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Abstract:

Throughout the last two decades or so the global pattern of wine production has undergone fundamental changes. New players have emerged and technological and organizational changes have reshaped the way wine is produced and marketed. The aim of this study is to increase our understanding into these processes. We map and compare trade and knowledge networks using social network techniques in order to show how globalization has affected this particular sector, and how the main actors of this industry have responded to these challenges. We are able to give account of the structural changes that have characterised the industry at global level over more than three decades and relate them to the features of the main trade and knowledge blocks.

1. Introduction

Throughout the last two decades or so the global pattern of wine production has undergone fundamental changes. The pattern had been very stable for centuries, with the production of wine being heavily concentrated in a selective number of European countries. These so-called 'Old World' producers (henceforth OW), such as France, Italy and Spain, dominated the international wine market. It is only relatively recently that other countries outside Europe, the so-called 'New World' wine countries (henceforth NW), take more prominent positions in the world wine market (Anderson 2004). Besides that, the wine industry, along with other agro-food sectors, has gone through remarkable technological and organizational changes that involve both traditional OW and NW producers (Cusmano et al. 2009). These two groups of countries have both increasingly invested in the creation of new scientific knowledge in the field of wine production, though urged by different motives: the NW countries as a means to catch-up with traditional wine-producing countries; the OW countries to renew their capabilities in order to face competition by newly emerging wine producers.

Despite the increasing interest in the broad economic literature for this sector, coming from either economic geographers, trade economists or innovation scholars (Anderson, 2004; Anderson et al 2003; Archibugi, 2007; Aylward, 2003 and 2004; Bell and Giuliani 2007; Gwynne, 2008; Lagendijk, 2004; Morrison and Rabellotti, 2007; Unwin 1991), few studies thus far have provided a comprehensive framework to jointly analyse the above mentioned dynamics of change in trade patterns and knowledge production. Most contributions have in fact paid attention to either the role of science and innovation in the sector, mostly carrying out in-depth qualitative research on the role of

single actors (e.g. firms, public research organisations, and universities), or to the evolution of trade patterns, focusing on the analysis of aggregate indicators.

Therefore, a detailed knowledge about the overall pattern of interconnectedness among wine-producing countries is largely lacking. For example, it is only poorly understood how the properties of the global structure of interactions across wine-producing countries change over time and to what extent upward and downward movements of the positions of individual countries within this structure have taken place. In order to answer to these kind of questions and with the aim of increasing our understanding of the globalization trends in the global wine sector, this study presents an analysis of the changing global organization of the wine sector by virtue of a network analysis approach.

As such, the aim of this study clearly connects to the wider literature on globalization conducted by sociologists and geographers on the world systems and global cities (Smith and White, 1992; Snyder and Kick, 1979; Taylor, 1988, Wallrestein, 1974), which already presents some attempts to apply structural analysis to the processes of global integration.

In the world-system literature network analysis methods are used to define the core, semi-periphery and periphery of economic and politic influence among countries in the world. These power structures are concealed in the way in which countries are interconnected through various types of networks and flows, such as trade networks, bilateral treaties, economic aid or political conflicts between countries. World-system theory holds that the positions countries occupy in such networks heavily constrain their economic development. Or as Smith and White (1992, p. 857) put it: *"The basic claim [of world-system theory] is that international connections, roles and relationships are independent*

variables in any causal analysis purporting to explain various dimensions of development within countries". The relational focus of world-system theory that is apparent in this quote makes it perfectly suitable for a multiple-network analysis approach. The underlying assumption of multiple-network analysis is that "the structure of social systems is specified by the simultaneous analysis of multiple networks of interaction among system units, whether they be members of a small group, an organization, a nation, or the world" (Kick and Davis 2001, p. 1565). As suggested by Kim and Shin (2002), social network analysis serves as a suitable toolbox to assess changing patterns of globalization in a quantitative way[*].

The same holds for the literature on globalization and world cities (e.g. Taylor 2004). In this literature the position a city takes in a hierarchy of world cities largely depends on its position in multiple networks that describe the structure of global air transport, capital flows or the locational pattern of multinationals' subsidiaries.

However, it is only recent that multiple-network analysis techniques are applied to this body of research. Most part of the literature so far was in fact dominated by qualitative discourse types of analysis and used the network concept at a very metaphorical level (Hargittai and Centeno, 2001). For the literature on world-systems and global cities the application of social network analysis techniques, particularly when applied to multiple networks, has proved to amplify the insights into the properties, origins and effects of globalization.

Besides that, thus far such methods have been largely disregarded in industry-specific studies on globalization. This is rather surprising considering that the increased

[*] A complementary stream of literature in physics and statistics shows how network theory and methods represent powerful tools to map and examine global interactions (Fagiolo et al. 2008; Kastelle, Steen and Liesch, 2005).

interdependence and interconnectedness of countries is a fundamental building block in any of the many existing definitions of globalization. In order to complement and integrated these approaches, which are mainly geared towards the analysis of whole economies, this study takes a particular industry as its object of study. Hence, it applies network analysis techniques to the wine sector in order to gain a better understanding of how the sector is organized globally. In this way, we can detect changes in the structural organization of the industry and show how and whether these trends, such as the emergence of NW wine-producing countries relate to the structural organization of the wine scientific community. Hence, in applying multiple-network analysis, this study explicitly takes a dynamic perspective and places the emphasis on the analysis of structural change in the global organization of the sector.

Two networks have been selected as being illustrative for the recent developments in the wine sector. First, the network of international trade among countries is used to illustrate the changing patterns of production and consumption in the industry. The trade network is specified as a valued matrix, in which the cells denote the monetary values of import and export flows between countries. Considering the increasing importance of scientific research in the sector, the co-publication network is taken as a second indicator to assess the structural organization of the sector at the global level. It needs to be emphasized that we do not intend to make any causal claim between the evolution of the trade network and the knowledge network. Although investments in science and technology might certainly enhance a country's position in global trade, the effect might also work the other way around. Countries with a dominant position in trade of a particular good will be strongly inclined to retain such position through investments in science and technology,

as most scientific advances are often pulled by sophisticated demand (Kline and Rosenberg, 1986). As explained previously, the multiple-network analysis intends to compare these networks in order to examine how globalization has affected this particular sector, and hence investigates to what extent these two different networks have responded in a similar way to globalization forces. In particular we address the following questions: do we observe a higher density of connections in the worldwide network of wine trade and scientific collaborations today than in the past? Do we observe any clear-cut patterns of relations in the world wine trade and knowledge networks and how they have changed over time? How have different countries, and in particular NW and OW producers, positioned themselves in these different patterns? Are these networks today more evenly distributed than in the past? Has the increasing participation of NW countries in the world wine trade network been accompanied by a similar engagement in the global wine research community?

The paper is structured as follows. The next section describes the most important changes the wine sector has experienced in the last decades. In order to do so, the section gives an overview of the most recent insights that the predominantly qualitative research on the industry has brought thus far. Then, a methodological section further elaborates how social network analysis methods contribute to the existing literature on globalization in the wine sector, paying particular attention to network comparison through block modelling techniques. Section 4 then provides the analytic results. Section 5 concludes by giving an overview of how network analysis techniques have advanced our understanding of globalization in the particular case of the wine industry and by formulating some recommendations for future research.

2. The evolution of the wine sector

The wine sector has experienced radical changes over the last three decades concerning the way wine is produced and marketed, the nature and variety of the actors involved in these processes and their geographical localization. Once dominated by a bunch of European countries – namely France, Italy, Spain, Portugal and Germany – the industry has encountered the emergence of new players that have challenged the position of the incumbents at the global level. Although the core of European countries, the so-called Old World countries, still represents the main producers, exporters and markets, New World wine producers have recently become increasingly prominent. These New World countries have rapidly gained market share and recognition among consumers in both traditional and new wine countries, also to an increasing extent in the high-end segment of the market that was once the exclusive domain of selected Old World producers (Aylward 2003 and 2004). New World wine producers, which include both affluent countries, such as the USA, Australia and New Zealand, and emerging economies such as Argentina, Chile and South Africa, nowadays account for more than 20,5% (2000-2004) share of the world export. By contrast, only a few decades ago, in the 1980s, their share was as little as 1,25 (1970-1974). The growth rates of export volumes clearly testify the extraordinary performance of these countries: for example over the decade 1996-2006 the wine export of South Africa grew at a rate of 350%, Australia and Chile at around 280% and USA at around 190% (European Commission, 2007). Surprisingly, the New World has outranked Old World producers in key markets; Australia, for example, has overtaken

France as the second largest exporter to the US market and has become the leader in the UK. Similarly, Chile is today the fifth largest exporter to the US.

As far as the value of export is concerned, New World producers have been able to enter the premium market segment through a steady process of quality upgrading of their wines. Just to mention a few remarkable cases, exports of premium wine[†] contributed to 97% of the growth of the value of Australia's wine exports and the unit price of their exports is just below France. Also countries such as Chile and South Africa, which have traditionally been producers for the bulk wine, have experienced a remarkable growth in the unit value of their exports, gradually converging towards the world average.

The unprecedented growth of New World countries is based on a broad set of intertwined factors that encompass both the demand and the supply side of the economy (Archibugi, 2007; Cusmano et al. 2009). On the demand side, the emergence and diffusion of new consumption habits, the so called "gourmet culture", was embraced and encouraged by New World countries. The NW countries rapidly responded to these changes by adapting the organization of production, the marketing strategies and above all the institutional setting in which the different players of the industry operate (Aylward 2003). Importantly, New World producers recognized the changing role of consumers in the industry, which in the new framework are those that decide the value of a product and can make the fortune of a brand (Aylward, 2003). On the supply side major transformations followed, first and foremost to respond and adapt to changes on the

[†] Wines are commonly ranked on a six-point scale, from the best quality to the lowest one (i.e. icon, ultra premium, super premium, premium, popular premium and basic). Wines included in the premium segment are characterized by brand recognition and appellation of origin; their price ranges between 5 and 7 euro (Heijbroek, 2003).

demand side. In this context, new actors such as wholesalers, wine experts and oenologists have gained importance as being those that influence and shape consumption behaviour, in particular inexperienced consumers that have become much more numerous in expanding markets such as the US. These new actors play a key role in aligning market trends, firms' production methods and research efforts in response to the changes on the demand side. In line with this alignment process, universities and public research centres have been restructured and modernized in order to comply with the requests of the new consumers and the emerging markets. New World countries, and particularly the state of California, have contributed to the emergence and consolidation of a market-driven scientific approach to wine production. This new strategy implies that academic research becomes closely related to the need of the market. Thus, for example, research efforts have been devoted to planting new grape varieties that are more in line with the prevalent tastes in the market. Scientific research in the wine sector has also focused on the development of new techniques that reduce the variability of outputs in order to meet the requirements of retailers asking for products with stable taste and quality over time. Another example is the scientific focus on the analysis of soil characteristics with the aim of finding the best conditions for planting highly demanded varieties of vines. In short, in this new paradigm, in which quality and recognition have become key competitive assets for any wine irrespective of its origin, academic research, along with the actors and institutions that carry it out, has been given central stage in the wine sector.

3. Data and methodology

3.1 Data sources and countries selection

This paper analyses the network of trade linkages and co-publication linkages across countries. The co-publication network, referred as knowledge network, is used to track the scientific collaboration within the international community researching in wine related issues. The trade network is used to analyse the overall structure of trade in wine production among the main countries of wine production and consumption.

The analysis of the scientific collaboration network is based on bibliographical data that cover a period of 18 years from 1989 to 2006. The data are extracted from the Web of Science edition of the *Science Citation Index Expanded* ^{TM} (SCIE) of the *Institute for Scientific Information* (ISI, Philadelphia, PA, USA). The number of publications is considered an important output measure of research activity (for a critical appraisal see Katz and Martin, 1997). This measure is widely used in bibliographic literature both at the level of the organization (e.g. university) and, as in our case, at the level of nations or regions. As in many similar studies (e.g. Glänzel and Veugelers, 2006), we restrict our analysis to the Science Citation Index. This set of publications may not cover all publications, but it has the advantage that it allows for comparison with publications in other fields. Only "citable" publications have been selected. Among those we selected only those papers for which we could clearly identify the affiliation of at least one of the authors. In order to select the publication of the research field "wine research" we followed the strategy adopted in Cassi et al. (2008), which is a slight modification of the criteria adopted by Glänzel and Veugelers (2006). In general terms, we used a lexical criterion (i.e. we search for specific strings among the keywords reported by each article)

and moreover we include all the articles published on top field journals. The dataset obtained this way contains 12373 distinct publications.

For the trade network two different sources of data are used in order to have a greater number of years. To be more precise, these sources are the NBER database (NBER-United Nations Trade Data, 1962-2000) and the COMPENDIUM database (Anderson and Norman, 2006). The former dataset is a generic trade-bilateral dataset reporting data for all the SIC sectors (4 digit), from 1962 to 1999, and concerning all countries worldwide. The latter is a dataset specific to the wine-sector, developed by Anderson and Norman at the Australian Centre for International Economic Studies. It reports a series of national indicators related to wine sector (e.g. specialisation index), as well as bilateral trade flows among the main importing and exporting countries between 1994 and 2004. Given the partial overlap between the two datasets, it is possible to check the consistency of the data between these two different sources. Table A1 in the Appendix displays the value of export, both in value and in percentage terms, for a selected number of countries over the time periods in which the two datasets overlap. The data reported shows that the COMPENDIUM source tends to overestimate the valued of traded wine for the countries of interest. However, since our analysis use ratios (see next section), these do not present significant differences.

Given the limited number of countries reported in COMPENDIUM dataset, we restricted our analysis to a selection of countries. Countries were selected on the basis of their relative importance as wine exporter or importer: all countries that were reported at least once over the period 1980-2004 with a yearly share of 1.5% or more in the overall trade of wine were considered for the analysis. However, some previously socialist

countries (USSR/Russia, FM Yugoslavia, Rep of Moldova, Czech Rep.) were excluded due to problems of name consistency over time. Some Asian countries, such as Singapore and Taiwan, were left out, since in Compendium these countries were reported in regionally aggregated data. The final sample includes 24 countries[‡]. The selected countries count for the great majority of the overall internationally trade of wine (i.e. more than 95% of the worldwide export in 2004) as well as in terms of international scientific collaborations in wine related research (i.e. more than 97% of wine related international collaborations in 2004). Therefore it is reasonable to assume that the exclusion of other countries does not affect the robustness of the results presented in the paper.

3.2 The network construction

Two sets of networks have been constructed: one is based on publication data, and it is named World Wine Knowledge Network, and the other uses trade data, it is named the World Wine Trade Network. Both networks are defined at the level of country, with each node in the network representing one of the 24 countries. The networks are weighted, and the value attached to each existing link between two countries measures the intensity of the relation. An important difference between the two networks is that the publication network concerns a symmetric relation (i.e. undirected network), while in trade network the relation involved is asymmetric (i.e. directed network). The literature analysing the worldwide network (e.g. Fagiolo et al. 2008) treats the trade network as an undirected

[‡] The selected countries are the following: Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Chile, Denmark, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Japan, Netherlands, New Zeeland, Portugal, South Africa, Spain, Sweden, Switzerland, and United States.

network, since, once all the sectors are considered, a substantial symmetry between import and export can be observed in the data. In this way, the computation difficulties are strongly reduced and some problems related to the implementation of some measures and algorithms are overcome. In our exercise, we consider the trade network as directed network. We believe that the assumption of equivalence between import and export value would be misleading once only one sector is taken in account, as it is in our case. Besides that, the reduced size of our network allows us to overcome the main problems related to the statistical implementation.

In order to measure the intensity of a relation, we consider the Salton index (Glänzel and Veugelers, 2006) of scientific collaboration that is widely used in the scientometrics literature. It is defined as follows:

The value of a link between countries *i* and *j* is:

$$v_{ij} = COPUB_{ij} / ((PUB_i * PUB_j)^{1/2})$$

where $0 \leq v_{ij} \leq 1$; v_{ij} is equal to 0 when countries *i* and *j* have no research collaboration, while it is equal to 1 all the scientific activities done in two countries are in common.

This measure grasps how important the scientific collaboration between two countries is relative to the size of the research activity conducted in each country. In analogy to the scientific collaboration intensity measure, the value of a link between two countries in the trade network has been defined as:

$$v_{ij} = EXP_{ij} / ((EXP_i * IMP_j)^{1/2})$$

where $0 \leq v_{ij} \leq 1$ and $v_{ij} \neq v_{ji}$; v_{ij} is equal to 0 when country *i* does not export to country *j*, while it is equal to 1 when country *i* exports only to country *j* and the latter does not import wine from any other countries.

It measures the capacity of country *i* to penetrate into the wine market of country *j*. Again, this measure considers the trade flow of a country relative to the size of the foreign market, but also to the overall capacity of the country to export its domestic production. Therefore, this measure enables us to grasp the growing importance of emerging producers, also for countries whose exports are low in absolute value, but high relative to the size of the industry in the importing country. Moreover, since we focus on the role of new global players as competitors of traditional producers, we decided to use export data expressed in value (in dollars of 2000) rather than volume. In such a way, we can better grasp the extent to which emerging countries are penetrating into foreign markets, in particular whether they enter top market segments.

For both knowledge and the trade networks we have used longitudinal data. As conventional in research on longitudinal network analysis (e.g. Fleming et al. 2007) each network comprises a five-year time window. In this way stable patterns can be detected and the noise due to sporadic events, for instance related to adverse climatic conditions, can be partially removed.

3.3 A stepwise analysis of the trade and knowledge networks

In order to analyse structural changes in the global structure and organization of the wine sector we use a stepwise approach in which both the trade network and the knowledge

networks are analysed. Once more, we need to acknowledge that we do not intend to put a causal claim concerning the relationship between knowledge and trade networks. Instead, we argue that both networks and the way in which they evolve over time can be utilized to describe changes in the global organization of the sector.

In the first step of analysis (Section 4.1) we describe the main features of both the trade network and the knowledge network and their evolution over time. This analysis is aimed at getting a first impression on how globalization has shaped the overall networks of trade flows and scientific collaborations among the main wine producing and consuming countries. In the second step (Section 4.2) we apply block modelling techniques, which cluster nodes into a predefined and homogenous number of groups on the basis of structural equivalence. Two nodes – countries in the case of this study – are structurally equivalent when they are connected to the same set of countries with similar intensity as expressed by the value of the linkages (Wasserman and Faust, 1994). Therefore, block modelling groups those countries together that occupy similar network positions in terms of hierarchy, power and dependence. We apply the block modelling CONCOR algorithm to the trade network at multiple points in time. In this way, we can describe the changing composition of blocks of countries and detect movements of countries across different blocks over time. Moreover, the detection of structurally equivalent blocks facilitates the analysis of changing patterns of trade among groups of countries, such as increasing or decreasing flows among and between NW and OW countries. In the third and final step (Section 4.3) of the analysis, the blocks that have been obtained on the trade network are applied to the co-publications network. To be more precise, that section describes the change in the intensity of scientific collaboration

within and between groups of countries that occupy similar positions in the worldwide trade of wine. In this way, it can be revealed to what extent the change in trade patterns is accompanied by a change in scientific collaboration in the field of wine.

4. Results

4.1 Globalization of the wine sector: trade and knowledge networks

Globalization, which many claim to be a defining character of our times, is not new to the wine sector. However, its importance – as expressed by the total value of worldwide export of wine – has increased significantly over the last few decades (see Figure 1) (Anderson et al. 2003).

INSERT FIGURE 1 ABOUT HERE

In this section we give account of these globalization trends by looking at the changes in trade patterns and scientific collaborations over the last few decades (i.e. 1970-2004). In doing so, we examine the worldwide trade network of wine and contrast it with the process of internationalization of the wine scientific community, which has become also more and more international in recent times (Glänzel and Veugelaars, 2006).

Table 1 illustrates the main features of the worldwide trade network in wine. It reports the conventional structural indicators of networks for our sample of wine

exporters and importers across four time periods[§]. The first time period (1974) is used as a benchmark: this is a year in which international markets were still dominated by a few OW countries.

INSERT TABLE 1 ABOUT HERE

In line with expectations, we observe a clear increasing trend towards globalization. Over the entire period of investigation (1970-2004), the mean degree (the average number of linkages) has been growing steadily. As shown in Table 1 the mean degree more than doubled over the period 1974-2004, at both cut-off values of 1 and 2 million dollar trade. Moreover, this trend has been particularly pronounced in the last decade (1994-2004), when the average number of connections increased substantially.

Differentiating between import and export linkages between countries we observe a more stable pattern. In-degree and out-degree standard deviations, which measure the variability of imports and exports, do not change over time, although the in-degree standard deviation (import) is consistently lower than that of out-degree (export). Nevertheless, whereas the out-degree is rather stable over time, the in-degree tends to increase, albeit only slightly. This latter trend might, on the one hand, point toward the fact that several new importers with relatively few connections enter the market. On the other hand, it also suggests that a limited number of countries absorbs a growing share of imports.

[§] Each time period is based on a five-year average. For example, the year 1974 represents the average of exports over the period 1970-1974. The computation of these averages level-off possible biases due to the strong variability of production that characterize the industry.

As expected from the increase in the mean number of ties, the network density indicator shows a growing trend over the entire period (though slightly declining in the period 1984-1994) In sociological terms, density reflects the degree of cohesiveness of a group (Blau 1977); it indicates the degree of embeddedness of actors in a web of relationships. In our context it suggests that worldwide trade network in wine has become more integrated and interdependent. This implies that changes occurring in one part of the network can spread and affect more easily any other part of the network. This effect is captured by the indicator of average geodesic distance that measures the average length of the shortest path between all pairs of nodes. A declining trend in geodesic distance can be observed in the 1970s, the late 1990s and early 2000s, whereas a growth is detected in late 1980s and early 1990s. Overall the average distance between two mutually reachable countries has decreased from 1.33 in 1974 till 1.13 in 2004. This outcome also points toward the increased connectedness of wine trade in the world.

INSERT TABLE 2 ABOUT HERE

Figure 1 shows a similar trend for the globalization of the international wine community of scientists. The international collaborations, as measured by the number of co-authored papers in scientific journals, have grown significantly in the last two decades (see Table 2). The number of international co-publications has increased significantly in the last three decades. If we consider the 3 co-publications cut-off, it went from 4 in 1994 up to 17 in 2004; similarly fro the 6 cop-publications cut-off has jumped from 1 up to 13.

As expected, the cohesiveness of the global community, as measured by the network density, has increased considerably in a very short period of time. In the middle of 1990s, each country co-published on wine with almost one-fifth of the other countries included (the density in 1994 is 0.17). Five years later this figure doubled: one third of all possible international collaboration linkages were existent. This result is even more important if we consider that the community of scientists and the number of countries that took actively part in knowledge production on wine expanded over the period under investigation. More cohesiveness also implies higher interdependence. As discussed above for the trade network, this aspect is nicely captured by the average geodesic distance. As expected, we observe a steadily and linearly declining trend that is largely in line with what was observed in the trade network. The average geodesic distance among countries in the knowledge network decreased with almost 20%, from 1.95 in 1994 to 1.60 in 2004. Thus, also in the global knowledge network countries have got more strongly interconnected over time.

4.2 Network analysis of the trade network

In this section we investigate the wine trade network using positional and role analysis or *block modelling* (Wasserman and Faust, 2004). In doing so, we represent the main patterns of complex networks in a simplified form, so as to reveal which countries share similar positions and relations in the wine trade network and how these patterns change over time. As explained in section 3, we first group countries according to their relational similarity or structural equivalence. Countries are grouped in to equivalence blocks on the basis of their similarity in network position in terms of the strength at which countries

are connected to other countries. Once these equivalence blocks have been identified, we interpret their position using the evidence on the wine sector as presented above. To be more precise, we compare the attributes (e.g. export, import) of these blocks with greater detail in order to highlight some systemic differences among the blocks of countries. It is followed by a detailed analysis of the relations between groups, which allows us to unveil the specific patterns of worldwide trade among countries.

INSERT TABLE 3 ABOUT HERE

Table 3 illustrates the CONCOR block modelling partitions[**], which identify four different groups of countries for each time period. Additional partitions have been computed also for intermediate periods, but for the sake of clarity they are not reported here, but only commented if needed. Four time periods (1974, 1984, 1994, and 2004) are considered to capture distinct eras in the global wine industry during the last half-century. Overall, the blocks illustrated in Table 3 are nicely consistent with the evolution of the global wine industry during the last three decades. Blocks 1 through 2 represent countries specialized in wine production, which can be further distinguished between traditional producers, mainly included in Block 2, and emerging exporters in Block 1. Blocks 3 through 4 include the major international importers (Block 4), along with a mixed group of countries that comprises both peripheral producers and emerging consumer countries that have none or very little production (Block 3). Accordingly we

[**] The software used to compute network indicators and structural equivalence is UCINET VI (Borgatti et al. 2002).

have labelled these clusters as follow: *core producers* (Block 2), *second tier and emerging exporters* (Block 1); *core consumers* (Block 4) and *peripheral producers/consumers* (Block 3).

Looking more into detail, we find a pattern that is strongly consistent with the developments described in Section 2. For example, the cluster of *second tier and emerging exporters* in 1974 includes a rather consistent group of relatively small producers (both of NW and OW countries), with a low, though not marginal share of exports. Similarly, the group of *core producers* in 1974 comprises traditional OW producers, with the only exception of Chile. A more refined partition shows that Chile links up with Spain, which clearly reflects the colonial heritage of this country. The fourth block consists mainly of consumer countries that do not have a significant tradition in wine production; therefore they also represent the main importers. However in some periods, this block also includes important wine countries, such as Germany or the USA, which nevertheless count more as importers than exporters in the global wine industry.

The third block is the only one presenting a more heterogeneous composition, mainly reflecting the position of countries that participate to the world market as both importers and producers. For example, in 1974 and 1984, this cluster includes countries, namely NW countries, that participated to the world market with very low share of exports, but at the same time partly import from OW producers. In 1994, the block reinforces this mixed structure: along with some producers, also emerging importers (i.e. Sweden) enter the picture. Ten years later, in 2004, the group is still consistent with the early periods; it is now populated by importers that also play a role in production. On the one side, there is a group of countries that both import and export (i.e. Austria and

Germany); on the other side there are pure importers (i.e. Denmark and Sweden). This distinction clearly emerges at a finer level of disaggregation.

INSERT TABLE 4 ABOUT HERE

Attribute differences among blocks are reported in Table 4 and Table 5. Table 4 presents data on the blocks' average import and export shares. The block of *core producers* decreases its importance over time. The share of exports for this group declines from 13.6% of the world trade in 1974 to 9.95% in 2004. However, it needs to be noticed that this trend is not linear, since in 1994 this group had a peak in exports reaching a share of 13.82%. Similarly, its import share also decreases over time, from 2.67% in 1974 down to 0.9% in 2004. The opposite trend can be detected for *second tier and emerging exporters* (Block 1): the weight of this block in terms of exports rises steadily over the entire period, from a modest 0.46% share of the world export in 1974, up to 3.36% share in 2004, which represents the second largest share. The group of *peripheral producers and second tier consumers* (Block 3) is stable over the first three decades, whereas it shows a substantial increase in its share of imports over the last period. Indeed in 2004, this is the second largest group in terms of import. The last block of *core consumers* (Block 4) shows the greatest stability over time. It is consistently the largest group of importers (a position that it slightly reinforces over time), while being rather marginal as an exporter.

INSERT TABLE 5 ABOUT HERE

Besides the average, the standard deviation is also very informative, as it gives us an indication of the heterogeneity within groups. Despite their similar relational structure as traders, countries differ in terms of the size of their wine industry. This is particularly striking in the group of *core producers* (Block 2) and *consumers* (Block 4), for which the standard deviation is always higher than the mean. This heterogeneity is further illustrated in Table 5, where countries are listed with their positions and main attributes (i.e. export, import, specialization index). Table 5 also provides an illustration of how countries changed their positions over time. It is worth highlighting that on the one side OW countries, such as France, Italy, Spain and Portugal have maintained the same positions over the entire period; they always pertain to Block 2. Conversely, the trend for NW countries is one of convergence towards a structural position that is close to the one of established producers. Along this convergence path they have moved from rather different positions. On the one side South-American new world producers, such as Argentina and Chile, which have been historically producing countries, have always been in the block of second tier producers (apart short interludes). On the other side, South Africa, New Zeeland and Australia, which are the youngest among NW countries, have come from Block 3, which includes countries that have being also net importers of wine. Gradually they have shifted from Block 3 to Block 1, with New Zeeland being the last country joining the group of emerging wine powers.

In order to represent positions we draw on the conventional density matrix (Wasserman and Faust, 1994). In brief, density tables are square matrices that indentify blocks on rows and columns rather than actors. Table 6 illustrates the block density

matrix for the trade networks for the four periods under investigation. The values reported in a matrix are the densities of ties within and between blocks[††]. The density value is put in bold if it is equal to or greater than the average total density of the network. The first relevant finding is that all matrices show a *cohesive* pattern (apart from 1994); density values within blocks are above the average. This result indicates that irrespective of the changes occurred in the global wine industry over the last three decades, intra-blocks trade flows remain one the main components of global wine trade.

INSERT TABLE 6 ABOUT HERE

A second persisting feature of the system is *centralization*, which emerges when all ties are pointed toward a single position. In our case, Block 4 (*core consumers)*, which includes the main markets for wine outside traditional producers, appears as the main receiver of ties from all other blocks. Both *emerging exporters* (Block 1) and *core producers* (Block 2) are persistently connected with Block 4 (*core consumers*). Interesting enough, the density of ties of *emerging exporters* (Block 1) towards Block 4 steadily rises over the four periods. In 1974, the density from Block 1 to Block 4 was 0.02; far below the density of ties of Block 2 toward Block 4, which was 0.074. Thirty years later this density went up to 0.047, a figure that is not far away from that of

[††] Intra-block (B_i) density is defined as

$$\Delta_i = \sum v_k / ((n * (n-1))$$

where: v_k it is the value attached to each arcs k, with where the set K includes all the arcs existing among the members of the block B_i; and n is the size of the block B_i.
The inter-blocks (B_i and B_j) density is defined:

$$\Delta_{ij} = \sum v_k / (n * m)$$

where: v_k it is the value attached to each arcs k, with where the set K includes all the arcs going from block B_i to block B_j; and n , m are respectively the sizes of the block B_i. and of B_j.

established producers (i.e. 0.055). This latter figure conversely decreased, though with discontinuities over time.

INSERT FIGURE 2 ABOUT HERE

A clear picture of such a dynamics emerge from Figure 2, which illustrates the evolution of inter-blocks densities from Block 1 and 2 towards Block 4 - as identified by the block modelling in 2004. As discussed above, Blocks 1 and 2 in 2004 identify the distinction between OW and NW countries in a rather consistent way. The convergence depicted in Figure 2 clearly indicates that *emerging exporters* strongly penetrated dynamic markets, as those included in Block 4. To sum up, we detect more evenness in the system, with NW countries progressively catching up with the traditional leaders. However the pattern of relation is persistently one of centralisation; the difference between the old times and today is that OW countries, which were the only core in the wine industry, are now accompanied by NW producers.

4.3 Network analysis of the knowledge network

This section presents the results of the *block modelling* for the wine knowledge network. The partitions are based on the block modelling of the 2004 trade network, which identifies blocks that consistently reflect the distinction between NW (Block 1) and OW countries (Block 2). Such an analysis allows us to further investigate the organizational changes in the wine industry, and in particular whether knowledge networks present relational patterns that differ from trade networks In other words, we aim at identifying

which trade blocks share similar relations in the wine knowledge network and how these patterns have changed over time. Our attention goes to the structure and dynamics of the group of *emerging exporters* (Block 1), in order to verify if it mimics that of *core producers* (Block 2).

INSERT TABLE 7 ABOUT HERE

Table 7 illustrates the density matrix for the four different trade groups for three time periods (1994, 1999, 2004). We first notice that the pattern of interactions is not as clear-cut as it appeared in the trade network. In 1994 there is some dominance of reflexive ties, which means that scientific collaborations are established prominently within trade blocks. However this is true only for non-exporting countries (Block 3 and 4). On the contrary, the scientific collaborations among *emerging exporters* (Block 1) are not even in place in 1994. This contrasts quite sharply with the subsequent evolution of the knowledge network of international collaborations. *Emerging exporters* indeed increase significantly their share of collaborations with all the other trade blocks. In particular, as shown in Table 7, their highest share of collaborations is established with countries in Blocks 4 and among themselves. This latter finding (i.e. High intra-block density) notably reflects the fact that NW countries (Block 1) have established strong scientific linkages among themselves, which is somehow plausible, since most of them share some similar features and needs (e.g. climatic conditions; structure of the industry; institutional actors). However, this result should not be regarded as straightforward or trivial: the story of many catching up countries is one of dependence, in particular as far as knowledge is

concerned. Therefore, the above finding clearly points to the growing scientific independence of NW producers and to their increasing activism as players in the international wine scientific community. The former result (i.e. High inter-block density with bock 4) is also striking and important. It suggests on the one side that NW countries achieve a structural position that increasingly resembles that of OW countries (Block 2), which in fact have also strong linkages with Block 4. Besides that, it also indicates that NW countries are nowadays able to engage in scientific collaborations with some of the most recognized world actors in wine research, namely with the US. The US indeed hosts some of the most prestigious research centres in wine related subjects (i.e. University of California at Davis); thus, being connected with these actors allows NW producers to get close to the scientific frontier in the field.

The comparison of intra-block densities between Block 1 and 2 also confirms some trends already highlighted in the wine literature. NW countries show a higher propensity to establish external contacts than OW countries. In fact their inter-block density with Block 4 is higher than their intra-block density; this is the opposite for OW producers, which are still highly inward looking. Nevertheless, it has to be acknowledged that this latter group has reinforced its relations with other trade blocks over time, in particular with Block 4. From the discussion above, it appears that Block 4 has become a major point of attraction of scientific collaborations, mainly due to the presence of the US in the group (see Table A2). This latter finding also emerges as a general feature of the present pattern of interactions in the knowledge network. In 2004 in fact it appears that a clear *centralization* structure, since most blocks establish linkages with Block 4, and most

probably with the US, which is nowadays the most central actor in the global wine scientific community.

5. Conclusion

This paper provides a detailed account of the changing global organization of a traditional sector, namely the wine industry. Drawing on the literature on the world trade system the paper explores the evolution of trade and knowledge networks in the global wine industry by making use of social network techniques. In doing so this paper's contribution to the literature is twofold: on the one hand it highlights the analytical power of network analysis, and in particular of role and positional analysis, in sector-level studies; on the other hand it advances the general understanding on the recent transformations in the industry by jointly analysing trade and knowledge networks. Indeed, the increased knowledge and scientific content of the sector, and more broadly, the general tendency towards a knowledge-based economy, call for a comprehensive and integrated approach to globalization that includes both the economic and knowledge dimensions.

A stepwise approach is followed to give account of the main changes occurred to the global structure and organization of the wine sector. In the first step we check for the presence of some globalization trends in the industry. Using data on international scientific co-publications and trade for different time periods, we show that globalization is a pervasive phenomenon in this sector. The participation of countries to the world trade network, both exporters and importers, increases over time. A similar evolution is observed in the scientific network of collaborations. In this context, the higher

interdependence of actors in the system might have the positive effect of facilitating the diffusion of knowledge. Researchers are part of a larger global community of scientists, as a consequence of which they more easily share and access to the relevant knowledge.

Besides these general trends, in our second step we detect the structural transformations in the organization of the industry. In line with the existing literature we detect the emergence of new actors, which steadily climb up onto the international wine rankings. The block modelling analysis nicely illustrate this trend pointing to a growing international division of labour, which reflects the distinction between core exporters and consumers on the one side, and emerging exporters on the other side. The relational positions identified with the application of block modelling clearly reproduce the evolutionary path followed by NW countries. NW countries, which are included in the group of emerging exporters, constitute a fast growing group in terms of export share. What is important, however, is not only to observe their overall growth in terms of exports, but rather the fact that the structure of their trade relations mimics the one of the established producers. The use of network analysis tools allows detecting the speed and dynamic of this evolution; in other words, it shows to what extent and how fast these countries got closer to the core by penetrating into the same dynamic markets. As far as the knowledge network is concerned, a different picture emerges. While trade networks show some neat and rather persisting features (e.g. cohesiveness, centralization), the knowledge network is characterised by a more heterogeneous and volatile structure. However, there are also some similar trends. Also in the knowledge network, we observe on the one side a tendency towards centralization, with the emergence of some leading actors (e.g. USA); on the other side the growing scientific independence of emerging

exporters, which at the end of the period under analysis constitutes a cohesive block. To conclude, we are convinced that the analysis of trade and knowledge linkages carried out with network techniques is a useful tool for understanding the global structure of industries and their changes over time. Nevertheless, we acknowledge that this study raises as many questions as the answer it tries to provide about the mechanisms of globalization in the wine sector. In order to unveil the complexity of the issues discussed in the paper detailed case studies are also needed. Our approach intends to be a complement rather than a substitute for these approaches, as it provides a comprehensive picture of the changing structure of an industry worldwide.

References

Anderson K. (ed.) (2004), *The World's Wine Markets: Globalization at Work*, Edward Elgar, Cheltenham.

Anderson, K., Norman, D. (2006), *Compendium of Wine Statistics*, Cies, Adelaide University.

Anderson, K., Norman, D. and Wittwer, G. (2003) "Globalisation of the World's Wine Markets", *The World Economy* 26(5): 659-87.

Archibugi D. (2007), "Introduction to the Special Issue on Knowledge and Innovation in the Globalising World Wine Industry", *International Journal Of Technology and Globalisation*, Vol.3 (2-3): 125-126.

Aylward, D. K. (2003), "A Documentary of Innovation Support among New World Wine Industries", *Journal of Wine Research*, 14 (1): 31-43

Aylward, D. K. (2004) "Innovation-Export Linkages within Different Cluster Models: A Case Study from the Australian Wine Industry", *Prometheus*, Vol. 22 (4): 423-435.

Aylward, D.K. (2006) "Innovation lock-in: unlocking research and development path dependency in the Australian wine industry", *Strategic Change* 15(7-8): 361-372.

Bell M., Giuliani E. (2007), "Catching up in the global wine industry: innovation systems, cluster knowledge networks and firm-level capabilities in Italy and Chile", *International Journal of Technology and Globalisation*, Vol.3 (2/3): 19-223.

Blau, Peter M. (1977). *Inequality and Heterogeneity*. Free Press.

Borgatti S.P., Everett M.G., Freeman L.C. (2002), UCINET VI, Columbia: Analytical Technologies.

Cassi L., Morrison A., Rabellotti R., (2008), "Collaboration in wine research: An exploration of co-authorship data", Fondazione CRT: Progetto Alfieri, Torino.

Cusmano L. Morrison A and Rabellotti R, (2009), Catching up and Sectoral Systems of Innovation: A Comparative Study on the Wine Sector in Chile, Italy and South Africa. AAWE Working Paper No. 34.

European Commission (2007), *Towards a Sustainable European Wine Sector*, Brussels.

Fagiolo, G Reyes, J. A. and Schiavo, S (2008), "The World-Trade Web: Topological Properties, Dynamics, and Evolution", LEM Papers Series, Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy

Glänzel, W. and Veugelers R. (2006). **"**Science for Wine: A bibliometric assessment of wine and grape research for wine producing and consuming countries**",** *American Journal of Enology and Viticulture*, 57 (1).

Gwynne R.N. (2008), "UK Retail Concentration, Chilean Wine Producers And Value Chains". The Geographical Journal, Vol. 174 (2): 97–108.

Kastelle, T., J. Steen and P. Liesch (2005), Measuring globalisation: an evolutionary economic approach to tracking the evolution of international trade", Paper presented at the DRUID Summer Conference 2005, Copenhagen, Denmark.

Katz, J.S. and Martin, B. R. (1997), "What is research collaboration?", *Research Policy,* 26 (1): 1-18.

Kick E.L. and B.L. Davis (2001), "Networks and Economic Growth across Two Time Periods World-System Structure and Change: An Analysis of Global Networks and Economic Growth across Two Time Periods", *American Behavioral Scientist* 44 (10): 1561-1578.

Kim S., E-H SHIN (2002), "A Longitudinal Analysis of Globalization and Regionalization in International Trade: A Social Network Approach", *Social Forces* 81(2):445-468

Kline, S. J., & Rosenberg, N. (1986). An overview of innovation. In R. Landau&N. Rosenberg (Eds.), *The positive sum strategy: Harnessing technology for economic growth* (pp. 275-306). Washington, DC: National Academy Press.

Hargittai E. and M.A. Centeno (2001). "Introduction: Defining a Global Geography". *American Behavioral Scientist* 44 (10): 1545-1560.

Lagendijk, A. (2004), "Global 'Lifeworlds' versus local 'systemworlds': How Flying Winemakers produce Global Wines in Interconnected Locales", *Tijdschrift voor Economische en Sociale Geografie*, vol. 95 (5): 511-526.

Morrison A. and Rabellotti R. (2007), "The role of research in wine: the emergence of a regional research area in an Italian wine production system", *International Journal of Technology and Globalisation*, Vol. 3 (2/3): 155-178.

Smith D.A, White D.R (1992), "Structure and Dynamics of the Global Economy: Network Analysis of International Trade 1965-1980", *Social Forces* 70(4): 857-893.

Snyder, D., E. Kick. 1979. "Structural Position in the World System and Economic Growth, 1955-1970: A Multiple Network Approach." *American Journal of Sociology* 84: 1096-1123.

Taylor, P. J. (1988), "World-System Analysis and Regional Geography", *Professional Geographer* 40:259-65.

Taylor, P.J. (2004), *World city network: a global urban analysis*. London/New York: Routledge.

Unwin, T. (1991), *Wine and the Vine: A Historical Geography of Viticulture and the Wine Trade. Routledge, London.*

Wallerstein, I. (1974), *The Modern World System*. Academic Press.

Wasserman, F., and Faust, K., (1994), *Social Network Analysis.* Cambridge University Press.

Appendix

Table A1. Comparison between COMPENDIUM and NBER datasets (export data) overlapping years, 1994-1999 (average value)

Country	COMPENDIUM DATASET		NBER DATASET	
	Million of dollars (2000)	Percent	Million of dollars (2000)	Percent
AR	118,65	0,93	119,75	0,91
AT	39,92	0,31	33,91	0,26
AU	497,85	3,89	568,11	4,33
BE	92,35	0,72	65,56	0,50
BG	137,72	1,08	133,23	1,02
CA	4,60	0,04	4,02	0,03
CH	27,60	0,22	29,94	0,23
CL	360,40	2,82	404,79	3,09
DE	519,55	4,06	538,54	4,11
DK	19,09	0,15	8,55	0,07
ES	1242,12	9,72	1255,15	9,58
FR	5406,87	42,29	5467,53	41,72
GB	120,72	0,94	91,90	0,70
GR	78,43	0,61	77,66	0,59
HU	105,39	0,82	93,48	0,71
IE	1,80	0,01	3,40	0,03
IT	2387,59	18,67	2465,74	18,81
JP	1,96	0,02	3,76	0,03
NL	62,75	0,49	49,36	0,38
NZ	45,84	0,36	61,71	0,47
PT	541,20	4,23	545,47	4,16
SE	4,73	0,04	4,06	0,03
US	371,60	2,91	408,40	3,12
ZA	179,86	1,41	195,73	1,49
World	12785,37	100,00	13105,46	100,00

Table A2. Degree Centrality in the WorldWide Knowledge Network

Country	1990-94	1995-99	2000-04
AR	0	4	7
AT	1	4	8
AU	1	14	17
BE	2	5	13
BG	2	1	7
CA	7	9	12
CH	3	10	12
CL	1	6	10
DE	9	12	18
DK	0	6	8
ES	9	13	19
FR	9	18	20
GB	8	17	21
GR	1	4	11
HU	2	8	10
IE	0	5	7
IT	7	16	17
JP	8	9	11
NL	2	6	11
NZ	1	3	10
PT	4	9	15
SE	1	12	14
US	12	21	22
ZA	2	6	10

Table 1: Main features of the World Wine Trade Network

Cut-off value (millions dollar trade between countries per year)	1974		1984		1994		2004	
	1 mln	**2 mln**	**1 mln**	**2 mln**	**1 mln**	**2 mln**	**1 mln**	**2 mln**
Number of nodes								
Mean degree	4.95	3.88	6.00	4.75	8.08	6.16	9.63	7.95
St. dev degree								
Mean in-degree	4.16	3.18	4.95	4.01	5.53	4.63	6.26	6.04
Mean out-degree	5.68	5.32	5.69	5.55	6.27	6.09	6.31	6.06
Minimum in-degree	0	0	0	0	0	0	0	0
Minimum out-degree	0	0	0	0	0	0	0	0
Maximum in-degree	16	9	16	13	19	15	19	18
Maximum out-degree	17	16	17	17	20	18	20	19
Number of isolates	0	2	0	0	0	0	0	0
Density	0.21	0.16	0.26	0.20	0.35	0.26	0.41	0.34
Av. geodesic distance	1.95	1.81	1.93	2.17	1.79	1.79	1.60	1.65

Table 2: Main features of the World Wine Knowledge Network

Cut-off values (n. of co-publications between countries in a 5-yr timeframe)	1994		1999		2004	
	3	**6**	**3**	**6**	**3**	**6**
Number of nodes						
Mean degree	0.58	0.08	2.66	1.58	5.33	3.75
St. dev degree	1.17	0.28	3.30	2.50	4.58	3.85
Minimum degree	0	0	0	0	0	0
Maximum degree	4	1	12	10	17	13
Density	0.025	0.003	0.11	0.06	0.23	0.16
Number of isolates	18	22	7	13	2	6
Av. geodesic distance	--	--	1.99	2	1.84	2.1

Source: own elaboration on ISI data

Table 3: Positions of Countries in the Trade Network

	BLOCK 1 *Second tier & emerging exporters*	**BLOCK 2** *Core producers*	**BLOCK 3** *peripheral exporters and consumers*	**BLOCK 4** *core consumers*
1974	Argentina Austria Bulgaria Hungary	Chile; France Greece; Italy Portugal; Spain	Australia New Zeeland South Africa	Belgium; Canada Denmark; Germany Great Britain; Ireland Japan; Netherlands Sweden; Switzerland United States
1984	Argentina Bulgaria Chile	Austria; France Greece; Hungary Italy; Portugal Spain	Australia New Zeeland South Africa	Belgium; Canada Denmark; Germany Great Britain; Ireland Japan; Netherlands Sweden; Switzerland United States
1994	Australia Bulgaria Chile South Africa	France; Greece Hungary; Italy Portugal; Spain	Argentina New Zeeland Sweden	Austria; Belgium Canada; Denmark Germany; Great Britain Ireland; Japan Netherlands; Switzerland United States
2004	Argentina; Australia Chile; New Zeeland South Africa	Bulgaria; France Greece; Hungary Italy; Portugal Spain	Austria Denmark Germany Sweden	Belgium; Canada Great Britain; Ireland Japan; Netherlands Switzerland; United States

Table 4: Blocks' features in terms of average export and import share

	BLOCK 1 *Second tier & emerging exporters*	**BLOCK 2** *Core producers*	**BLOCK 3** *Peripheral exporters/consumers*	**BLOCK 4** *Core consumers*
1974				
Average export share	0.46	13.63	0.26	0.57
(std dev)	(0.33)	(14.20)	(0.22)	(1.25)
Average import	0.22	2.67	0.24	6.51
share (std dev)	(0.35)	(5.07)	(0.1)	(6.17)
1984				
Average export share	0.40	11.78	0.21	1
(std dev))	(0.24)	(15.09)	(0.16)	(2.58)
Average import	0.04	1.21	0.31	7.27
share (std dev)	(0.02)	(2.32)	(0.25)	(7.08)
1994				
Average export share	1.25	13.82	0.21	0.84
(std dev)	(0.85)	(18.19)	(0.16)	(1.7)
Average import	0.12	1.3	0.88	7.35
share (std dev)	(0.21)	(1.86)	(1.1)	(6.62)
Average export share	3.36	9.95	0.93	0.78
(std dev)	(3.03)	(13.87)	(1.36)	(1.29)
Average import	0.21	0.9	4.89	7.69
share (std dev)	(0.24)	(1.14)	(6.01)	(6.5)

Table 5: Countries' features in terms of position, export and import share, specialization

Country	*Blocks*				*Export Share*		*Import Share*		*Index of comparative advantage in wine (2004)*
	74	*84*	*94*	*04*	*70-74*	*00-04*	*70-74*	*00-04*	
Argentina	1	1	3	1	0.14	1.07	0.01	0.05	2.37
Australia	3	3	1	1	0.42	8.26	0.35	0.51	10.68
Austria	1	2	4	3	0.89	0.41	0.76	0.89	0.46
Belgium	4	4	4	4	0.50	0.66	6.17	5.32	0.23
Bulgaria	1	1	1	2	0.30	0.47	0.02	0.01	3.71
Canada	4	4	4	4	0.02	0.07	3.17	4.50	0.02
Chile	2	1	1	1	0.19	4.65	0.00	0.02	11.74
Denmark	4	4	4	3	0.05	0.31	1.79	2.73	0.33
France	2	2	2	2	37.21	37.58	12.31	3.18	7.27
Germany	4	4	4	3	4.40	2.97	16.40	13.72	0.30
Great Britain	4	4	4	4	0.73	0.40	15.53	19.46	0.29
Greece	2	2	2	2	1.34	0.97	0.15	0.18	2.43
Hungary	1	2	2	2	0.57	0.44	0.10	0.04	0.63
Ireland	4	4	4	4	0.02	0.01	0.49	1.13	0.002
Italy	2	2	2	2	23.70	18.10	3.11	1.58	4.82
Japan	4	4	4	4	0.08	0.01	1.01	5.20	0.000
Netherlands	4	4	4	4	0.34	0.40	4.48	5.05	0.12
New Zeeland	3	3	3	1	0.01	0.83	0.23	0.47	4.38
Portugal	2	2	2	2	8.27	3.17	0.02	0.74	7.91
South Africa	3	3	1	1	0.35	2.21	0.16	0.06	5.16
Spain	2	2	2	2	11.32	9.26	0.34	0.59	4.06
Sweden	4	4	3	3	0.01	0.03	1.63	2.12	0.00
Switzerland	4	4	4	4	0.11	0.19	6.42	4.34	0.00
United States	4	4	4	4	0.14	3.85	14.94	16.56	0.40

Table 6: Block density matrix on the trade network (1974-2004)

	1974					***1984***			
	1	*2*	*3*	*4*		*1*	*2*	*3*	*4*
BLOCK 1	**0.016**	0.004	0.002	**0.020**		**0.058**	0.000	0.000	0.011
BLOCK 2	0.012	**0.032**	0.014	**0.074**		0.005	**0.029**	0.012	**0.065**
BLOCK 3	0.000	0.000	**0.038**	0.012		0.000	0.000	**0.054**	0.008
BLOCK 4	0.001	0.001	0.004	**0.016**		0.000	0.001	0.004	**0.018**
	1994					**2004**			
	1	*2*	*3*	*4*		*1*	*2*	*3*	*4*
BLOCK 1	0.001	0.001	**0.046**	**0.023**		**0.028**	0.003	0.021	**0.047**
BLOCK 2	0.009	**0.045**	**0.018**	**0.071**		0.005	**0.032**	**0.060**	**0.055**
BLOCK 3	0.007	0.001	0.007	0.011		0.002	0.006	**0.043**	0.014
BLOCK 4	0.001	0.005	0.006	**0.017**		0.004	0.007	0.005	**0.023**

Note: density value higher than the average density are reported in bold

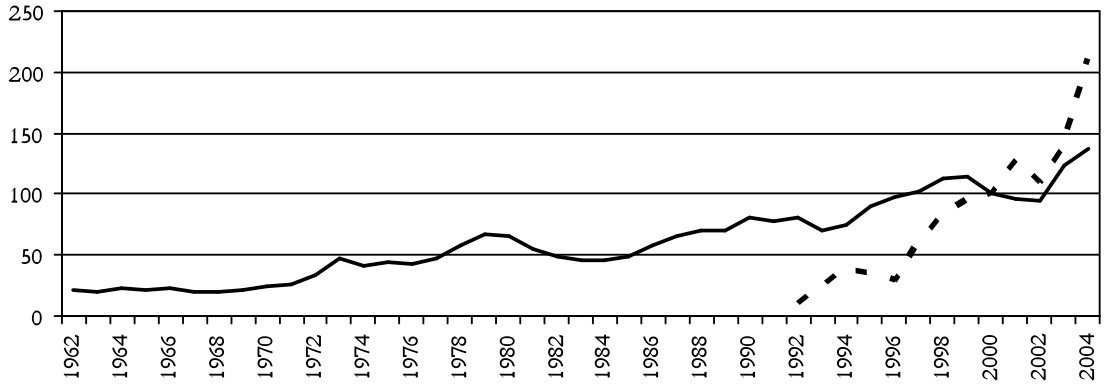
Table 7: Block density matrix of the knowledge network (1994-2004)

	BLOCK 1 *Second tier & emerging exporters*	BLOCK 2 *Core producers*	BLOCK 3 *Peripheral exporters consumers*	BLOCK 4 *Core consumers*
1994				
BLOCK 1	0.000			
BLOCK 2	0.002	0.006		
BLOCK 3	0.000	**0.009**	**0.011**	
BLOCK 4	0.003	**0.016**	0.007	**0.008**
	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4
1999				
BLOCK 1	0.009			
BLOCK 2	0.006	**0.013**		
BLOCK 3	0.005	0.008	**0.017**	
BLOCK 4	0.009	**0.011**	**0.015**	**0.014**
	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4
2004				
BLOCK 1	0.0135			
BLOCK 2	0.0057	**0.0193**		
BLOCK 3	0.0066	0.0129	**0.0223**	
BLOCK 4	**0.0173**	**0.0157**	**0.0177**	0.0113

Note: the block partitioning is based on the block modelling on the 2004 trade network.

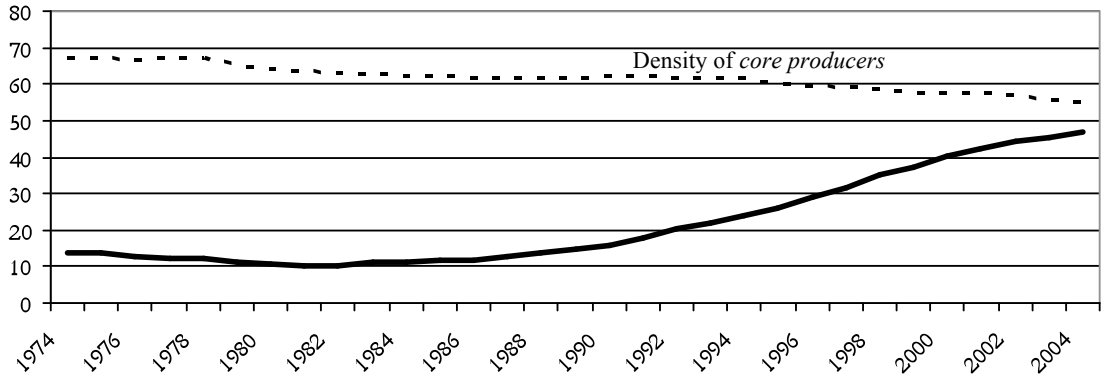
Density values higher than average are reported in bold.

Figure 1: Total amount of worldwide export (continuous line) in constant currency (2000), and total number of international scientific collaboration (dashed line), 2000=100



Source: own elaboration on NBER-COMPENDIUM and ISI data.

Figure 2: Inter-blocks density over time



Note: density (X 1000) of Block 1 towards Block 4 (continuous line) versus density of Block 2 towards Block 4 (dashed line). The block partitioning is based on the block modelling on the 2004 trade network.