The International Olive Oil Trade
A network analysis

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Abstract

Aim of this paper is to test weather or not the Network Analysis (NA) could possibly help to grasp Country level competitiveness in the International Trade Network (ITN) of a specific commodity. We focus over the positions that each Country occupies within the net of international trade exchanges assuming this could lead to competitive advantage. Starting from Ronald Burt's structural holes theory, we move forward analyzing the whole network evolution in the last years. We apply NA to the world network of valued exchange relationships of virgin olive oils building a 12 years time series of weighted directed networks (WDN).

Keywords: *olive oil, international trade network.*

1 Introduction

Olive oil international trade recently grew consistently both in values and in volumes. This paced growth can be addressed to a variegated set of causes leading to several effects. The increasing olive oil consumption attracted *new competitors* in the world wide market. New consumers started using olive oil regularly, even of the best qualities. Demand grew so fast that traditionally producing Countries could not face it, provided their large internal consumption. Olive orchards grew considerably in Australia, Chile, Argentina, Maghreb Area, and so forth, making the net of international trade more complex than what market globalization already did. As large industrial multinational groups started to concentrate the olive oil supply, their cross national interests influenced the exchange patterns among Countries (Pupo D'Andrea, 2007). The recently modified international trade agreements concurred to reshape the map of exchanges, mainly under the influence of globalization and liberalization of trade (Dell'Aquila, 2005; Mili e Zuniga, 2001) but also because of a set of new regulations that some Governments issued to indirectly protect the national supply (e.g. Italy). Last but not least the olive oil market is mainly managed by skilled operators able to blend different qualities of olive oils coming from a kaleidoscope of origins, in order to get exactly the desired end-product. These blending skills, possibly detached by the producing and milling stages are mainly entitled to traders and once gathered to market knowledge and experience make the industry able to supply both an highly standardized and tailored end-product. Many operators seem to operate such a brokerage activity importing and exporting olive oils, mixing and blending, and often packaging with own label. In recent years a large share of these operations were centralized by a set of few large groups (Pupo D'Andrea, 2007), one above all the Spanish Deoleo S.A[1]. It stems out the necessity to control for such a variety of factors, deepening knowledge about those factors affecting the international trade exchanges other than those addressing competitive advantage to scale economies, productivity, technological progress, market organization, etc, offered by

1 Deoleo bought the Italian long course labels Sasso, Bertolli and Carapelli, whose factories continue to operate on the Italian territory but probably bottle a considerable share of Spanish olive oil.

the international trade literature.
Pursuing this goal, we explore the statistical and topological properties of the international trade network of virgin olive oil over a time span of 12 years, from 1996 to 2008, using both weighted and unweighted directed networks (WDN and UWDN)2. Data were gathered from the United Nation, freely available on the UnComTrade website. We offer a new set of indexes and measures of competitive advantage able to condense information about strength relationships and dominant positions that could possibly be integrated in more commonly used models. Finally, we propose the use of a network perspective alternatively to the dichotomous perspective adopted by most of the available models that consider bilateral relationships at the time.
Very few researches tried to model the olive oil market dynamics and structure (Pupo D'Andrea, 2007) or the position or specialization of some specific Countries. These works, while providing a complete picture of the world market, analyze trade flows at an aggregate level passing over the flows' structure and dynamics. In addition, the use of inferential models in international trade modeling were recently questioned (Cardamone, 2009). Network analysis is now widely used in the study of international trade (Serrano and Boguña, 2003; Li, Jin, and Chen, 2003; Garlaschelli and Loffredo, 2004, 2005; Kastelle, Steen and Liesch, 2006; Fagiolo, Reyes and Tajoli, 2007; Reyes, Wooster and Shirrrel, 2009; He and Deem, 2010). Complex models (Goyal, 2007) alone or integrated with established inferential models (De Benedictis and Tajoli, 2009) and indicators (Arribas, Pérez and Tortosa-Ausina, 2009) are among the latest researches. In this work we excluded any assumption on the interdependence of relationships. The occurrence of each relationship is here regarded completely independent by the occurrence of the others, thus excluding any deterministic network generation mechanism. Nonetheless, the NA enables the identification and measurement of selected behaviors that depend both on each node's set of relationships and features, and on the same set of all the other nodes. This dependency implies that a change in the personal network of an actor, provokes an effect, of varying size, over the entire structure of the network, and then over each nodes' performances. Two types of measures were used here: descriptive measures of the network as a whole, and descriptive measures of the position of each individual actor (Countries). Both were employed to obtain a description of the internal functioning of the network itself. The analyses were conducted with the help of dedicated software: UciNet ver. 6.232, Netdraw and R3.

1.1 *The paper organization*

The second paragraph introduces the theoretical background and a short description of the adopted methodology. The third paragraph briefly describes the recent dynamics in the virgin olive oil market4 including some statistics about the network

2Some indexes were calculated on the *weighted directed network* (WDN) of the WOTN.

3Borgatti, S.P., Everett, M.G. and Freeman, L.C. 2002. Ucinet for Windows: Software for Social Network Analysis. Harvard, MA: Analytic Technologies. R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

4Virgin olive oil, Code 15910, classification HS6.

structure, its evolution in recent years, the analysis of positional indexes distributions of individual actors (actor centered). Results are discussed, moving from the aggregate level toward focusing on specific Countries of greater interest. Finally, we present conclusions and suggestions for future developments.

2 The NA applied to international trade analysis

The earliest representations of a "System of multilateral trade" as a network dates back to just before the end of World War II (Hilgerdt, 1943). This first performance "testifies as the complex network is suitable to represent the image of the structure of international trade". The advent of NA and graph theory marked a leap forward in the evolution of the study of trade relations between Countries. Both these approaches moves attention over the relationships between the elements generating the action and their structure, rather than on individual attributes. The earliest examples of formalization can be traced back to the Snyder and Kick's (Snyder and Kick, 1979), Ronald Breiger (Breiger, 1981), and Wasserman and Faust, (Wasserman and Faust, 1994), resumed later by other authors who all shared the idea to represent networks where Countries were knots, and import/export trade flows were relationships, arguing that the relational type variables were most useful than Country level attributes in explaining the macroeconomic dynamics that stem from the exchange patterns (Serrano and Boguña, 2003; Li, Jin, and Chen, 2003; Garlaschelli and Loffredo, 2004, 2005; Kastelle, Steen and Liesch, 2006; Fagiolo, Reyes and Tajoli, 2007). The idea that using these methods could be complementary to others that begin to show their limits, such as the gravitational models[5], began to take its shape only recently[6] (De Benedictis and Tajoli, 2009).

So far international trade network studies focused on the global analysis of trade between Countries, considering the total amount of good and/or financial flows. The use of the relational perspective mainly concerned the research and identification of structural network properties, the presence of groups and of those individual properties that could better describe the flows' composition and a Country's competitive position and role. Among these applications found its place the use of complex network analysis (Goyal, 2007) to search for structures and their functional relationship with Regional Trade Agreements (RTAs), (Reyes, Wooster and Shirrrel, 2009), to analyze the level of integration and the relationship between trade and financial networks (Fagiolo, Reyes and slave, 2007), or for the assessment of the effects of the international financial crisis according to a Country's position within the network of trade (Kali and Reyes, 2005). Other studies were dedicated to network mapping,

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5For a critical review about the effectiveness of gravitational models see Paola Cardamone (Cardamone, 2009) stating "the econometric methods [..] do not always address in a satisfactory way the potential sources of bias in the estimations, such as unobserved heterogenity, endogeneity of some regressors and zero flows.".

6The NA found large share of consensus in social sciences, where several scientific areas borrowed although the relational dynamics among people cannot be fully incorporated in other circumstances. Albeit this problem, it is extremely interesting the contribution of Mustafa Emirbayer. In his "Manifesto for a relational sociology" (Emirbayer, 1997), Emirbayer explains the opportunity to adopt a relational approach to reality as opposed to the widely used substantialist one where entities and not relations are the center of the action thus largely using variables as proxies of the individual attributes.

researching behavioral patterns, strategic positions, presence of subgroups (De Benedictis and Tajoli, 2009), or the influence of macroeconomic phenomena as globalization and global recessions over the trade network (He and Deem, 2010). Some applications focused on the influence of the network of international policy relations development (Hafner-Burton, Kahler and Montgomery, 2009). However, few are the efforts devoted to the analysis of the international trade network of a single good or of a group of goods, and it still lacks a standardized method, as well as examples of evolutionary dynamics analysis (Trobia and Milia, 2011) that make use of inferential methodologies.

2.1 The methodology

In our analysis the ties between Countries that add up to form the WOTN are the basic unit of research (UWDN), as opposed to the individual Countries. To compute some indexes, however, ties have been measured by the value of the trade flows (export; WDN). Among the network indexes here adopted the *brokerage*, whose algebraic construction is too complex to be shown here, is the closest to express a position of advantage, and to highlight the behavior of intermediation. We compared here different indexes of brokerage. The influence of the intermediaries in determining the highest levels of export was also evaluated separately and compared with other indexes. The brokerage is generally defined as number of pairs not directly connected. Better, the brokerage idea is that an *ego* may represent the only obliged gate to connect a pair of actors. In a *egonetwork*, *ego* is connected to every other actor present (by definition). If these others are not directly connected, then the ego can exert power. This index is therefore interesting to measure how much potential for brokering can be there for each actor (i.e. how often pairs of actors in his *egonetwork* are not directly related). Additionally, we here consider a family of indices of individual brokerage offered by Gould and Fernandez7 (1989; G&F). The total brokerage of a given vertex $v$is generally defined as the total number of ordered pairs (v', v'')such that $(v', v), (v, v'') \in L$and $(v', v'') \notin L$, is to say the number of pairs for whom $v$is a *local bridge*. Now, suppose that $s$is a vector of attributes for $s_i$is the attribute of $v_i \in V$("attribute" shall mean any covariant). G&F defines five types of brokerage (or *brokerage roles*), based on the state (or rather attribute) of each of the three vertices members of the triplet (*locally bridged pair*). For a ordered triad $(v_i, v_j, v_k)$the vertex v_j act as broker, and the five possible roles are *"coordinator"* $(s_i = s_j = s_k)$, *"consultant"* $(s_i = s_k, s_i \neq s_j)$, *"gatekeeper"* $(s_j = s_k, s_i \neq s_i)$, *"representative"* $(s_i = s_j, s_j \neq s_k)$,e *"liaison"* $(s_i \neq s_j, s_j \neq s_k, s_i \neq s_k)$(see diagram 1). The brokerage index of the vertex $v$with respect to each of these roles is therefore defined as the number of ordered triplets onto the corresponding brokerage type where $v$is a broker. The software routine calculates these scores (and their sum) for all vertices8.

7 See J. Gould, J. Fernandez, "*Structures of mediation: a formal approach to brokerage in transaction networks*", Sociological Methodology, 1989, pp.89-126. "*Brokerage occurs when, in a triad of nodes A, B and C, A has a tie to B, and B has a tie to C, but A has no tie to C. That is, A needs B to reach C, and B is therefore a broker*."

8 "Brokerage scores for all vertices, as well as the total amount of brokerage within each role performed throughout the network. First and second moments for brokerage scores under a null hypothesis of random association (holding xed **s** and the expected density) are also provided as well as the **z**-tests suggested by Gould and Fernandez. [..] The

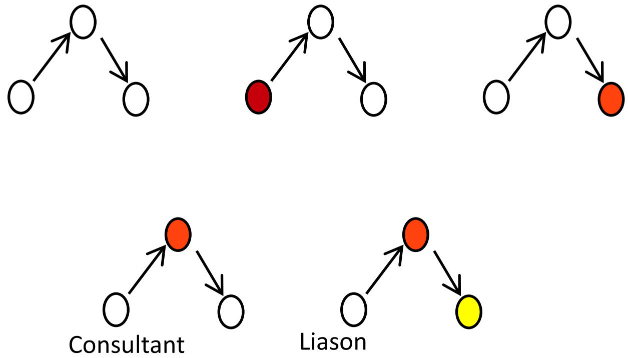

Diagram 1. *Brokerage roles according to Gould & Fernandez.*

3 The world olive oil market

In recent years the shape of the market changed in favor of some new players, while some features have remained unchanged. Comparing imports and exports data in 1996 and 2008, Italy is the largest importer of virgin olive oil, although its role is significantly reduced: the share of Italian imports in fact moved from 45.3% to 32.2%. France and the United States still remain rich end-markets, as well it remains almost unchanged the market shares of Portugal, Spain, Germany and UK. New markets emerge: Brazil covers the 3.2% of total imports of virgin olive oils, Australia, South Korea, Switzerland and Belgium hold a share between 2% and 3% each. Export quotas see Italy climbing to about 27% of world exports, from 23.9% in 1996. The great producer, Spain, has substantially altered its share of a 6%, Greece has seen its export share shrinking from 31.6% in 1996, to 6.9% in 2008, while Tunisia has experienced a substantial increase. Also new exporters approached the market: Turkey, Portugal, Argentina and Syria hold an export share between 1% and 2% each.

4 NA of the WTON.

4.1 Network dimension

Starting to analyze the WTON from the flows' amount (tab.1) the total export value of virgin olive oil is more than doubled from 1996 to 2008, while the average flow value lowered by almost 500 thousands dollars.

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authors did not prove that the statistics in question are asymptotically normal under the null model, and hence the statistical foundation for their associated tests is somewhat dubious; when in doubt, it may be wise to perform a simulation-based conditional uniform graph or permutation test." (in Carter T. Butts, "*Social Network Analysis with SNA*", Journal of Statistical Software, n.4, issue 6, Feb. 2008).

Table 1. WTON, descriptive statistics.

Virgin olive oil	*1996*	*2008*
Average flow value	*$ 3,567 million $*	*$ 3,054 million $*
Total flow value	*2,044 billions $*	*4,685 billions $*
Average unit price	*4,483 $*	*$4.326,00*
N. of trade flows	*573*	*1.534*
N. of nodes comprising the 90% of flows	*13 (8% of the nodes)*	*41 (20,5% of the nodes)*
N. of flows comprising the 90% of the total market value	*22 (3,8% of the flows)*	*56 (3,65% of the flows)*
Network density	*0,0216**	*0,0384*

Source: our calculation over U.N. ComTrade data. * density is significantly different from the null hypothesis of Y=1 with p=0,0002

Since 1996 the number of exchanging Countries moved from 163 to 200, for a number of trade flows (arcs) going, respectively, from 573 to 1,534 (tab. 1). The 90% of the value of the market was governed, in 1996, by 13 Countries (8% of the total number of actors) 41 in 2008 (20.5%; tab. 3). Similarly the 90% of the value of the World exports flowed through 22 trade flows in 1996 (3.8% of the total 573, and with the 1% of flows representing the 67.7% of the market value), 56 in 2008 (3.65% of the total number of flows, and with 1% of them to represent the 65.81% of the whole exports). There is therefore a lower concentration of market value in terms of Countries, an unchanged concentration in terms of trade flows in general, but a minimal increase in concentration in a few exchange relations. Overall, therefore, the growth in demand for olive oil has led to a differential growth of world exports, Country by Country, and such to a structured net of trade flows. The calculated density for the binary network9 shows a growing trend. Surprisingly the density increases despite the network size increases. Generally, in enlarging networks density values are lower, because a larger number of nodes requires an increase more than proportional of the number of links so that density remains constant. This index is quite different from other indices of openness (De Benedictis and Tajoli, 2008), such as the percentage of export and/or import compared to GDP, that consider the degree of market openness at individual Country level. The increasing density indicates that, on average, every Country has a larger number of trading partners, and that the whole system is more intensively connected. However, the density is quite low throughout the considered period, indicating a spread network, as well as it could be expected bearing in mind that the majority of trade (as well as production) is clustered in the Mediterranean area. However, the index may indicate the presence of few and restricted *leading groups* and a vast number of net importers Countries who depend on few or very few business partners10.

9The density of a binary (unweighted) network is calculated as the count of the arcs divided by the maximum attainable number of arcs. The measure used here excludes the effect that the flows' values could have over the index calculation.

10 The density values were tested against theoretical values being statistically significant. See: Tom A.B. Snijders and Stephen P. Borgatti (1999) Non-Parametric Standard Errors and Tests for Network Statistics. Connections 22(2): 1-11).

The density calculated on the WDN, since the relationships are assigned with the trade values, coincides with the average value of the same (tab. 1). This measure is indicative of the overall value dispersion within the network. By comparing these values with the density measures for the UWDN (tab. 2) we notice that from 1996 to 2008 the network is not only *denser* but it also presents a greater standard deviation, hence a greater variability in the distribution of trade flows. The average distance is slightly higher, then the average number of "steps" connecting two random actors is higher. The *network diameter* in 2008 (the largest geodesic distance) is 6 but the *compactness* is greater. In detail, the percentage of actors bound by a geodesic distance equal to one is lower than in the past, while it increased the percentage of actors connected with distances equal to two and three steps. The figure indicates the presence of a "cloud" of wider ties, no less dense, but with a minimum distance greater than in the past: the network is structured.

Tabble 2. Density measures.

Index	*1996*	*2008*
Density	*0,0216*	*0,0384*
Standard deviation	*0,146*	*0,193*
Average distance (between connected actors)	*2,36*	*2,42*
Compactness	*7,4%*	*18,7%*
% of nodes with a minimum distance equal to 1 arc	*14,6%*	*9,7%*
% of nodes with a minimum distance equal to 2 arcs	*44,9%*	*47,4%*
% of nodes with a minimum distance equal to 3 arcs	*31,3%*	*34,9%*
Diameter	*5*	*6*

Source: our calculation over U.N. ComTrade data.

4.2 Centrality measure

Ultimately the networks were measured in terms of centrality (tab. 3 and 4), beginning with the *network centralization index* (N.C.I). The N.C.I provides the distance, in percent, from a hypothetical structure to its extreme possible centralization (or hierarchical structure), and it expresses the degree of inequality in the distribution of links.

Table 3. Centrality measures.

Year	*Betweenness*	*nBetweenness*	*coeff. of var. (referred to the betweenness; very close for the n-betw)*	*Network Centralization Index*	*Sum*	*N.C.I. Outdegree*	*N.C.I. Indegree*
1996	*32,564*	*0,125*	*0,238*	*4,51%*	*5308*	*64,90%*	*5,30%*
2008	*113*	*0,287*	*0,282*	*8,71%*	*22600*	*70,90%*	*14,30%*

Source: Our calculation using United Nations ComTrade data.

Since we are dealing with very sparse networks, the N.C.I are quite low, albeit gradually increasing. Changes in density values are not evenly distributed among the actors, as the variation of centralization index suggests. The increase in the *betweenness* *centralization index* (CB), in addition, implies that the increase in the number of relationships/trade flows was rather centralized in favor *hubs* and/or indicating the new ones. In detail the centralization has grown not only in terms of *indegree*, as it could be expected given the increase in imports, but also to a large extent on the *outdegree*. Overall, it seems to emerge an increasing competition between a core of actors at the expense of the periphery of the network, despite this core is enlarging or, perhaps, because of it. It seems, therefore, that new entrants enter the market into a n already existing chain instead of establishing new relations of direct export.

4.3 Meso-level network analysis

In this section we analyze the distribution of a selection of network indexes at node level11 analyzing their *egonetworks*. A *egonetwork* (*egonet*) is the network formed by the actors (*alters*) directly related to an actor (*ego*) and by the links between them. In our analysis, alters were selected no further than a one-step distance. The selected features' distributions outline some general conducts. The same characteristics were analyzed at single node level for the most interesting cases.

In recent years, the *egonet* size distribution (rather their *egonet*) did not substantially change (Figure 1). Most of the *egonets* include from 1 to 10 alters, a rather small number, given the size of the networks. However, the share of actors with more than 60 or 100 alters decreases from 1996 to 2008, while it seems to be increased the *egonets* including from 10 to 50 alters and those with more than 130 alters. In terms of density (Figure 2), if in 1996 were clearly distinguishable 3 groups of Countries with increasing *egonet* density, in 2008 there is a fairly normal distribution except for a small group with highly dense *egonets*. The trade partners of these latter actors are then, in turn, very active and in relation to each other, or we can say that these nodes are integrated into more active neighborhoods. Thus a few actors have a significant role in determining the flow of product, but they are immersed in a more competitive (or globalized) environment than ever before. In the future, in fact, these relationships between alters could bypass the ego. The highest level of competitiveness in the market seems to arise in figure 6 that represents the evolution of the *egonet* diameters distribution (i.e. the larger geodesic distance). If in 1996 four groups of Countries were clearly distinguishable, with most of the Countries belonging to the group with shorter diameter (zero, "isolates" or net importing Countries), in 2008 the same distribution appears flatter. There are less net importers and an higher number of nodes with diameter length between 1 and 4. An higher diameter corresponds to an higher number of relationships that confirms the increased level of competitiveness.

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11 To represent the index distributions we used *kernel density plot transformations* (gaussian). Graphs were drawn using R software (Ricci, 2005).

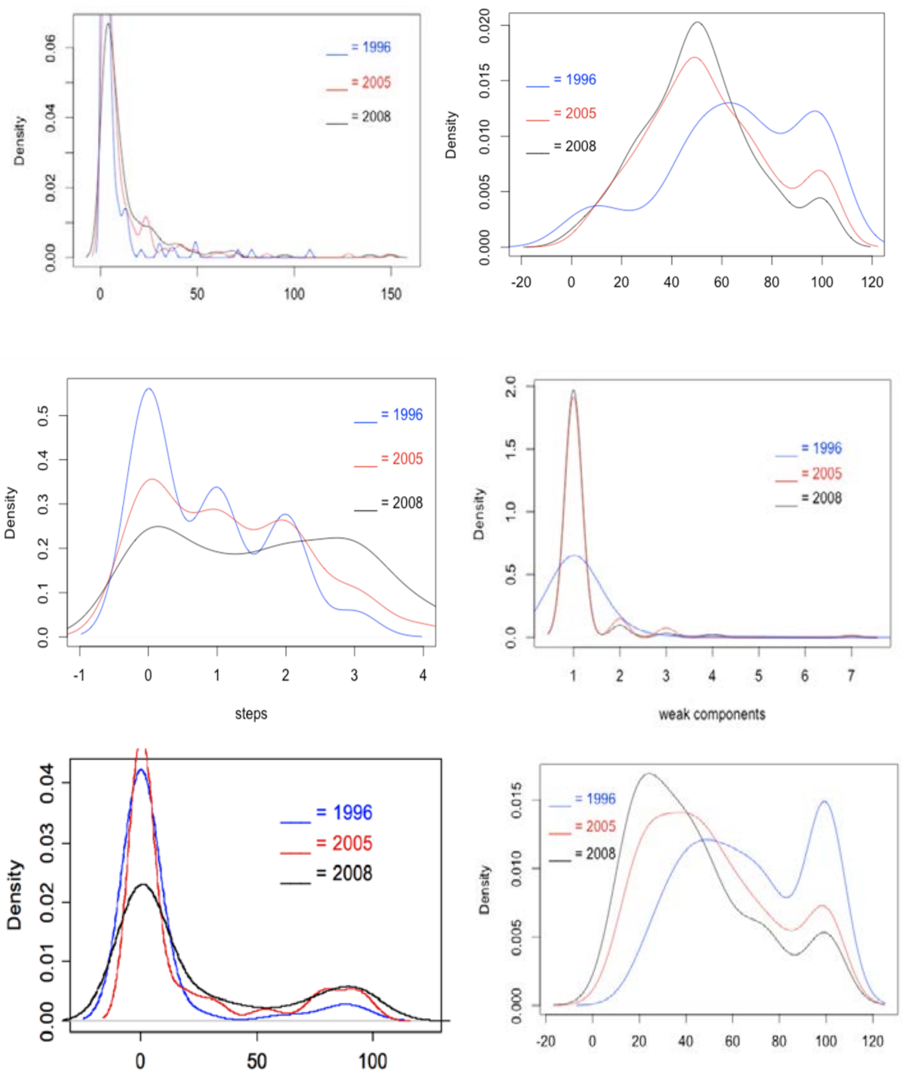

Figure 1 to 6. Trends in the distribution of the *egonet* indexes, 1996-2008. Fig.1: egonet size (number of alters); Fig. 2 egonet density; Fig. 5: 2-steps reachability (x axis: % of actors on the x axis). Fig: 6: reach efficiency (x axis: number of contacts).

The number of *weak-components*, is the highest number of groups of actors of an eogonet that, without the ego, would be disconnected. Figure 3 shows as such *egonet* have significantly increased in number over the years, while well below are three groups of Countries whose ego network would be "split" into two, three, or four parts if they were to fail. Overall, therefore, the number of actors with very strong positions of flows' control over their alters fell, while the trade flows intensified to form more interconnected networks. The analysis of *cutpoints and blocks* shows that in 1996 the network was structured in 49 Countries totally dependent on a single supplier and one block interconnected of 114 Countries, while in 2008 the network is composed of 21 Countries *cutpoints*, 9 not otherwise related, and a block of 179 interconnected Countries. The following graph shows the distribution of the *2-steps-reachability* that is the percentage of nodes within an *egonet* reachable within a two steps distance (Fig. 8). Since we considered only export flows the *2-steps-reachability* is a further measure of competition within the *egonet*. Also, since each new exchange generally increases the product price, actors with a high *2-steps-reachability* could be inefficient in their business strategies, gaining a lower percentage of the end price or lower added value. To better highlight this aspect we calculated how much (as a percentage) of the actors within two steps in the whole network are not included in a Country's *egonet*. This makes it possible to compare the actors with the same 2-*steps-reachability* and check who loses, potentially, the largest share of added value12. Below we report the results for 2008 (table 5).

Table 5. *Two steps reachability, 2008.*

Country	*Two-steps-reachability*	*(potential) added value loss*	*country*	*two-steps-reachability*	*(potential) added value loss*
Italy	*100*	*25,0%*	*Germany*	*99*	*70,2%*
Spain	*100*	*30,5%*	*Belgium*	*99*	*75,8%*
France	*100*	*52,5%*	*Lebanon*	*98,5*	*70,6%*
UK	*100*	*74,5%*	*Greece*	*98*	*64,8%*
Portugal	*99.5*	*68,3%*	*USA*	*98*	*66,3%*
South Africa	*99.5*	*78,4%*	*Australia*	*98*	*78,6%*

Source: Our calculation using United Nations ComTrade data.

Another way to look at the same phenomenon is shown in Figure 6, which describes the distribution of frequencies of the *reach-efficiency.* This is nothing more than the *2-steps-reachability* "normalized" by the *egonet* size. The reach-efficiency expresses how many contacts are generated on average for each actor to whom an ego is directly related. We have considered only the reach-efficiency for the *out-egonets*. In this case the higher the reach-efficiency the less efficient is an actor, compared to its "customers", in reaching the end markets and, presumably, the highest valued markets. Countries with a *reach-efficiency* higher than others are located near the bottom of the market chain. Graph 6 shows us how many Countries improved their efficiency, since 1996, exhibiting a set of Countries "unable" to compete (*reach-efficiency* close to 100) and a group of Countries with good competitiveness (*reach-efficiency* between 10 and 30).

12E.g. in 2008 Italy had and *egonet* made up of 150 *alters*, 75% of the whole network dimension (200 nodes). Its *2-step-reachability* was 100is to say that, considering the whole network, Italy was connected to the 100% of it by 2 steps The (potential) added value quota Italy did not reached can be expressed, as the difference in %, by that 25% of Countries that buy olive oil from Italy's trade partners. Although spain has the same *2-step-reachability,* this potential loss of added value sum to 30,5%. The complete formula used here can be summarized as: given s*egonet size*, S*the network size*, and $stp$the *2-step-reachability value*, the (potential) loss of added value is:

$$lossadv = \frac{stp - \frac{s}{S} * 100}{100}$$

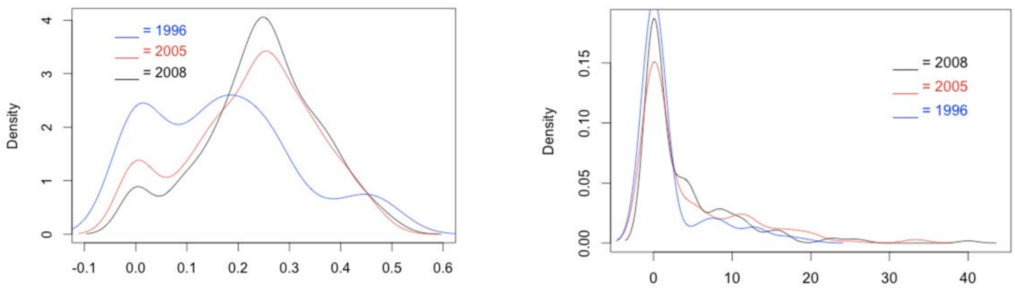

Figure 7 and 8. *Egonet n-broker (left panel) and n-betweenness distribution 1996-2008*
Source: our calculation over U.N. ComTrade data.

The last two features are the *normalized-brokerage (nBroker*) and the *normalized-betweenness* (*nbetweenness*; figures 7 and 8). Since brokerage refers to the *egonets*, it expresses the potential for ego to act as a "broker" in a flow of trade. Dividing this number for the number of all couples of actors, we have a measure that does not depend on the size *egonet* and so it is more useful for descriptive purposes. Figure 7 clearly exhibits as higher *nBroker* values occur more often in 2008, compared to 1996 when there were 3 blocks of Countries ordered for increasing values of *nBroker*. This figure is particularly interesting as representative of a substantial redistribution of brokerage ability and of a path towards market integration and globalization of the market, also expressed by the significant disappearance of groups and by the lower number of actors with high *nBroker*. If in 1996 there were Countries that if hypothetically removed would left numerous isolated pairs of actors, in 2008 the number of these Countries significantly decreased. The *n-betweennes* is obtained by dividing the betweenness for the highest attainable value within the *egonet*13. The n-betwenness, therefore, measures the distance from this limit. The idea of brokerage and betweenness are slightly different: while the brokerage refers to an intermediary position, like a "bridge" between two players or groups of players otherwise disconnected, the betweenness expresses an idea closer to centrality, or the frequency with which an actor is located along shorter flows between others. The distribution of the *nbetweenness* in figure 8, however, does not add any particularly interesting information compared to what has already been presented.

4.4 Micro-level analysis of actors' behavior

The players with the highest market share in 2008, also have the highest values for density and size of *egonet*, and for the brokerage and betweenness indexes. Some new players, however, seem to overlook competitively including Lebanon, Turkey, United Kingdom, U.S.A and Canada. Finally, note how the presence of actors from the Mediterranean is narrower than we might expect.

13The highest attainable value is reached in a network where all the nodes are disconnected except with ego (star network).

Table 6. *In* and *out degree WDN*, 1996-2008.

1996			*2008*		
Country	*OutDegree (Export value, US $)*	*InDegree (Import value, US $)*	*Country*	*OutDegree (Export value, US $)*	*InDegree (Import value, US $)*
Spain	*771.377.984*	*106.785.648*	*Spain*	*2.068.088.832*	*176.731.840*
Greece	*646.460.544*	*858,98*	*Italy*	*1.228,472.960*	*1.510.244.864*
Italy	*489.193.312*	*926.910.720*	*Tunisia*	*568.611.392*	*88.505,0*
Turkey	*71.201.112*	*348.019,0*	*Greece*	*322.733.920*	*5.063.790*
France	*32.241.600*	*310.640.160*	*Syria*	*135.759.872*	*797.014,0*
Portugal	*7.861.978*	*122.992.432*	*Portugal*	*103.405.392*	*194.692.096*

Source: Our calculation using United Nations ComTrade data.

In 2008 the Country whit the largest exchange (or most directly influenced) area remains Italy with an *egonet* comprising 150 Countries (table 7) and almost 1,200 trade relationships followed by Spain and, with a large gap, from France (95 alters, surprisingly) and Turkey. Quite interesting the performance of the United States with a number of trade partner equal to Greece14. The Countries that have expanded the most their *egonets* from 1996 to 2008 were Spain, Italy, Lebanon and Tunisia (table 7). Overall, all these Countries have seen an increase in the *egonet* size as a result of an expansion of the market and the intensification of trade. Table 7 shows as this increase meant a substantial enlargement of the trade partners' portfolio for some of these Countries (Lebanon, Tunisia, Chile; tab. 7 Col. 4), while for others it meant a real leap forward (Canada and Australia). Focusing the analysis on the two leaders, Spain and Italy, given the already rather large size of their portfolio it would have been rather difficult to notice a substantial increase, still the highest for Spain; an important difference between these two Countries relies in the acquisition of new partners: Spain acquired partners especially among those Countries that were already in business relationships with members of its *egonet* in 1996: 71.6% versus 38.8% of Italy (tab. 7, Col. 4). A further specification can be inferred by observing how many of the new partners are new markets, i.e. by observing variations in export and import, represented by the *outdegree* and *indegree* indexes (table 8). It is clear that Spain mainly increased its export flows, 60 against 40 for Italy, which is even more interesting if compared with table 5. Similarly, Lebanon, Tunisia and Chile have gone far from being net importers to export towards a considerable number of Countries. Also interesting is the advancement of Portugal, registering an increase of 34 new destination Countries and 5 new suppliers.

14 Looking at the *out-degree*, is to say to the export target markets, the USA move – in the same time span – from 29 (against 12 for the *in-degree*, is to say number of Countries were to import from) to 47 (against 36 *in-degree*), while Greece moves from 49 (against 5) to 69 (against 13).

Table 7. Changes in the *egonetwork size* since 1996 to 2008.

Country	*Diff. 96-08*	*Egonet size 2008*	*Increase (%) as to 1996*	*% of new partners, already trading with own alters in 1996*
Spain	*61*	*139*	*+ 48,2*	*71,6*
Lebanon	*55*	*58*	*+ 1883*	*86*
Italy	*42*	*150*	*+ 38,8*	*54*
Tunisia	*42*	*44*	*+2100*	*86*
Portugal	*33*	*63*	*+ 110*	*80*
Canada	*30*	*40*	*+ 300*	*80*
USA	*30*	*66*	*+ 83,3*	*77*
Australia	*28*	*42*	*+ 200*	*85*
Germany	*28*	*59*	*+ 90,3*	*81*
Chile	*27*	*31*	*+ 675*	*92*

Source: our calculation over U.N. ComTrade data

The situation described so far, is largely confirmed by the values recorded for the indices of brokerage, especially considering the variations between the two reference years (tables 9 and 10). Spain registers a significantly greater increase than Italy, albeit Italy improves its position remaining the main broker. With respect to the ability of brokerage, Italy and Spain are followed at long distances from France, Turkey, and Greece, remembering that the brokerage is strongly dependent onto the local (*egonet*) context[15].

It is appropriate, instead, to focus on Turkey, Greece and the United States, more interesting as for business values (table 8) and growth potential. The first two, both producers, "play" on the same ground, the Mediterranean basin, thus culturally, historically and physically close to a wide range of low cost supply. The performance recorded in 2008 is rather similar, a sign of a potential high level competitiveness between the two, which sees Turkey maintaining a slight edge. Beside, the U.S.A., presumably, refer to a totally different sink. Given the lack of domestic production, the high brokerage level suggests that the US "manage" the inflows to restructure its own offer. Right now the exchanges amount to modest values and quantities comparted to the "hard core" of the market, however we believe that the result is not to be underestimated rather it expresses an overall behavior of the market operators that conforms as a "hub" in the Atlantic area. The U.S.A are even more remarkable when compared to Chile, a new producer too, geographically next to South American Countries and that, despite having recorded good growth performance export oriented, disappears from the top brokers' list. The analysis deserves a comparison in the composition of the *egonets* (possibly to assess the degree of overlap), to better assess the behavior of the individual Countries within larger trade structures.

15 This mean that in its personal “trade flows' portfolio” France has a role comparable to other traditional market leaders, but out of it France loose its power/relevance.

***Table 9.** Brokerage 1996. Country*

Country	*Brokerage 1996*	*Diff. 96-08 (%)*
Spain	*2833*	*218.6*
Italy	*5591*	*89.2*
France	*2366*	*70.1*
Lebanon	*1*	*1478.5**
Portugal	*367*	*362.4*
US	*562*	*233.8*
Turkey	*1104*	*96.9*
Germany	*378*	*259*
Greece	*1062.5*	*91*
Tunisia	*0*	*770*

Table 10a. Brokerage 2008.

Country	*Brokerage 2008*
Italy	*10576*
Spain	*9027.5*
France	*4025.5*
Greece	*2029.5*
USA	*1876*
Portugal	*1697*
Lebanon	*1479.05.00*

Source: our calculation over U.N. ComTrade data.

Finally, we analyzed brokerage to identify particular aptitudes, using the G&F approach that refers to the activity of brokerage between and within groups of actors defined by the researcher. Consequently G&F brokerage is not measured referring to the structural holes in the Countries' *egonets*, but to the entire network. For our analysis, we divided the Countries into "producers" and "non producers", where producers are all those Countries for which the IOC (the International Olive Committee) has reported any production level in selected years. At a first sight data reveals a remarkable increase in brokerage from 1996 to 2008 with a distinctly prevalence for producers (see table 10 and 11).

***Table 10b.** Groups of Countries for Gould & Fernandez brokerage.*

Year	Non-producing Countries	Of which *total borker* > 0	Producing Countries	Of which *total broker* > 0
1996	144	19	19	9
average *total brokerage*	36,11		268	
2008	176	62	24	23
average *total brokerage*	87,03		484,04	

Source: our calculation over U.N. ComTrade data

Table 11. *Groups of Countries for Gould & Fernandez brokerage.*

2008	*Coordinator*	*Gatekeeper*	*Representative*	*Consultant*	Total16
Germany	376	368	86	80	910
UK	398	210	90	47	745
Belgium	241	236	25	19	521
Netherlands	185	124	42	24	375
Canada	120	158	12	7	297
1996					
UK	121	99	12	5	0
Germany	101	53	26	9	0
Belgium and Lux.	32	26	3	2	0
Swiss	14	16	4	5	0
Australia	6	18	0	0	0

Source: our calculation over U.N. ComTrade data.

Both in 1996 that in 2008 nearly every non-producer behaved mainly as *Coordinator* or *Gatekeeper*, with a prevalence of Coordinator when narrowing to those Countries with significant total score brokerage, while producers behave predominantly as *Consultant* and *Representative* thus covering structural holes between non-producers and between producers and non-producers (tables 12 and 13).

Table 12. *G. & F. brokerage scores: first 5 non-producing Countries in 2008 and 1996 as for total brokerage.*

2008	*Coordinator*	*Gatekeeper*	*Representative*	*Consultant*	Total
Italy	167	267	1218	1671	3323
Spain	150	184	1042	1096	2472
France	73	122	675	1000	1870
USA	47	65	584	620	1316
Greece	23	106	59	337	525
1996					
Italy	38	69	289	485	881
France	18	25	259	247	549
Spain	18	25	174	228	445
USA	16	6	153	67	242
Greece	10	10	45	65	130

16 Since the selected groups are just two, the "*liason*" brokerage results zero.

Table 13. *G. & F. brokerage score: first 5 producing Countries in 2008 and 1996 as for total brokerage.*

Variable	*model1*	*model2*	*model3*	*model4*	*model5*	*model6*	*model7*	*model7bis***
product	*1.04**	*0,36**	*0,62**	*0,62**	*0,31**	*0.31**	*0.33**	*0.68**
brokerage		*84677,5**						
unotot			*181854**	*201440**	*-70729**	*8849.9 N.S.*		
indegree				*-0,7**	*-0,32**	*-0,29*	*-0.33**	*-0.21**
size					*-6957272**	*-7114514**	*-7202799**	*-8970734**
ties					*368814**	*319263**	*411756**	*491266**
pairs					*98321**	*108292**	*98121**	*87360**
density					*-331566**	*-355342**	*-332172.6**	*-1305290**
avg_dist					*1,76e+07**	*18900000**	*18200000**	*51700000 N.S.*
diameter					*-9875815**	*-10600000**	*-10300000**	*-22400000 N.S.*
nweakcomp					*-6299666**	*-5809123**	*-6028643**	*-5279705**
stepreach					*68078 N.S.*	*61565 N.S.*	*69789 N.S.*	*586488 N.S.*
reacheff					*-785238**	*-857002**	*-792593.**	*-752896**
egobetween						*-146451**		
un_coor							*-228318**	*-206282 N.S.*
un_gatek							*-69055 N.S.*	*-58360 N.S.*
un_repr							*291794**	*347237**
uncons							*-380838**	*-470267**
costant	*68924 N.S.*	*-4522705**	*-2844248**	*-2848990**	*9,02e+07**	*96900000**	*90700000**	*107000000**
R2overall	*0,70*	*0,77*	*0,75*	*0,76*	*0,83*	*0,84*	*0,84*	*0,87*
N.obs	*2472*	*2472*	*2472*	*2472*	*2472*	*2472*	*2472*	*848*

We tested the hypothesis that Countries belonging to the same group have a tendency to establish relationships with each other rather than with others, in order to check indirectly the significance of consultant and gatekeeper. We used a nonparametric Chi-squared test conducted by randomly generating a number of expected relationships inside and among groups using a reasonable number of permutations (10,000). The actual value was compared against the expected value derived from 10,000 permutational networks of size equal to those examined and equally distributed. Results confirmed the hypothesis with high statistical significance ($p = 0.0001$). Finally, we assessed the correlation between proximity in the network and production level using the test of Geary, noting a weak correlation. On these basis we have formulated a series of hypotheses about the role that a selection of network indexes here presented may have in determining the level of *outdegree* (or export values), listed below (the first 8 hypotheses refer to *egonet* measures):

- $Hp1: \uparrow density \rightarrow outdegree \downarrow$
- $Hp2: \uparrow \text{size} \rightarrow outdegree \uparrow$
- $Hp3: \uparrow diameter \rightarrow outdegree \downarrow$
- $Hp4: \uparrow nweakcomp \rightarrow outdegree \uparrow$
- $Hp5: \uparrow stepreach \rightarrow outdegree \downarrow$
- $Hp6: \uparrow reacheff \rightarrow outdegree \downarrow$
- $Hp7: \uparrow egobetween \rightarrow outdegree \uparrow$
- $Hp8: \uparrow broker \rightarrow outdegree \uparrow$
- $Hp9: \uparrow unrepr \rightarrow outdegree \uparrow$
- $Hp10: \uparrow ungatek \rightarrow outdegree \uparrow$

As for the G&F brokerage we tested whether the roles of *representative* and *gatekeeper* were positively correlated with the *outdegree.* The results of the analyses, obtained through a series of different regressions, are shown in table 14. Regressions were performed according to the panel model. The model number 7 is repeated on a sample of observations containing only those Countries whose *outdegree* was greater than zero, to understand if this has any influence on the G&F indexes, because of their peculiar construction. All the regressions were developed starting from a model where the Country's production level is the only independent variable thus used as a baseline to estimate the net gain in explanatory power. It should be noted at this point that slightly different results could be obtained by normalizing the G&F score by the total brokerage at Country level. Also, G&F scores deserve a deeper detailed analysis to better distinguish subsets of actors within each kind of brokerage.

Table 14. *Brokerage ed export: comparing results.*

The results show that 4 of our hypotheses are confirmed: the *egonet* density is negatively correlated with the value of exports as well as the *diameter* and *reach efficiency*. The role of the brokerage presents ups and downs depending on the specification of the model, while it is confirmed the positive correlation between the conduct of *representative* and the value of exports. Evidently, the index of brokerage in its general specification cannot be identified as source of competitive advantage. The *2-steps reachability* and the *gatekeeper* index are not statistically significant in any of the models, probably because other indices have a higher descriptive power. No confirmation for the hypotheses about the *egonet size*, the number of *weak components*, and the *betweenness*. We do not have a plausible explanation for these results, thus calling for a further specification of the model. Altogether, all models are explaining a fairly high percentage of variance, which varies from a minimum of 70% (corresponding to the explanatory power of the domestic production) to a maximum of 87% for the more complex model. It still remains to explain the behavior of the constant term.

In summary, there is a significant correlation between the level of export and the brokerage ability, greater than the production one although accompanied by the import levels, especially for those brokerage behaviors that cover structural holes between producing and non-producing Countries. It seems therefore useful to start from here for a future inclusion of such behavioral indices to refine the predictive ability of the international trade models. To do this, it is necessary to understand the nature of this contribution (e.g. solving for multicollinearity problems) for example by standardizing the Gould & Fernandez's brokerage indexes, or considering alternative or complementary dichotomies to producer/non-producer. It will also be necessary to choose the most appropriate panel data model especially to take into account the non-independence of the observations typical of the network analysis, as well as it could be appropriate to select a different reference distribution other than the normal. Finally, useful investigative insights can be derived testing hypotheses about the combined effect of multiple network indices.

5 Conclusions.

Thanks to NA we could highlight phenomena non-observable with other methodologies. First we identified a widening "*core*" of Countries controlling the market, the consolidation of a *core* even more restricted as for trade flows, and the presence of a few small *leading groups* that control a large number of net importing Countries depending on few or very few business partners. Overall, the growing demand for virgin olive oils has led to a differential growth in the world exports resulting structured organization of the trade flows. Moreover, the analysis showed how the network of trade of virgin olive oil is actually structured. Within this structure, the increase in the *betweenness centralization index* indicates that the increase in the number of trade flows was rather in favor of centralized hubs indicating the probable formation of new ones. The business partners of these hubs are also very active and in relation to each other, and then, though there are very few actors who have a significant role in determining the product streams, these are immersed in a competitive (or globalized) environment than before. Jointly observing the brokerage it follows a further evidence of an evolutionary path towards integration and the globalization of the market. Thanks to the network perspective, we could highlight the appearance on the market of new competitors as Lebanon, Turkey, United Kingdom, Germany, U.S.A, and how the (strategic and future) relevance of the Mediterranean players is narrower than we might expect. Among the formers Spain significantly improved compared to Italy, albeit Italy holds the higher brokerage score.

There is a significant correlation between the level of export and the brokerage scores, particularly for the type *representative;* future models should include behavioral indices in order to refine the predictive capability of models for analysis of international trade. To do this,several issues needs to be solved, e.g. multicollinearity, indexes' standardization, alternative or complementary dichotomies for the G&F scores. Additional results may be reached by comparing the composition of *egonets* (possibly to assess the degree of overlap), analyzing the network by geographical area in order to assess the behavior of individual countries within the larger trade structures, taking into account the different types of olive oil. The latter have commercial specifications and different uses: from edible live oils of the highest quality (extra virgin and virgin) to those edible but of lower quality (olive oil), not directly edible (lampante oil or crude pomace oil) that become edible only after an industrial process of refining and mixing with virgin and extra-virgin olive oils. Our main assumptions are confirmed.

There is a relationship, likely functional, between market development and the evolution of the trade network. With regard to the interpretation of the NA indexes, the judgement is positive for structure analysis and egonetworks, also thanks to a developing literature, while the positional analysis of the individual actors remains to be explored. This should include above all the specificities of each market and the nature of the product, both for the results' interpretation, and in the database preparatory phase. It appears evident, however, the power of the *betweenness* and *brokerage*.

The evolution of the index distribution over time seems to indicate the existence of underlying behaviors of individual countries, which makes NA able to display the result of the aggregation of individual behaviors intimately dependent on the actors' performances. Future analyses should use olive oil WDN suitably manipulated (e.g. considering three-year averages of the trade values), investigate certain structural behaviors (e.g. assortativity) and search for a correlation between indices of individual network and business performance. The results so far achieved, therefore, prove us that NA may add value to other methodologies, unable to consider the interrelationships between countries if not singularly, cannot provide. The network perspective allows to display otherwise hidden behaviors, that probably affect the trade balance, in the medium and long term, thus showing an interesting predictive ability.

References