1

Overview of the Globalization of Trade in Industrial Goods: 1980–2004

1.1. Introduction

The aim of this chapter is to present a full range of tools derived from social network analysis (SNA) to provide an overview of the globalization of trade in industrial goods between 1980 and 2004.

Other authors have already undertaken this exercise using specific data sets (at least from the works of [SMI 92] to [DEB 13]). The merits of the chapter lie in the fact that it structures SNA indicators so that it is complete in both the forms of networks that are studied (directed and undirected, binary and weighted) and in the structural phenomena that are apprehended (density, connectivity, centrality, clustering, assortment). The works of the LEM are used as the basis to produce this version of the overview of SNA.

1.2. Data

We will use data from TradeProd database on bilateral trade flow collected and organized by CEPII for 28 products (ISIC, Revision 2 nomenclature), in thousands of current dollars, for the period 1980–2004[1]. Among all the countries listed in this database (227 entries), we consider 171 (section A.2 in the Appendix). This sample results from

1 http://www.cepii.fr/anglaisgraph/bdd/TradeProd.htm; see [MAY 08].

stages. The first stage consists of consolidating some countries that came into being during the study period, after the breakup of the Socialist Republics.

– "Russia": Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Uzbekistan, Russia, Tajikistan, Turkmenistan, Ukraine;

– "Czechoslovakia": Czech Republic, Slovakia;

– "Yugoslavia": Bosnia and Herzegovina, Croatia, Macedonia, Serbia and Montenegro, Slovenia.

Other groupings are made by the designers of the TradeProd database for the entire period (Belgium and Luxembourg) or by us (Eritrea and Ethiopia).

The second stage of the selection process involves applying an iterative procedure which ensures that the selected countries, regarding their global trade in industrial goods, have in and out degrees at least equal to 1 throughout the period (i.e. involved in both import and export of the trade in industrial goods).

The outcome of these two stages is a "giant component" that includes all the 171 countries, each year, at the global industrial trade level. This does not, however, guarantee that this giant component is also extends to trade by product. In this case, the tools we offer below are well suited from scattered and/or disconnected structures.

1.3. Structural indicators resulting from social networks analysis

Figures 1.1 and 1.2 represent, for 1980 and 2004, countries participating in international trade in industrial goods and the links between them at the aggregate level by applying a multidimensional scaling, or MDS, procedure in which the intensity of bilateral links is treated as a proximity index between countries (the names of the countries are represented by their international three-letter code).

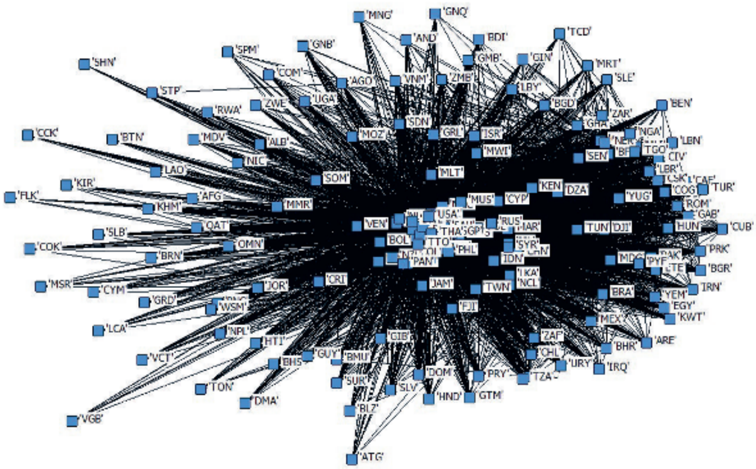


Figure 1.1. *MDS of international trade in industrial goods – 1980*

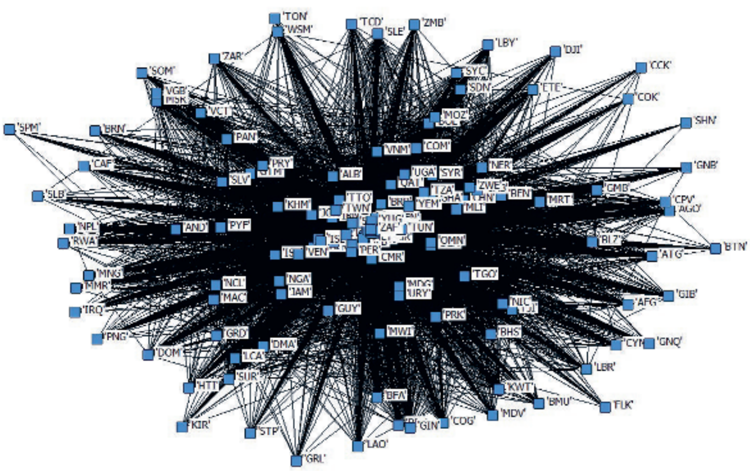


Figure 1.2. *MDS of international trade in industrial goods – 2004*

These figures thus allow the isolation of countries that are part of the “periphery” poorly connected to a “core”. These peripheral countries are themselves poorly interconnected. However, this “core” seems to be a cluster which is difficult to interpret.

The position of countries in the plan simultaneously takes into account the density and intensity of links and as such the interpretation difficulties we encounter when reading these graphs are representative of those that may be encountered from simple structural measures of the nodes degree and strength as found in the articles written by [KIM 02] and [MAH 06]. This has been briefly presented in the Introduction of the book. It seems necessary to refine the structural tools in order to study the topology of international trade in industrial goods.

This is precisely the contribution made by Giorgio Fagiolo and his colleagues of the LEM. In a series of articles on the dynamics of international trade [FAG 07a, FAG 07b, FAG 08, REY 08], these authors apply categories of structural analysis (centrality, clustering, assortment) to identify the main trends of the recent decades. Table 1.1 shows all indicators that are found in these articles, classified by analytical categories (rows) and the characteristics of links between countries within the networks (in columns).

The international trade network can be directed or undirected ("D" or "U"), that is it distinguishes or not between the role of countries as importers and exporters. It can also be weighted or unweighted ("W" or "U") by the amount of transactions. The columns of Table 1.1 mean "undirected and unweighted network" (UUN), "undirected and weighted network" (UWN), "directed and unweighted network" (DUN) and "directed and weighted network" (DWN). The initial flow information is the same for all these structures. It is noted $x_{ij,t}$, the amount of exports of country i to country j in year t. A flow matrix is constructed for each year in the format $N \times N$ (N = 171), where exporting countries are found in rows, and importing countries in columns. In the case of undirected flow structures (UUN and UWN columns), matrix X considers the average of bilateral connections. In the case of directed structures, matrix X is not transformed. Boolean matrices A of the same format are associated with these X flow matrices. The value of cell (i,j) of A takes the value 1 if the same cell of X is different from zero and the value 0 otherwise. A is therefore symmetrical in the case of undirected structures. Finally, weighting W matrices are associated to these same flow matrices in the case of

UWN and DWN structures. These matrices relativize the absolute values of flows, either by the maximum value of X (case of UWN) or by the sum of arguments of X (DWN). We limit ourselves here to replicating the weighting patterns found in the articles produced by the LEM. Matrices A are used as a basis for structural measures on unweighted graphs; matrices W are used on weighted graphs.

	UUN	UWN	DUN	DWN
X	$x^n_{ij,t} \equiv 1/2\left(x_{ij,t} + x_{ji,t}\right)$		$x^o_{ij,t} \equiv x_{ij,t}$	
A	$a^n_{ij,t} = 1$ if $x^n_{ij,t} \neq 0$, 0 otherwise		$a^o_{ij,t} = 1$ if $x^o_{ij,t} \neq 0$, 0 otherwise	
W		$w^n_{ij,t} = x^n_{ij,t}/\max(X^n_t)$		$w^o_{ij,t} = x^o_{ij,t} \Big/ \sum_h \sum_l x^o_{hl,t}$
Density	$d^n_t = \dfrac{\sum_i \sum_{j>i} a^n_{ij,t}}{N(N-1)/2}$		$d^o_t = \dfrac{\sum_i \sum_j a^o_{ij,t}}{N(N-1)}$	
Connectivity	*Degree* $D^n_t = A^n_t.\mathbf{1}$		*in*-degree $D^{in,o}_t = {}^T A^o_t.\mathbf{1}$ *out*-degree $D^{out,o}_t = A^o_t.\mathbf{1}$ *Total degree* $D^{tot,o}_t = D^{in,o}_t + D^{out,o}_t$	
		Strength $S^n_t = W^n_t.\mathbf{1}$		*in*-strength $S^{in,o}_t = {}^T W^o_t.\mathbf{1}$ *out*-strength $S^{out,o}_t = W^o_t.\mathbf{1}$ *Total strength* $S^{tot,o}_t = S^{in,o}_t + S^{out,o}_t$
Centrality		RWBC (Fagiolo, Reyes and Schiavo, 2007)		α-centralité (Bonacich and Lloyd, 2001)
Clustering	$C^{rnn}_{i,t} = \dfrac{[A^n_t]^3_{ii}}{D^n_{i,t}(D^n_{i,t}-1)}$	$C^{rnp}_{i,t} = \dfrac{\left[[W^n_t]^{[\frac{1}{3}]}\right]^3_{ii}}{D^n_{i,t}(D^n_{i,t}-1)}$	$C^{ron}_{i,t} = \dfrac{[A^o_t + {}^T A^o_t]^3_{ii}}{2\left(D^{tot,o}_{i,t}(D^{tot,o}_{i,t}-1) - [A^o_t]^2_{ii}\right)}$	$C^{rop}_{i,t} = \dfrac{\left[[W^o_t]^{[\frac{1}{3}]} + {}^T[W^o_t]^{[\frac{1}{3}]}\right]^3_{ii}}{2\left(D^{tot,o}_{i,t}(D^{tot,o}_{i,t}-1) - [A^o_t]^2_{ii}\right)}$

		with $[W_t^n]^{\left[\frac{1}{3}\right]} \equiv \left\{w_{ij,t}^{n}{}^{\frac{1}{3}}\right\}$	(see table 1.2 for disaggregation of $C_{i,t}^{ron}$ and of $C_{i,t}^{rop}$)	
Assortment	$T_{i,t}^{n} = \frac{[A_t^n]_i A_t^n . \mathbf{1}}{D_{i,t}^{n}}$ avec $[A_t^n]_i$ with the i^th^ line of A_t^n	$T_{i,t}^{rnp} = \frac{[A_t^n]_i W_t^n . \mathbf{1}}{D_{i,t}^{n}}$	$T_{i,t}^{\frac{out}{out},o} = \frac{[A_t^o]_i A_t^o . \mathbf{1}}{D_{i,t}^{out,o}}$ $T_{i,t}^{\frac{out}{in},o} = \frac{[A_t^o]_i \, {}^{T}A_t^o . \mathbf{1}}{D_{i,t}^{out,o}}$ $T_{i,t}^{\frac{in}{out},o} = \frac{[{}^{T}A_t^o]_i A_t^o . \mathbf{1}}{D_{i,t}^{in,o}}$ $T_{i,t}^{\frac{in}{in},o} = \frac{[{}^{T}A_t^o]_i \, {}^{T}A_t^o . \mathbf{1}}{D_{i,t}^{in,o}}$	$T_{i,t}^{\frac{out}{out},rop} = \frac{[A_t^o]_i W_t^o . \mathbf{1}}{D_{i,t}^{out,o}}$ $T_{i,t}^{\frac{out}{in},rop} = \frac{[A_t^o]_i \, {}^{T}W_t^o . \mathbf{1}}{D_{i,t}^{out,o}}$ $T_{i,t}^{\frac{in}{out},rop} = \frac{[{}^{T}A_t^o]_i W_t^o . \mathbf{1}}{D_{i,t}^{in,o}}$ $T_{i,t}^{\frac{in}{in},rop} = \frac{[{}^{T}A_t^o]_i \, {}^{T}W_t^o . \mathbf{1}}{D_{i,t}^{in,o}}$

Table 1.1. *Structural indicators used in the works of the LEM*

The rows of Table 1.1 show the structural indicators associated with the trade relations graphs:

– the density of a graph carries the actual number of connections to the number of possible connections in the graph. It is determined through matrices A;

– the connectivity of a node regroups “degree” (number of direct neighbors, determined with A) and “strength” (intensity of connections with these same direct neighbors, determined with W) indicators. The orientation of the relationships leads to the distinction between in- and out-degrees/strengths, corresponding respectively to the number and intensity of flows to the nodes (imports) and transmitted by the nodes (exports);

– the centrality of a node in an exchange structure is traditionally assessed in three ways. First of all “total” or “global centrality” [FRI 91] measures the sum of a node’s direct and indirect influences over all the others. It uses matrix calculation techniques: the inverse of the exchange structure ([SAL 86], see Chapter 2) or the eigenvector associated with the largest eigenvalue of the exchange structure [BON 87]. It is a variant of this latter measure that Fagiolo *et al.* [FAG 07a, FAG 07b, FAG 08] consider when analyzing the directed and weighted network of international trade (α-centrality; see [BON 01]). Then, "closeness" [FRE 79] or "immediate centrality" ([FRI 91], see Chapter 2) classifies nodes based on the distance/average speed that enable them to be connected to all the other nodes. [FRI 91] notes that the concept refers to a twofold idea: that of independence (the influence exerted by core nodes relies only to a limited extent on intermediate nodes, while that exerted by peripheral nodes passes mainly through these same intermediaries); that of efficiency (the influence exerted by core nodes spreads more quickly to the entire structure than that exerted by peripheral nodes). Finally, "betweenness centrality." [FRE 79] elaborated this measure in order to demonstrate the ability of nodes to ensure a role of coordination and control. The more intermediate position an actor has the more it is able to control the flows that pass through the structure. [FAG 07b] designed a new measure of betweenness centrality, called Random Walk Betweenness Centrality (RWBC), adapted from [NEW 05] and [FIS 06]. Contrary to the usual measure of betweenness centrality, RWBC not only takes into account the shortest paths passing through the evaluated node, but all possible paths crossing it and integrates the intensity of links between nodes. To summarize, the topological studies of the LEM consider two indicators of centrality: a measure of global centrality in the case of DWN (α-centrality) and a measure of betweenness centrality in the case of UWN (RWBC);

– clustering indicators come close to the capacity of nodes to connect and thereby form groups. What is the probability of connection between nodes h and j when i is directly connected to them? The number of "triangles" to which i belongs (a triangle is a triadic relationship where i, h and j are directly connected) is related to the number of paths of length 2 centered on i. [FAG 07] innovates in the definition of these indicators in directed configurations. Several types of relationships between i, h and j can indeed be envisaged in such cases (Table 1.2): two circular and six transitive types (two by dominant node), grouped according to the position of the reference node (i in this case) in the corresponding graphs. In the "out" triangles, i dominates h and j, while in the "in" triangles it is dominated by these same nodes. In "middleman" it is dominated by one of the two nodes and dominates the other;

– assortment or homophily indicators aim to compare the structural characteristics of a node (in terms of degree and strength) with those of its immediate neighbors. Fagiolo and his colleagues [BAR 09] also innovate in this area. They are indeed considering specific assortments for directed structures, which help to reveal structural similarities with the direct neighbors of the nodes at input (in-degrees and in-strengths) and output (out-degrees and out-strengths).

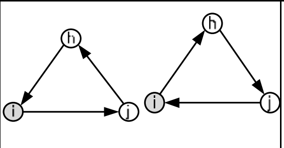
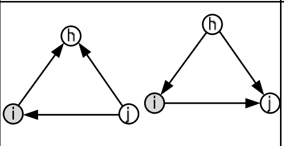
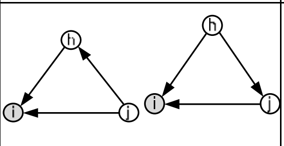
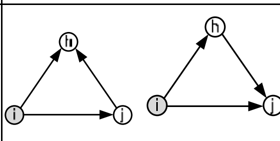
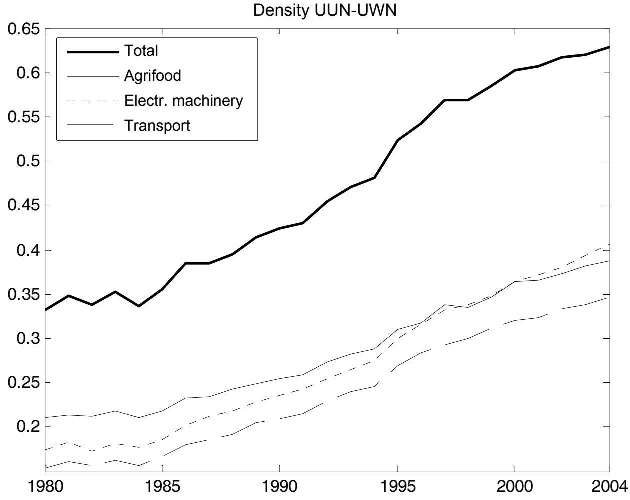
	Graphs	DUN	DWN
Cycle		${}^{cyc}C^{ron}_{i,t} = \frac{[A^o_t]^3_{ii}}{D^{in,o}_{i,t} D^{out,o}_{i,t} - [A^o_t]^2_{ii}}$	${}^{cyc}C^{rop}_{i,t} = \frac{[\widetilde{W}^o_t]^3_{ii}}{D^{in,o}_{i,t} D^{out,o}_{i,t} - [A^o_t]^2_{ii}}$ with $\widetilde{W}^o_t \equiv [W^o_t]^{[\frac{1}{3}]}$
Middleman		${}^{mid}C^{ron}_{i,t} = \frac{[A^o_t\,{}^T A^o_t A^o_t]_{ii}}{D^{in,o}_{i,t} D^{out,o}_{i,t} - [A^o_t]^2_{ii}}$	${}^{mid}C^{rop}_{i,t} = \frac{[\widetilde{W}^o_t\,{}^T\widetilde{W}^o_t \widetilde{W}^o_t]_{ii}}{D^{in,o}_{i,t} D^{out,o}_{i,t} - [A^o_t]^2_{ii}}$
In		${}^{in}C^{ron}_{i,t} = \frac{[{}^T A^o_t {A^o_t}^2]_{ii}}{D^{in,o}_{i,t}(D^{in,o}_{i,t} - 1)}$	${}^{in}C^{rop}_{i,t} = \frac{[{}^T\widetilde{W}^o_t {\widetilde{W}^o_t}{}^2]_{ii}}{D^{in,o}_{i,t}(D^{in,o}_{i,t} - 1)}$
Out		${}^{out}C^{ron}_{i,t} = \frac{[{A^o_t}^2\,{}^T A^o_t]_{ii}}{D^{out,o}_{i,t}(D^{out,o}_{i,t} - 1)}$	${}^{out}C^{rop}_{i,t} = \frac{[{\widetilde{W}^o_t}{}^2\,{}^T\widetilde{W}^o_t]_{ii}}{D^{out,o}_{i,t}(D^{out,o}_{i,t} - 1)}$
	Total	$C^{ron}_{i,t} = \frac{[A^o_t + {}^T A^o_t]^3_{ii}}{2(D^{tot,o}_{i,t}(D^{tot,o}_{i,t} - 1) - [A^o_t]^2_{ii})}$	$C^{rop}_{i,t} = \frac{\left[[W^o_t]^{[\frac{1}{3}]} + {}^T[W^o_t]^{[\frac{1}{3}]}\right]^3_{ii}}{2(D^{tot,o}_{i,t}(D^{tot,o}_{i,t} - 1) - [A^o_t]^2_{ii})}$

Table 1.2. *Measures of clustering for directed structures (according to [FAG 07])*

1.4. Main results

1.4.1. *Density of graphs*



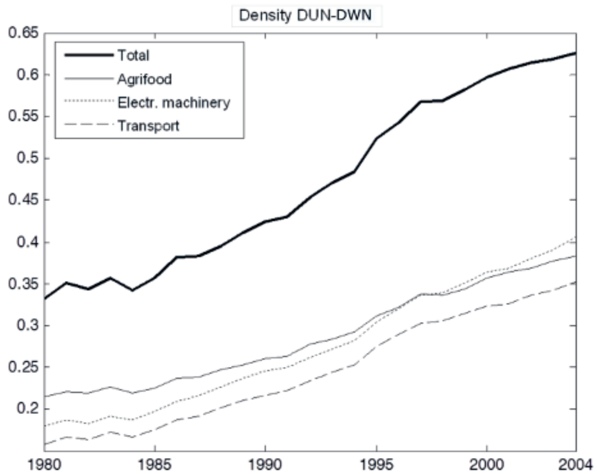
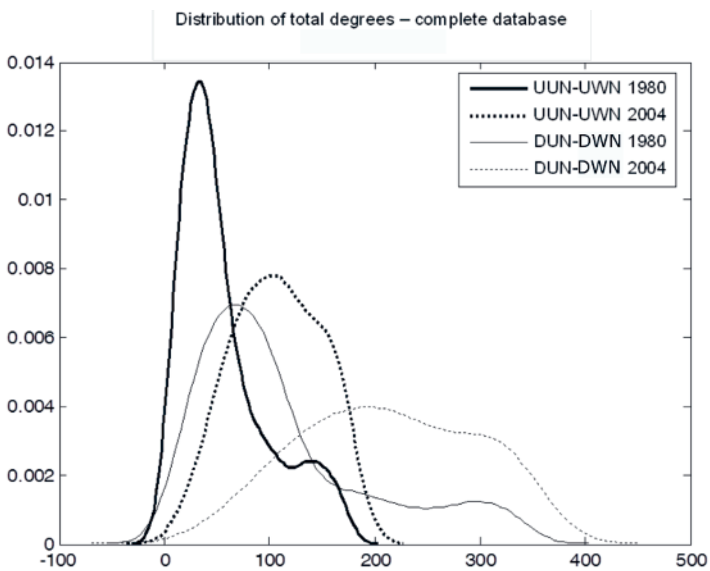
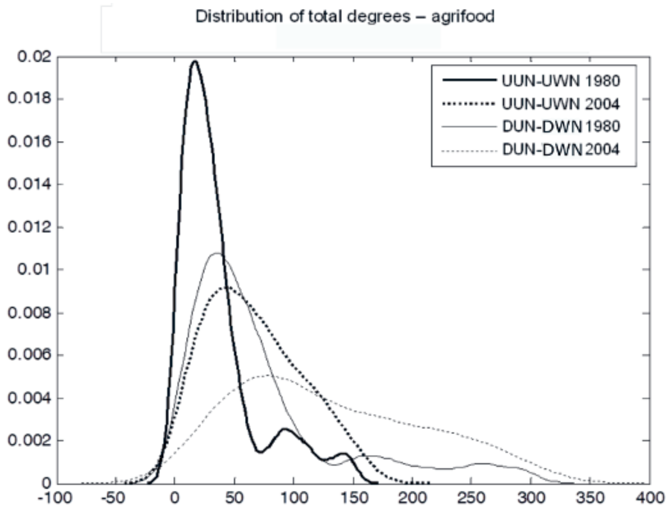


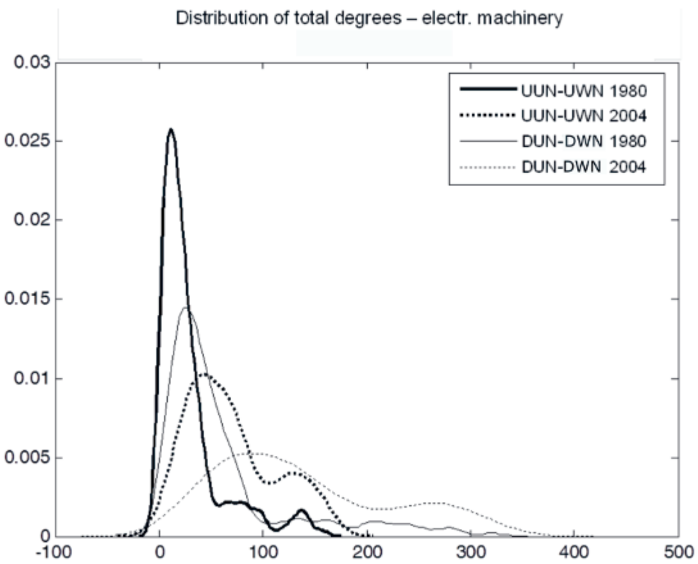
Figure 1.3. *Density of the network of international trade in industrial goods – 1980–2004*

Two lessons can be learned from the evolution of the density of graphs (Figure 1.3). On the one hand, whether we reason on the aggregation of the 28 products of TradeProd database or on agrifood products (low tech), electrical machinery (high tech) and transport layers (medium tech according to the nomenclature of [CAS 08]; see section A.1 in the Appendix), the graphs are becoming significantly and almost continuously denser since the mid-1980s. This positively reflects the findings of [KIM 02]. On the other hand, the levels reached are almost identical in undirected and directed structures. This finding partly illustrates the view of [FAG 06] on the analysis of the topological dynamics of socio-economic networks in general and international trade in particular: it is sometimes sufficient, in computational terms, to reason on simplified structures (i.e. undirected) to review the basic characteristics and evolutions of these complex networks.

1.4.2. *Node degrees*




Distribution of total degrees – agrifood
UUN-UWN 1980
UUN-UWN 2004
DUN-DWN 1980
DUN-DWN 2004
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-100
-50
0
50
100
150
200
250
300
350
400


Distribution of total degrees – electr. machinery
UUN-UWN 1980
UUN-UWN 2004
DUN-DWN 1980
DUN-DWN 2004
0.03
0.025
0.02
0.015
0.01
0.005
0
-100
0
100
200
300
400
500

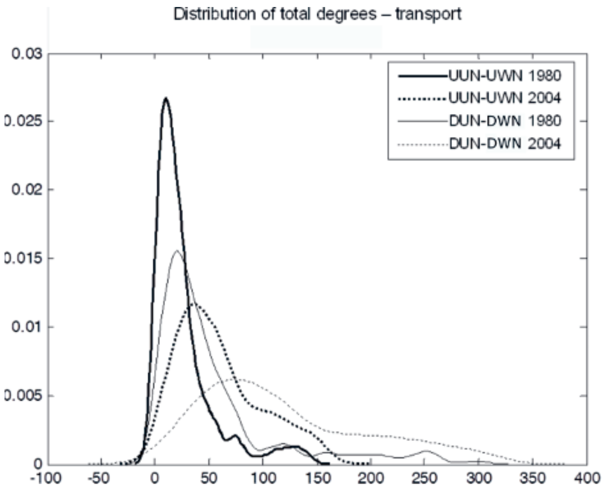
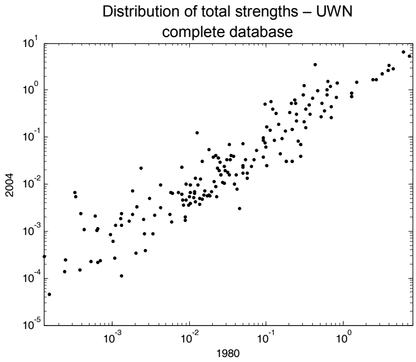


Figure 1.4. *Distribution of nodes degrees (kernel density)*

The distribution of nodes degrees present multimodalities that tend to decrease with time, as shown in Figure 1.4. The heterogeneity of nodes degrees thus tends to decrease and their average number increase. This trend is consistent with the findings of [KIM 02] and with the observation of a significant densification of trade flows (Figure 1.3). This trend applies to the layers of agrifood products, electrical machinery and transport, whether we reason with A_t^n or A_t^o.

1.4.3. *Node strengths*



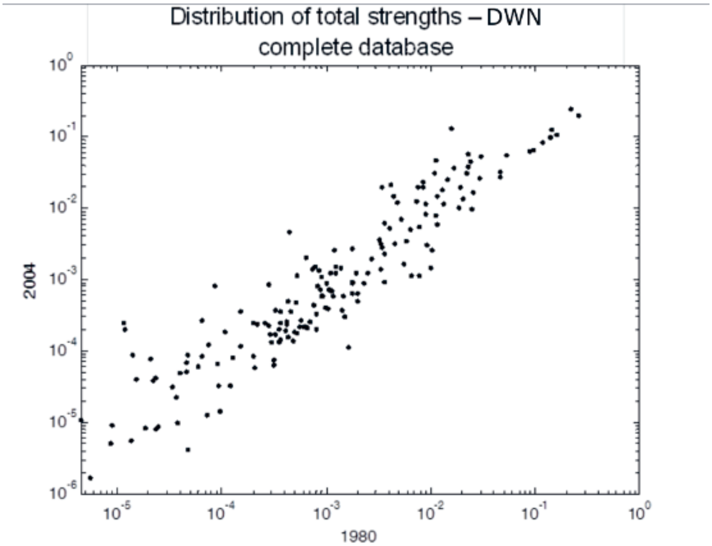
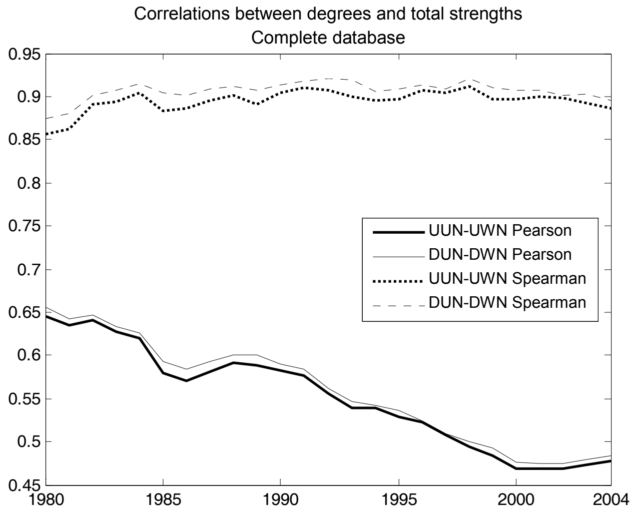
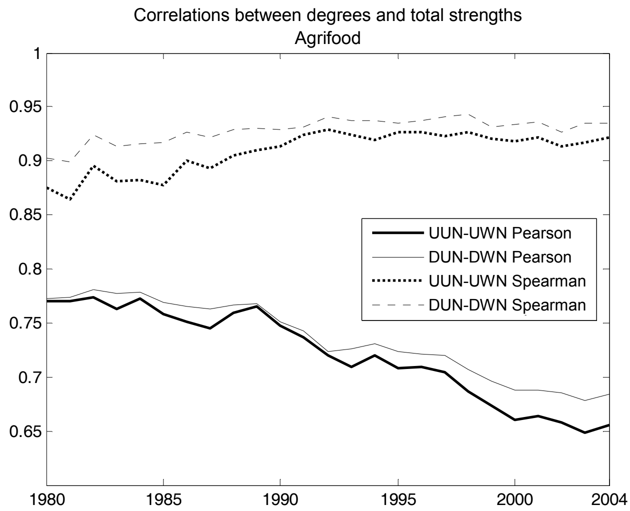


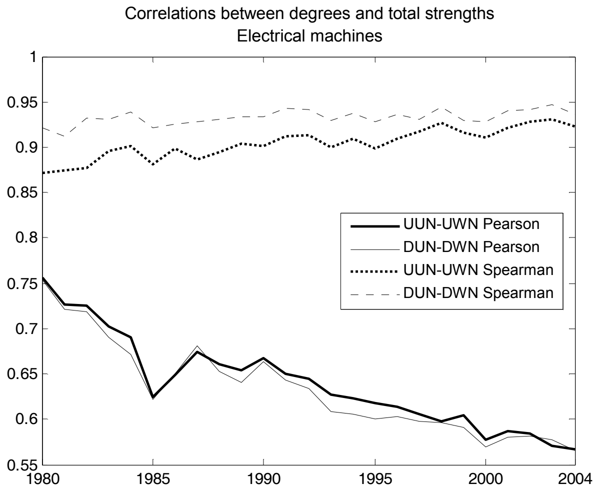
Figure 1.5. *Distribution of total strengths on weighted structures – Comparison 1980–2004*

The distributions of node strengths for weighted structures are strongly and positively correlated between 1980 and 2004, whether we adopt a directed or undirected version of exchange structures (Figure 1.5). Nodes that strongly influenced their direct neighbors in 1980 did the same in 2004, and very few countries that weakly influenced their direct neighbors at the beginning of the period strongly influence them today. In other words, hierarchies in terms of transmitted direct influences are relatively stable over the entire period.

The distribution of total strengths remains highly asymmetrical during the period, whether we reason on the aggregation of all product layers or on specific product categories: the vast majority of weights are extremely low. This allows us to anticipate that a small number of countries have total strengths that are far more significant. This finding further reflects the findings of [MAH 06]: the densification of connections does not mean the homogenization of the intensities of relationships.







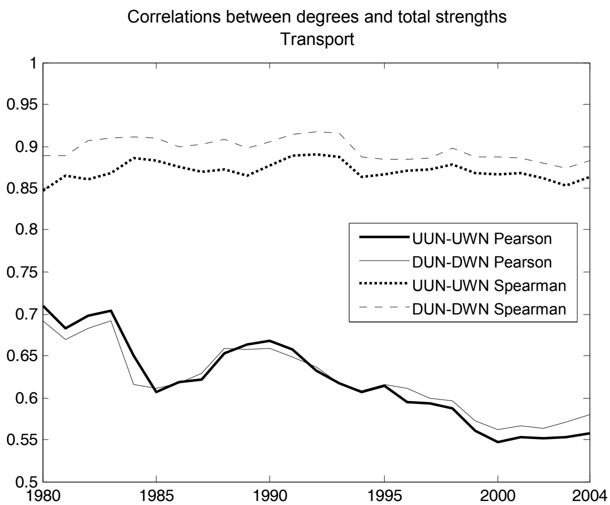
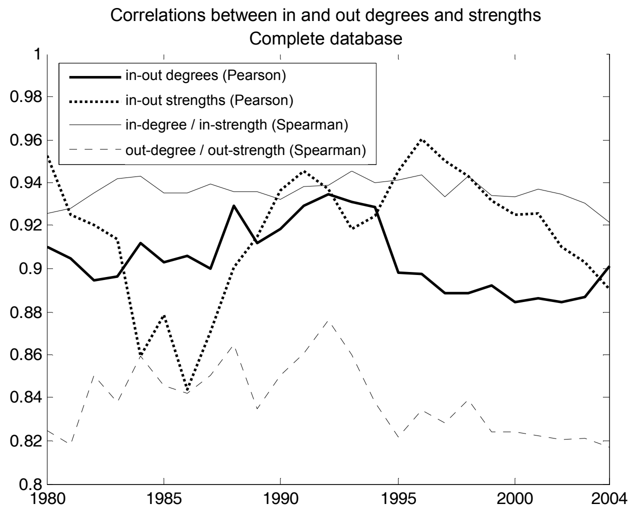
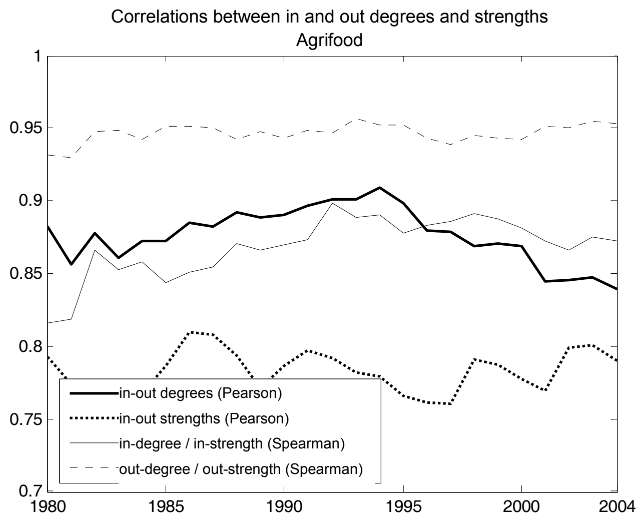


Figure 1.6. *Correlations between degrees and strengths*

Figure 1.6 shows correlations between degrees and strengths in undirected structures (UUN and UWN) and in directed structures (DUN and DWN with regard to total degrees and strengths), both in terms of indicator values by country (Pearson) and in terms of country ranks (Spearman). These correlations are strongly positive. The most highly connected countries are those that exert greater influence (are influenced) on (by) their direct neighbors, those with the most intense trade relations. No sectoral specificity seems to emerge from this view.





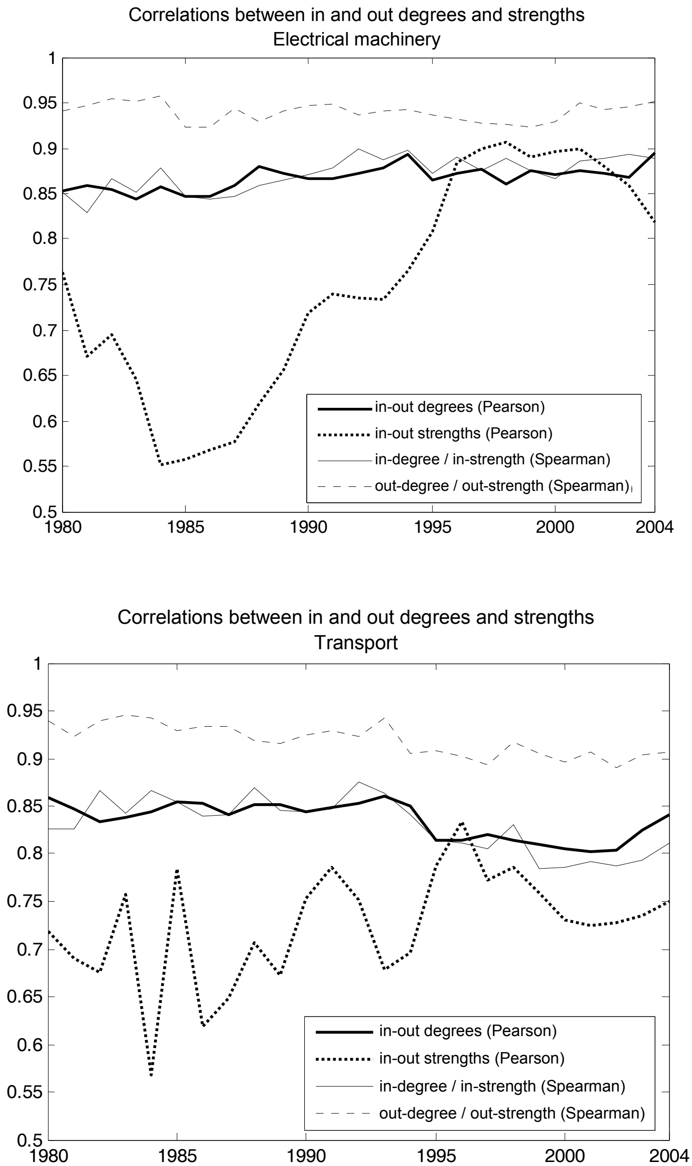


Figure 1.7. *Correlations between in and out degrees and strengths in directed structures*

When we disaggregate the total degrees and strengths in the case of directed structures between in/out degrees and strengths, the finding that prevails is that of a strong and positive correlation, whether we reason only on degrees, only on strengths or cross the two indicators (Figure 1.7). Countries exporting to more countries are equally more open in terms of supply sources, and those exporting with more intensity are also those that import intensively, whether we reason at the general level or in terms of agrifood products, electrical machinery and transport.

1.4.4. *Node centralities*

Betweenness centrality by random walk in the graph of global industrial trade relations (RWBC) shows China's increasing influence, which in 2000 appeared in the seventh position in the core of central countries. It rose to the third position in 2004. The core also changes very little; it is still composed of long-standing industrialized countries (Table 1.3).

	1980	1985	1990	1995	2000	2004
1	Germany	United States	Germany	United States	United States	United States
2	United States	Germany	United States	Germany	Germany	Germany
3	France	Japan	Japan	Japan	Japan	China
4	Japan	France	France	France	France	Japan
5	Great Britain	Great Britain	Great Britain	Great Britain	Great Britain	France
6	Italy	Italy	Italy	Italy	Italy	Great Britain
7	Netherlands	Canada	Netherlands	Netherlands	China	Italy
8	Belgium-Lux.	Netherlands	Belgium-Lux.	Belgium-Lux.	Canada	Netherlands

Table 1.3. *Top rankings for RWBC centrality indicator – aggregate flows*

With regards to product graphs (Table 1.4), the interpretation somewhat changes. Whereas in 1980 the core countries were virtually the same, with close rankings its composition significantly changed in 2004 in the electrical machinery sector. In this sector, six of the top eight are now from Southeast Asia, while the hierarchy slightly changed in the other two sectors.

	1980			2004		
	Agrifood	Elect. mach.	Transport	Agrifood	Elect. mach.	Transport
1	United States	Germany	United States	Germany	United States	United States
2	Germany	Japan	Germany	United States	China	Germany
3	France	United States	Japan	France	Japan	Japan
4	Netherlands	France	France	Netherlands	Germany	France
5	Great Britain	Great Britain	Great Britain	Great Britain	South Korea	Great Britain
6	Italy	Italy	Italy	Italy	Singapore	Canada
7	Belgium-Lux.	Netherlands	Canada	Belgium-Lux.	Hong Kong	Spain
8	Japan	Belgium-Lux.	Belgium-Lux.	Japan	Malaysia	Italy

Table 1.4. *Top rankings for RWBC centrality indicator – product flows*

Rank correlations over 25 years still give another image of betweenness centralities (Figure 1.8). Now, it is the transport sector that witnesses the most constantly changing hierarchy during the period. This can be explained by the fact that position changes that have affected the electrical machinery sector are concentrated within the core, and do not significantly affect peripheral countries, contrary to what can be observed in the transport sector; this also indicates that core countries that are today central in the electrical machinery sector were, early in the period, relatively close to the core. Transport and electrical machinery sectoral trajectories indicate that structural changes were concentrated between the late 1980s and mid-1990s; since then, hierarchies are stabilizing.

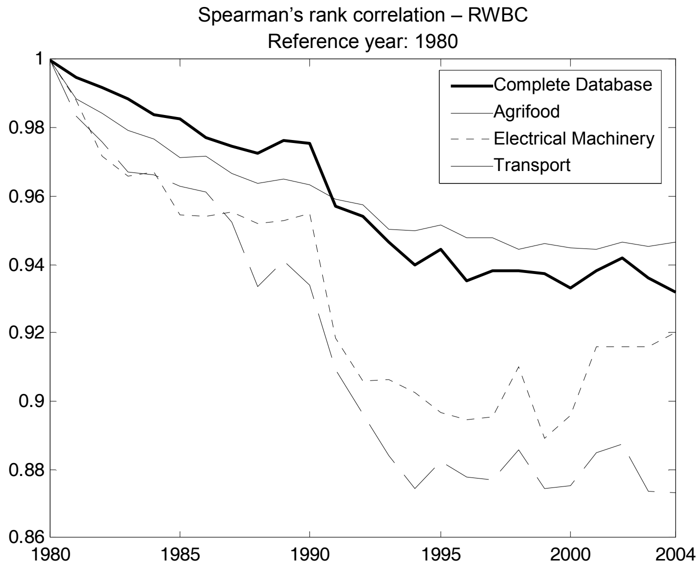


Figure 1.8. *Spearman's rank correlation for RWBC indicator – 1980–2004*

	1980	1985	1990	1995	2000	2004
1	Germany	United States	United States	United States	United States	United States
2	United States	Germany	Germany	Germany	Germany	Germany
3	France	Great Britain	France	France	Great Britain	Great Britain
4	Great Britain	France	Great Britain	Great Britain	France	France
5	Italy	Italy	Italy	Japan	Japan	Japan
6	Netherlands	Canada	Japan	Italy	Italy	China
7	Belgium-Lux.	Netherlands	Netherlands	Netherlands	Canada	Italy
8	Japan	Japan	Belgium-Lux.	Hong Kong	Mexico	Belgium-Lux.

Table 1.5. *Top rankings for α-centrality indicator – aggregate flows*

	1980			2004		
	Agrifood	Elect. mach.	Transport	Agrifood	Elect. mach.	Transport
1	Germany	Germany	United States	United States	United States	United States
2	United States	United States	Germany	Germany	Hong Kong	Germany
3	Great Britain	France	Great Britain	Great Britain	Germany	Great Britain
4	France	Great Britain	France	Japan	China	France
5	Italy	Italy	Canada	France	Singapore	Spain
6	Japan	Netherlands	Italy	Italy	Japan	Italy
7	Netherlands	Belgium-Lux.	Belgium-Lux.	Netherlands	Great Britain	Belgium-Lux.
8	Belgium-Lux.	Japan	Netherlands	Belgium-Lux.	South Korea	Canada

Table 1.6. *Top rankings for α-centrality indicator – product flows*

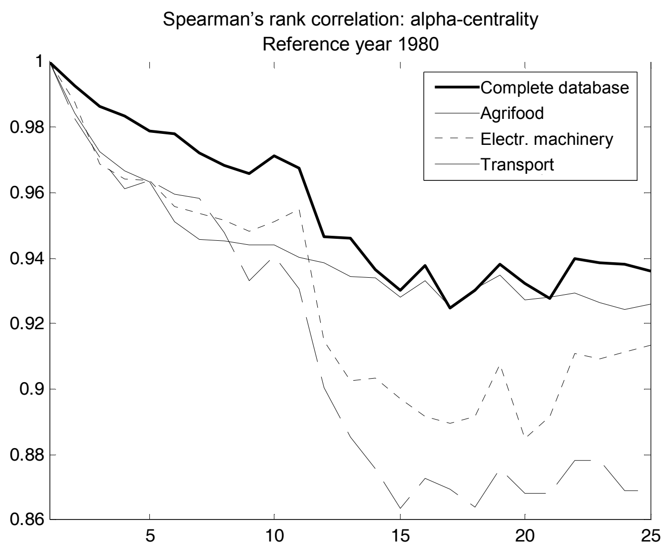
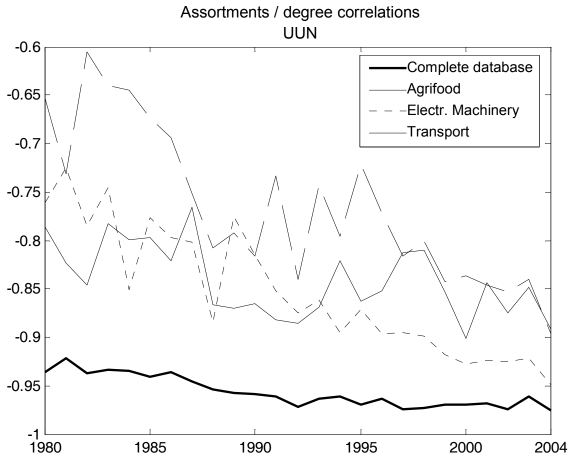
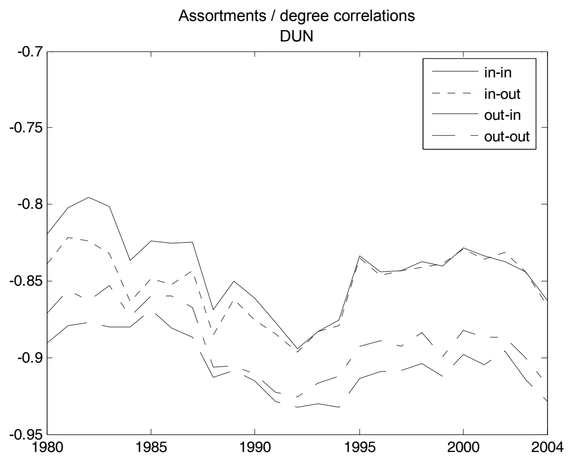


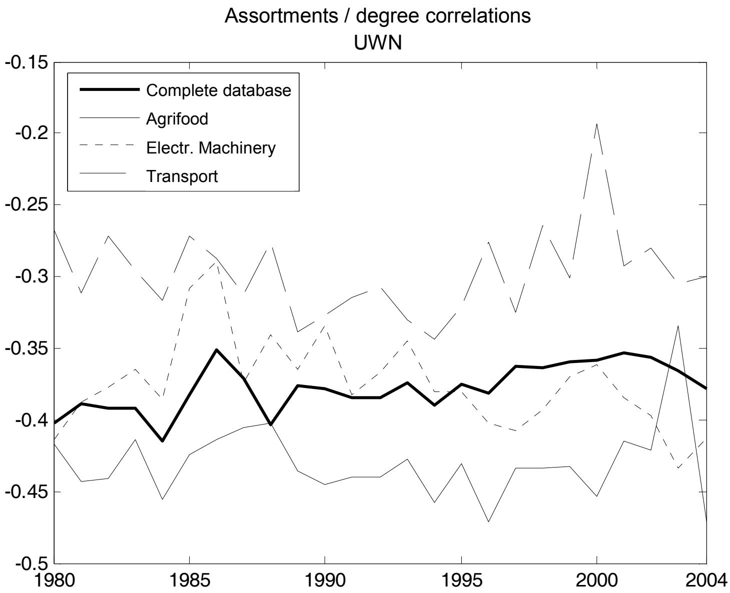
Figure 1.9. *Spearman's rank correlation on alpha-centrality indicator – 1980–2004*

The observations that can be made from the alpha-centrality indicator of [BON 01] on directed structures are very similar to those obtained with the RWBC indicator on undirected structures (Tables 1.5 and 1.6 and Figure 1.9). This further supports the point of view of [FAG 06] on the choice of a simplified structural configuration to bring out the major statistical trends of complex networks.

1.4.5. *Assortments*







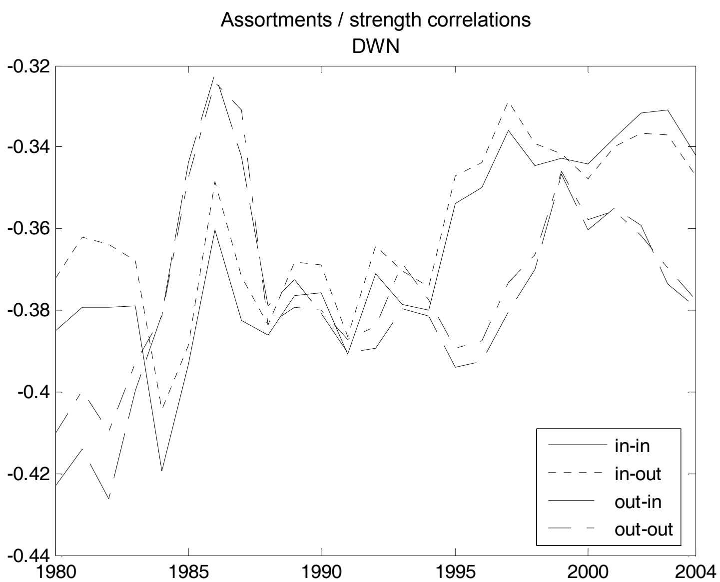
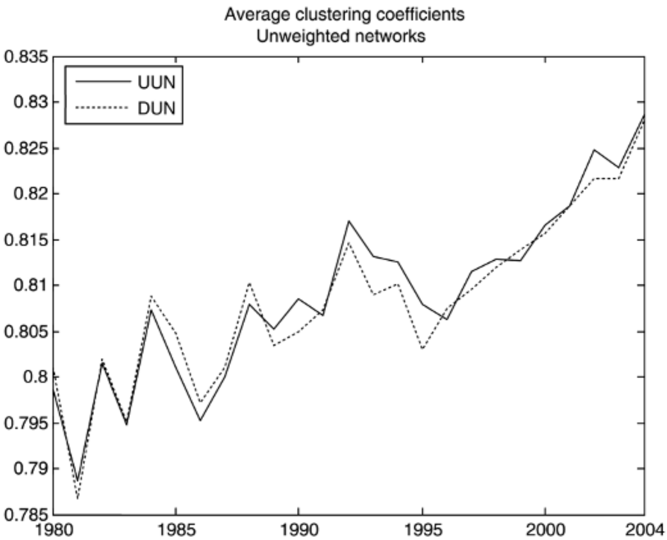


Figure 1.10. *Correlations on average values of assortments – 1980–2004*

The correlations between nodes degrees and strengths and their assortment (the characteristics of their direct neighborhood in terms of degrees and strengths) are very negative; on average, our trade partners are not like us. For unweighted and undirected structures, countries connected to many others trade with countries which are on average weakly connected. We find the same results as [SER 03] and [GAR 04]. For weighted and undirected structures, they are similar to those of [FAG 07a]. Regarding directed and weighted structures (DWN), the findings are comparable to those of UWN structures, whatever the viewpoint we adopt, that of the partners from which we import or partners to which we export. This means that the intensities of bilateral connections transmitted or received by a country are more heterogeneous when this country strongly influences or is strongly influenced by its direct neighborhood. This also means that *the core/periphery topology is true not only in terms of orientation of links, but also in terms of the intensity of these links.*

1.4.6. *Clustering*



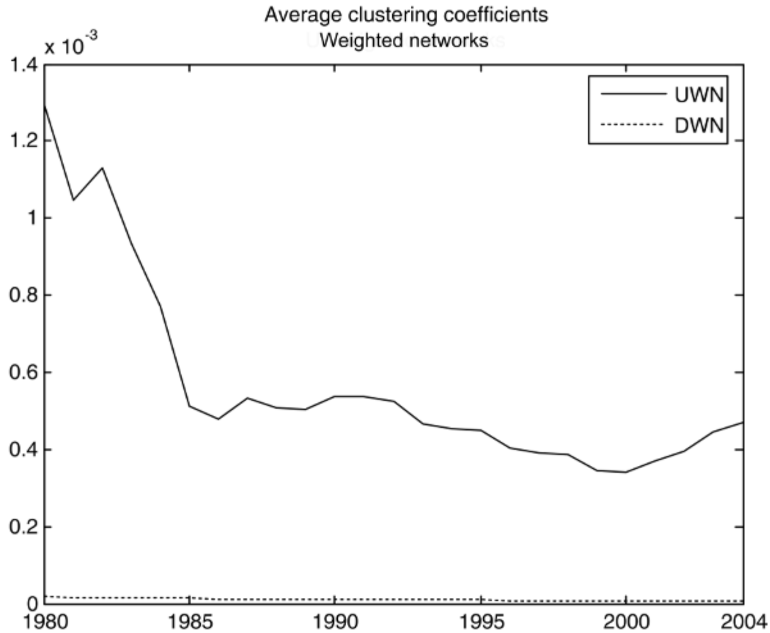


Figure 1.11. *Average clustering coefficients*

The rise in clustering coefficients on unweighted structures reflects the densification of Boolean matrices associated with these structures (see above). However, clustering coefficients on weighted structures indicate that this densification is based on the creation of less intensive flows (Figure 1.11). For unweighted structures, clustering scores are always higher than the network density scores; they are identical in a random graph [FAG 07a]. According to this analysis, countries, on average, have trade relations with partners who are themselves trading together. This finding is the reverse for weighted structures: clustering scores thus appear to be significantly lower than they would be in a random graph. This means there is a significant heterogeneity within each group of countries. This finding is consistent with the idea of a hegemonic core (acting as a hub) and a disconnected periphery. This trend continued during the period 1980–2004.

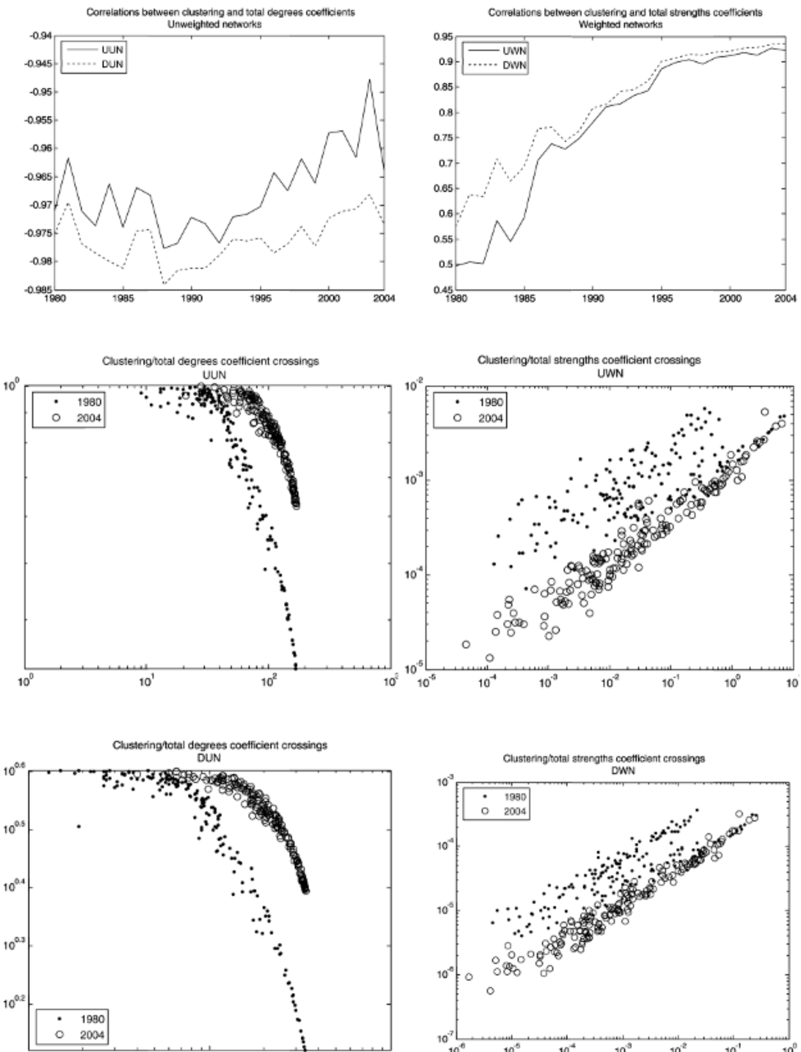


Figure 1.12. *Correlations between clustering indicators and total degrees and strengths*

Correlations between clustering indicators and nodes degrees/strengths present complementary results when we consider weighted or unweighted structures. For UUN and DUN structures (unweighted; graph to the left of Figure 1.12), partners of highly connected countries are on average less interconnected than partners of poorly connected countries, and this fact remains valid throughout the period without major changes. This finding casts some doubt on the reality of a global rise in economic integration (seen here through international trade of industrial goods) in recent decades, as noted by [GAR 05]. The graph density indicator is therefore insufficient even when we reason from the number of nodes connection to assess a significant deepening of the globalization of trade. These findings contradict [KIM 02]. The findings on the weighted structure are complementary (right part of Figure 1.12). Clustering indicators and nodes strengths are strongly and positively correlated. This correlation increased during the period. Countries with a high connection intensity are part of the most highly valued triangles. This finding suggests the existence of a rich-club phenomenon ([MCA 07], adapted here to weighted structures): core countries are more strongly interconnected than periphery countries. The intensification of this phenomenon between 1980 and 2004 implies a deepening of the relative disconnection of peripheral countries.

The disaggregation of the clustering indicator in directed structures (DUN and DWN) in circular and transitive components does not fundamentally transform the finding. The orders of magnitude and trends are comparable to the aggregate indicators (Figure 1.13). There are also few specificities with regard to product layers on unweighted structures (Figure 1.14). We may possibly notice a weak upward trend of coefficients evolution compared to the case where all products are aggregated (Figure 1.13). This would mean that these sectors (food, electrical machinery and transport) partially contribute to this global trend.

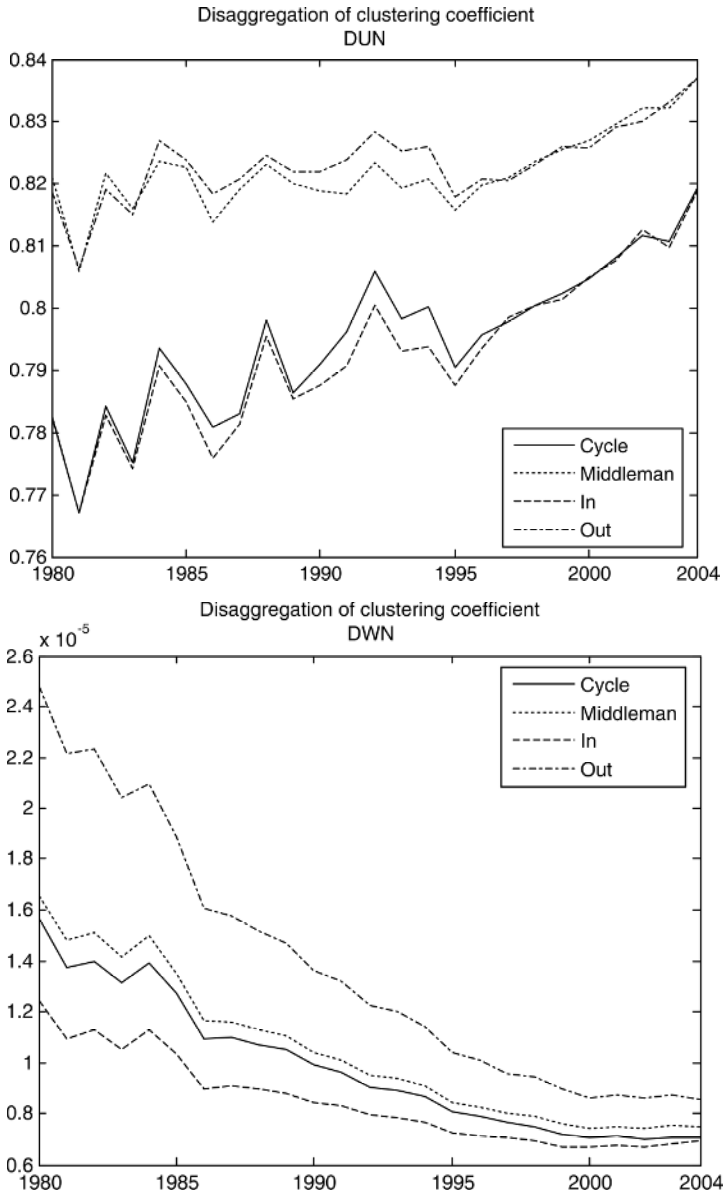
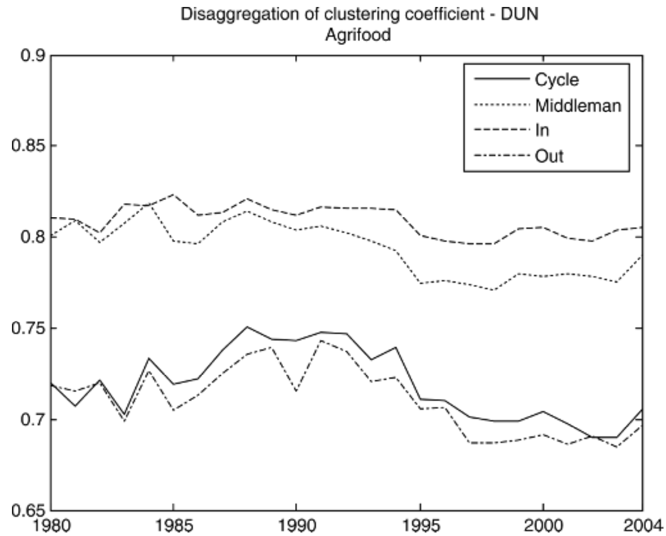
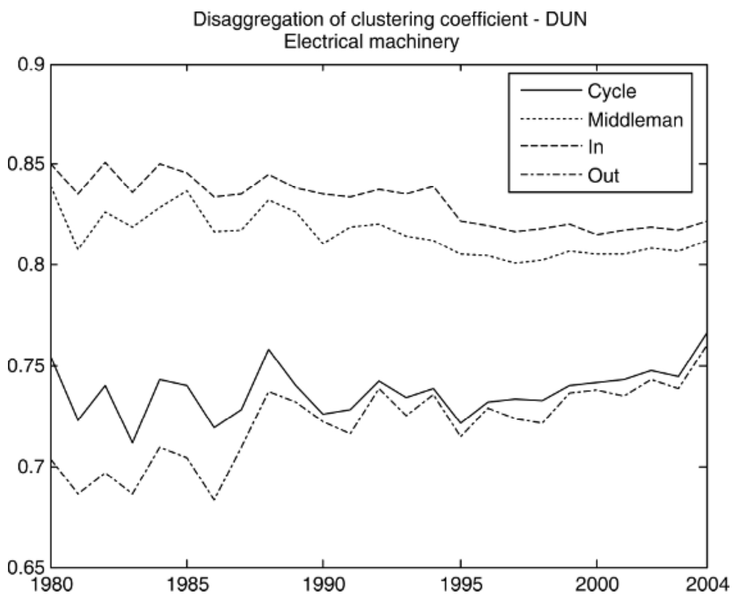


Figure 1.13. *Disaggregation of average values of clustering indicators*


Disaggregation of clustering coefficient - DUN
Agrifood
Cycle
Middleman
In
Out
0.9
0.85
0.8
0.75
0.7
0.65
1980
1985
1990
1995
2000
2004


Disaggregation of clustering coefficient - DUN
Electrical machinery
Cycle
Middleman
In
Out
0.9
0.85
0.8
0.75
0.7
0.65
1980
1985
1990
1995
2000
2004

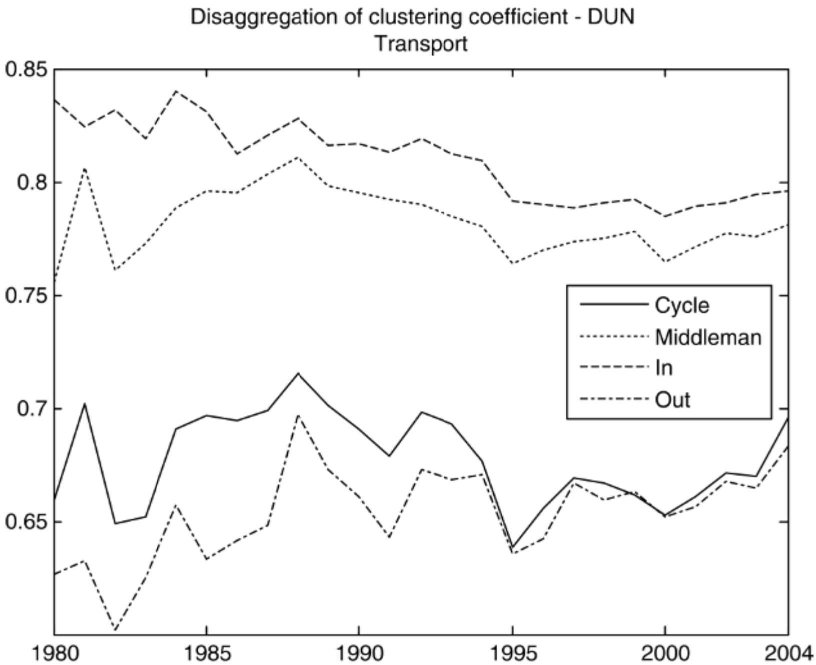


Figure 1.14. *Disaggregation of average values of cluster indicators*

1.5. Conclusion

The picture we can paint regarding the topological dynamics of international trade of industrial goods during the period 1980–2004 using tools deployed by LEM researchers is quite ambivalent. Depending on the structural characteristics considered (directed or undirected and weighted or unweighted graphs), what emerges is the image of a significant opening of many peripheral countries to international trade, or that of the maintenance or intensification of polarizing effects which lastingly excludes a considerable number of these countries from catching up. However, the use of the most sophisticated tools make our analysis and that of LEM researchers favor the second image. In other words, the period of globalization of trade leaves behind little evidence of a real deepening of international economic integration.