CEM 2002	AS-CEM 2006
Size	89	89		
N. of links	2,446	3,121		
Total trade (10^6)	149,013	22,535		
AVBT (10^6)	60.9	7.2		
Adc	27.48	35.06		
H_k	0.04	0.04		
Reciprocity	0.59	0.58		
Density	0.31	0.40		
In-Dc CE(F)	0.02	0.04		
Out-Dc CE(F)	0.05	0.03		
In-Dc CE(F) dic	0.58	0.46		
Out-Dc CE(F) dic	0.70	0.55		
In-Dc CE(F) log	0.43	0.32		
Out-Dc CE(F) log	0.59	0.43		
In-Dc CE(S)	0.37	0.38		
Out-Dc CE(S)	0.54	0.54		
QAP			0.42	0.33
QAP log2			0.62	0.64
SM			0.8	0.79
Jaccard coefficient			0.5	0.54
Modified Jaccard coefficient			0.21	0.25
Persistency	0.19	0.27		
Bc-Fre	0.14	0.06		
Apl	1.7	1.60		
Cl	0.53	0.58		

Legend: see that of table 1.

have discussed in the previous section) periphery, which was composed by all marginal countries, was definitely sparse. Moreover, once "deleted" them, CEM network appears a little bit more clusterized, and with a little bit shorter Apl. However, being these differences very small and having the same network size, also the small-world degree of the two networks is very similar.

As concerning centralization, the values of the various indicators are very close, and in particular the two built on the most appropriate Snijders' measure are identical for exports (Out-Dc) and almost identical for imports (In-Dc). *What strongly differs is the intermediating power of few countries*, which in As is more than double than in CEM, which likely mirrors a higher concentration of AS production and export in few countries, respect to CEM more evenly distribution.

What surprises and is noteworthy is that, once cleaned for zeros, a pure topological comparison (through the MJ index) evidences a sharp difference between the two networks: only 21% of links in 2002, and 25% in 2006. The growth of structural homogeneity between the two years could be interpreted as a sign of structural inter-sectoral convergence of international trade. What is even more interesting is that diversity prevails also when comparing the two structures in economic terms (through the QAP coefficient), even though it is much less accentuated than in pure topological terms. Noteworthy, when squeezing highest values through log2, AS and CEM networks become more similar than dissimilar, and its similarity increases during the five years. It means that *reducing economic distance between core and periphery trades, the two networks become more and growingly similar*. Finally, *persistency of trades between the same pairs of countries is low in both networks, but much higher in CEM than in AS*.

After "cleaning" CEM original network for 28 peripheral countries, its core-periphery analysis changes radically (table 20), and fitness values become very good for all the three network configurations in both 2002 and 2006: valued, log2 valued, and dichotomous links. Surprisingly, here we see a network with a marked and highly polarized core-periphery structure: only two countries build the core when considering the valued links network. They become 28 and 36 when considering log2 values or dichotomous links, respectively. It means that there are about 26-34 countries that have so important and numerous connections to be added to the top two countries constituting a core. Remarkably, the fitness value of these two structures is significantly higher than that of the other (simple valued links) configuration in both years.

Table 20.

CEM - Core-Periphery									
	Core			Periphery			Total Avg. Density	size	fitness
	N. Countries	% Countries	Density intra core	N. Countries	% Countries	Density intra periphery			
2002	2	2.2	524837056	87	97.8	1341915	1730050	89	0.623
2002 log2	28	31.5	17.66	61	68.5	1.49	6.07	89	0.794
2002 dic	36	40.4	0.86	53	59.6	0.09	0.35	89	0.773
2006	2	2.2	673936704	87	97.8	2313529	2877346	89	0.547
2006 log2	36	40.4	18.38	53	59.6	1.68	6.82	89	0.807
2006 dic	38	42.7	0.90	51	57.3	0.10	0.40	89	0.787

Respect to AS core-periphery CEM core results to be even more elitist, restricted to a lower number of countries in all configurations in both 2002 and 2006. Indeed, the core-periphery structure of the valued configurations is quite singular, because core is composed by only two countries – US and Canada – that exchange so much to push all the rest of 87 countries to build one huge group. Exchange size can be seen also from table 22, which shows that, while in terms of number of connections they cover about 2%, in terms of values they account for 96-97%. This share drops down around 50% either in log2 or in dichotomous terms, because in these cases we are considering a core of 28 and 36 countries in 2002, and 36 and 38 countries in 2006. And thus, these two should be taken into account as the most meaningful structures. Remarkably, in both cases intra-core density is about nine times intra-periphery density, suggesting a strong cohesion within each partition, and confirming the significance of the algorithm in this application. During the five years, the densities of the four partitions – c-c, c-p, p-c, and p-p – all grow up (table 21), but the share of each partition remains substantially unchanged (table 22). Moreover, there is of course much more density in relationships directed from core to periphery than vice versa (table 21).

A direct comparison of AS and CEM core-periphery structures can be done between the dichotomous and log2 configurations in 2002 and 2006. Density of the four partitions of either the dichotomous or the log2 configurations in both years is much higher in CEM than in AS, showing its clear higher cohesion. However, the shares of connections of each partition on the total connections are very much similar. Moreover, excepted for 3-4 countries, *all the members of CEM core in the log2 and dichotomous configurations are in AS core too*.

Table 21.

CEM - Density matrix of core-periphery						
2002	**valued**		**dichotomized**		**log2**	
	Core	**Periphery**	**Core**	**Periphery**	**Core**	**Periphery**
Core	524837056	6825841	0.88	0.46	17.7	8.00
Periphery	7311309	1341914	0.28	0.09	4.5	1.5
2006	**valued**		**dichotomized**		**log2**	
	Core	**Periphery**	**Core**	**Periphery**	**Core**	**Periphery**
Core	673936704	9937628	0.9	0.49	18.4	8.4
Periphery	12347807	2313529	0.33	0.1	5,00	1.7

Table 22.

CEM - Proportional shares of the core-periphery four combinations						
	Shares of the four sub-networks				**Size share**	
	c-c	**c-p**	**p-p**	**p-c**	**core**	**periphery**
CEM valued 2006	0.97	0.01	0.02	0.00	0.02	0.98
CEM dichotomous 2006	0.50	0.27	0.18	0.06	0.38	0.62
CEM log2 2006	0.55	0.25	0.15	0.05	0.43	0.57
CEM valued 2002	0.97	0.01	0.01	0.00	0.02	0.98
CEM dichotomous 2002	0.52	0.27	0.16	0.05	0.40	0.60
CEM log2 2002	0.56	0.25	0.14	0.05	0.31	0.62

SYNTHETIC EVALUATIONS

It's not easy to draw concluding remarks on this comparison because when there isn't a full convergence (or dominance) toward similarity or dissimilarity. Thus, a hard question arises: similar in terms of what? And further, when there are no previous studies of this type with whom benchmarking evaluations, another hard question arises: where is the "similarity threshold" for each criterion (and even for each indicator)[9]? The right methodological way to correctly face with these two answers requires two operations. The first one is deciding ex-ante under which aspects the comparison is considered meaningful or just interesting (or useful) to the researcher's aims. This requirement is usually accomplished by structuring the analysis by raising research hypotheses, from which the corresponding criteria and indicators are derived. The second operation is even more complex, because very often implies the application of multicriteria decision making, as it has been discussed at the end of the previous chapter of this volume (see Angelini & Biggiero).

Overlooking formal multicriteria methods, it's possible to draw a synthetic – albeit imperfect - picture of the similarities and differences evidenced through the comparison. The second column of table 23 indicates whether AS is superior, equal or inferior to CEM; the third column shows similarities of the 32 indicators in 2006[10]; and the fourth shows similarities over the trend 2002-2006. Let's comment them by grouping indicators into the following categories:

- Very general: size, AVBT, Adc, Apl, density, Cl, SW, assortativity;
- Hierarchy focused: reciprocity, H_k, various forms of centralization, SF;
- Strictly topological: QAP, QAP log2, SM, J, MJ, persistency, core-periphery.

Starting from the first group, we see that, likely due to its high-value products, AS average bilateral trade has a much higher value than CEM, so much that their comparability is low. Even if they resemble because in both sectors this value tend to considerably grow during the five years, in CEM this growth is much sharper. If we move from economic to pure dichotomous values the situation reverts: CEM average degree centrality is 6 links higher than AS (26.4 during the five years), and grows a little bit faster (17.3 respect to 14.7). In spite of this, CEM density is slightly inferior to AS, but anyway very high and close. Conversely, Apl is very short in both networks (about 1.7), and it is slightly reducing in both. So far, *the two networks substantially differ only in terms of average value of bilateral trade, being very similar respect to average degree centrality, average path length, and density*.

Remaining within the first group of general indicators, global clustering is high in both networks and almost identical, and it grows at the same rate too. For Apl is low and almost identical too, no surprise that both networks have a small-world topology, and that it is nearly the same. Both networks are dis-assortative - less in valued terms – with AS more dis-assortative than CEM in dichotomous terms, and vice versa in valued terms. Concluding on this first group of indicators, the two networks result very similar: 6 indicators (out of 9) with high similarity in 2006, and 7 as trend.

The indicators of the second group help mostly to analyze hierarchy under many respects[11]: reciprocity and H_k focus more on the dyadic aspect of hierarchy, which is rooted into dyads possible asymmetries; Freeman's centralization points at the relative involvement of nodes respect to the leader; Snijders' centralization takes into account multi-centered topological variance; and finally, scale-free evidences a distribution unbalance (nonlinearity). In both networks reciprocity is very high and close, and it grows significantly: in all cases more in AS than CEM. Consistently, H_k is very low, and it decreases dramatically

Table 23.

	AS vs. CEM	2006	trend 2002-2006
Size	<	L	
AVBT (10^6)	>	L	M
Adc	<	H	H
H_k	<	H	M
Reciprocity	>	H	H
Density	>	H	H
In-Dc CE(F)	<	H	L
Out-Dc CE(F)	>	H	H
In-Dc CE(F) dic	>	H	M
Out-Dc CE(F) dic	>	H	H
In-Dc CE(F) log	>	H	L
Out-Dc CE(F) log	>	M	H
In-Dc CE(S)	>	H	H
Out-Dc CE(S)	>	H	H
Bc-Fre	>	H	H
Apl	<	H	H
Cl	>	H	H
QAP^	=	H	H
QAP log2^	<	H	H
SM^	=	H	H
Jaccard^	<	H	H
Modified Jaccard^	=	H	H
Persistency		H	
QAP*		L	
QAP log2*		M	
Simple Matching*		H	
Jaccard*		M	
Modified Jaccard*		L	
Scale-free	=	H	H
Small-world	=	H	H
Dichotomized assortativity	>	M	H
Valued assortativity	<	H	H
Categorical core-periphery analysis			

Legend: • similarity is estimated in terms of high (H), medium (M), low (L); • ^ average similarity during 2002-2006; • *straight comparison.

in both networks, but more in AS than CEM. Therefore, according to these two indicators of hierarchy, both networks are lowly hierarchical: in average AS less than CEM, and in perspective AS is reducing it more than CEM. Put in other words, it means that in both networks it happens almost always that if a country exports to another, then it imports from it too, and vice versa[12]. Moreover, it means that exports (or imports) of almost any country could "reach" (or could be reached by) any other, alongside a potential global value chain. This result is quite surprising, because one expected much more hierarchy, but it can be explained by the fact that both measures have been taken in dichotomous terms. Apparently, trade relationships are rather reciprocal, and due to the role of a pool of hubs, potential global vale chains cross each other: therefore, they should be regarded more as global value "networks", rather than chains, being (the common sense of[13]) a chain a unidirectional - and hence, not reciprocal – structure.

When moving from a dyadic to an aggregate aspect of hierarchy, things change dramatically. Dc CE(F), which is an hierarchy index too (see Biggiero and Mastrogiorgio in this volume), jumps at 59% in AS and 45% in CEM: that is, both trade patterns are very much centralized - let say concentrated, with the caveats discussed above – with AS much more centralized than CEM, as expected by the main research issue put at the base of this chapter. Anyway, during the five years both networks reduce their centralization degree at the same rate, and in both exports are substantially less centralized than imports, even if at high levels: 43% in AS and 31% in CEM. Interestingly, in both networks import centralization increases instead of decreasing, and with significant values: 7.5 and 9.4%, respectively. Even more interestingly, calculating centralization in value terms but reducing the weight of highest exchanges by employing log2 algorithm, centralization increases in both sectors, and proportionally more in CEM than in AS. These results indicate that *there are important middle size (in value terms) exporters and importers in both networks, and proportionally more in CEM*. Snijders' index confirms a strong centralization of both sectors either in export or in import, and with very close values. In sum, *centralization shows that both sectors are very hierarchical either in exports or in imports*, with a clear major concentration of AS respect to CEM (only in terms of the less appropriate index), and a certain similarity only in trend terms. Due to the low dyad-based hierarchy, Bc is low (and decreasing) in both sectors, with a significant more centralization in AS. Still looking at hierarchy from another perspective, we see that both networks are shaped in a scale-free topology in value terms of export and import share. Thus, few countries have very high shares, some more are secondary but still significant, and most countries are definitely not influential in any sense. Giving a conclusive evaluation on the hierarchical nature of these two networks, we see that, *with the exception of the dyad-based hierarchy, they are strongly hierarchical, with AS much more than CEM*, as it was reasonable to expect.

Let's now move to the third group, which includes strictly topological measures. As we have seen, *in both sectors during the five years links distribution changes very much* (about 75%) only if we overlook missing exchanges, and here we underline that this – which we called Modified Jaccard coefficient – is the true indicator in all networks whose density is not very high (let say, more than 50%[14]), because otherwise missing links mislead results and interpretations. In fact, the other two dichotomous measures – SM and, to some extent, Jaccard coefficient – would indicate a substantial topological stability. As well misleading are the two QAP measures when, like in this case, value variance is very high, because if the major traders exchange most among them and maintain this pattern over time, then the whole network would appear very stable. This way, turbulence in trade patterns with volatility and new access would be hidden. Once correctly measured, that is through MJ *over the whole period, persistency appears very low* (about 19%) in both networks. Consequently, they behaved very similarly in this respect.

The situation changes radically if we directly compare the two networks, that is, if we check whether AS trades are distributed as CEM trades among the same countries. If we calculate the MJ coefficient, then in 2006 they differ radically: more than 75%, though with a decreasing diversity over time. Interestingly, almost the same degree of diversity holds even when considering the value of exchanges: QAP correlation is only 33%, and further, this difference increased respect to 2002. It means that the heaviest connections are distributed in a different way[15]. As discussed previously, unfortunately the core-periphery structure of the two networks can be compared only in two cases, because fitness results of the algorithm applied to CEM network are acceptable only for 2005 log2 and 2006 dichotomous: the corresponding density matrixes and core-periphery sizes are very similar. On the other hand, the measure in value terms for AS gives high fitness scores every year, and identifies a very polarized core-periphery structure: there is a 10% core countries, while in CEM it rounds about 50%, transforming the core and the periphery in just two slightly different groups.

Listing all together the three types of indicators – very general, hierarchy focused, and strictly topological – we obtain 27 indicators comparing the two networks as they are, plus six strictly topological indicators applied to the comparison of the manipulated versions of the two networks, built in order to make them directly comparable. Respect to the 27 indicators (table 20), in more than half of them AS records values major than CEM. It means that AS trades have major reciprocity, density, centralization, clusterization, persistency, and assortativity. They have instead almost the same level of topological self-similarity, power-lawness, and small-wordliness. Moreover, if we look at the range of differences of all these indicators in 2006 and during the five years, then we see that they are very small for 21 out of 27 indicators. Therefore, without manipulating data, the two networks appear rather similar in terms of all aspects, excepted for size and average bilateral trade values.

Things change substantially is we reduce the two networks to its common 89 countries (table 19), an adjustment that leaves AS almost unchanged but deletes 28 peripheral countries from the CEM network. In this direct comparison, what differs mostly and surprisingly is that CEM density is much higher than AS and that their structures are remarkably different. Links correlation is quite low (42%) in 2002 and 33% in 2006), and actual trade occur among the same pairs of countries only in 21% of cases in 2002 and 25% in 2006.

CONCLUSION

The aims of this work were three: i) exploring the specific research issue of the supposed similarities between global value chain and trade pattern, and the consequent differences between trade patterns corresponding to different global value chains, and the longitudinal similarity of trade patterns of each network; ii) offering a detailed example of social network analysis application finalized to a quite complex task as comparing two international trade networks; iii) showing the methodological problems raised by the interpretation of some indicators. As concerning the first aim, a clear result is that, if properly measured, trade patterns of both sectors are rather unstable, either yearly or during the whole period of analysis. This result is quite strong, even though it could be common to other international trade sectors. Conversely, as concerning inter-sectoral diversity, quite surprisingly we have seen that marked differences are limited only to three aspects: 1) the surprisingly higher density of CEM respect to AS; 2) the distribution of links among countries, which seems rather diverse, and anyway it is becoming more similar during the five years; 3) the degree of few countries intermediating power, which in AS is more than double than in CEM. Conversely, especially if we compare indicators in terms of variation range – as it is done in the third and fourth columns of table 21 - similarity would prevail. One way to conclude is that the expectation from which our analysis started is wrong: very different industries under technological and market structure, and thus, presumably in terms of global value chain, can have similar international trade patterns. Put in other words, the two supposed different global value networks corresponding to AS and CEM determine two international trade networks that are very similar under most respects, either in general and structural terms or in their trend during the five years of analysis.

Another way to conclude respect to inter-sectoral similarity is that the global value networks corresponding to the two sectors are not so markedly different. Indeed, as declared at the beginning, we are not aware of industry studies on CEM, neither at national nor at international level. Hence, we just speculated that, contrarily to AS, which does not require natural resources and it is high-tech, CEM is a natural resource based sector on the supply side, and these resources are not concentrated in few countries. Moreover, though some CEM sub-sector could be characterized by high-tech and large scale plants, most likely in many developing countries domestic demand could be matched also by small-scale and low-tech plants. Indeed, these speculations could be wrong, and so it could be discovered that the technologies and the global value networks of the two sectors are very similar. In this case, we shell conclude that our results confirm the theory that a sector's technology and global value network should "shape" the corresponding international trade.

However, there is a third way to conclude, which addresses to some methodological problems that perhaps prevent differences to be evidenced, and that require a more refined and modified comparison. A first problem comes from the high heterogeneity of these two sectors, and in particular of CEM. In fact, an issue left open by our analysis concerns the trade aggregation level at which this comparison has to be done in order to let differences emerge more markedly. In fact, both these trade sectors are very heterogeneous (see tables 22 and 23 in Appendix), and likely they include different industry structures and correspondingly different global value chains. When many sub-sectors are merged into a unique sector it could happen that sub-sectoral differences were "compensated" by "smoothing poles". If this were true, most sector-specific international trade networks would resemble hiding its inner diversity. Future studies aiming at deeply investigating into this research question had to be very careful in choosing the right trade sectors, taking into account: i) available scientific literature on the corresponding global value chain; ii) structural differences of technological and market structures, like entry barriers, number of competitors, filiére length, high-, medium- or low-levels of products and technologies; iii) a high degree of homogeneity within the sector. Likely, it would be necessary to get down at four digit level of aggregation (while the two sectors analyzed here rest on two digit level of aggregation), and maybe change the classification system.

Another source of doubts, which is also a limitation of this study, is the shortness of the time span that we have analyzed. In order to draw more solid conclusions it has to be considered a much longer period. Likely, it could happen that phases of stability are followed by others of instability. Perhaps, it is noteworthy that the instability we have found happens during the "golden age of globalization". Moreover, 20 or 25% of stability could be evaluated as very low in absolute sense, but it could be considered normal for international trade networks. To decide on the correct interpretation we had to compare these results with other sectors, a task for a future research agenda. This problem of lack of other analogous comparisons affects almost all other indicators too, and at the very end it makes difficult to draw any conclusive statement. In fact, in our synthetic evaluation we decided to consider highly similar variations within a range of 2-3 percentage points in a rather arbitrary way, because we indeed do not know whether in this specific phenomenal domain that variation can be considered irrelevant or, like for instance in comparing GDP, extremely remarkable. In this latter case, all the previous conclusions had to be reversed. Future studies will tell us the truth.

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ENDNOTES

1 See note 1 of the previous chapter.

2 Indeed, accordingly to recent studies in international trade from a social network analysis perspective, the global value chain had to be called, more appropriately, global value network, because instead of a simple topology like the chain, a specific good gives rise to more complex structures.

3 See Lewis (2008) and Newman (2010) and Watts & Strogatz (2008) for a discussion of these different evaluations.

4 These are the same used in the previous chapter – see Angelini & Biggiero - to compare R&D collaboration network and international trade network in the EU AS area. To know the meaning of each indicator and its differences, see that chapter.

5 For more details see table 25 in Appendix.

6 For more details see table 26 in Appendix.

7 Likely, this is due also to the fact that the technological content of these goods is supposed to be not as uniformly high as that of AS. More likely, in many CEM sub-sectors high-, medium, and low-tech production plants operate at the same time in various countries according to its general technological development.

8 A direct correspondence with the dichotomous-based partition in core-periphery cannot be done, because core enlarges 5 times.

9 This distinction comes from the fact that one criterion could potentially be described and measured by more than one indicator.

[10] Indeed, in the second and fourth columns there are only 27 indicators, because 5 – QAP, QAP log, SM, J and MJ - cannot be applied, because they indicate a not longitudinal comparative value.

[11] More specifically on this issue see the next chapter (Biggiero and Mastrogiorgio) of this book.

[12] Noteworthy, Hk grasps also indirect reciprocity.

[13] In fact, in principle, a chain can be fully reciprocal.

[14] Indeed, the socio-economic literature we know, and our direct empirical experience, suggests that in socio-economic networks else than international trade networks (at least at two digits, as the present ones) density should be considered very high even at 20%. In fact, alliance networks, knowledge or supply or trade inter-organizational networks and similar types score density much lower than that, often limited to 5%.

[15] A deeper understanding of this result aimed at knowing which links and countries make the major differences would require "unpacking" this comparison but, as well as for core-periphery, we did not develop the corresponding analysis at this level of detail.

APPENDIX

Table 24.

CEM Countries De-Selected for Straight Comparison	
Albania	
Algeria	
Armenia	
Azerbaijan	
Bahrain	
Barbados	
Belarus	
Cape Verde	
Dominica	
Ethiopia	
Gambia	
Grenada	
Honduras	
Hungary	
Iran	
Jamaica	
Jordan	
Malta	
Mongolia	
Oman	
Panama	
Qatar	
Rwanda	
Saint Kitts and Nevis	
Saint Lucia	
Saint Vincent and the Grenadines	
Sao Tome and Principe	
Suriname	
Syria	
TFYR of Macedonia	
Tunisia	
Viet Nam	
AS Countries De-Selected for Straight Comparison	
Botswana	
Namibia	

Table 25. Code, name and descriptions of AS according to COMTRADE

88	Name: Aircraft, spacecraft, and parts thereof
	Description: Aircraft, spacecraft, and parts thereof.
8801	Name: Balloons, dirigibles, gliders, non-powered aircraft
	Description: Balloons and dirigibles; gliders, hang gliders and other non-powered aircraft.
8802	Name: Aircraft, spacecraft, satellites
	Description: Other aircraft (for example, helicopters, aeroplanes); spacecraft (including satellites) and suborbital and spacecraft launch vehicles
8803	Name: Parts of aircraft, spacecraft, etc
	Description: Parts of goods of heading No. 88.01 or 88.02.
8804	Name: Parachutes, parts and accessories thereof
	Description: Parachutes (including dirigible parachutes and paragliders) and rotochutes; parts thereof and accessories thereto.
8805	Name: Aircraft launching gear, flight simulators
	Description: Aircraft launching gear; deck-arrestor or similar gear; ground flying trainers; parts of the foregoing articles.

Table 26. Code, name and descriptions of CEM according to COMTRADE

25	Name: Salt; sulphur; earths and stone; plastering materials, lime and cement
	Description: Salt; sulphur; earths and stone; plastering materials, lime and cement
2521	Name: Salt; sulphur; earths and stone; plastering materials, lime and cement // Limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement.
	Description: Limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement.
252100	Name: Salt; sulphur; earths and stone; plastering materials, lime and cement // Limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement. // Limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement.
	Description: Limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement.