Environmental Performance in the Leather Supply-Chain: The Role of Inter-organizational Networks

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ABSTRACT

This paper presents partial results of a broader research program called "Cicle Pell: Industrial ecology in the animal-to-leather chain", funded by the EU in the framework of the Community Programme "Interreg III C", Regional Framework Operation "Ecosind". The goal of the Cicle Pell project was defining the basis to implement a new strategy of industrial sustainable development in Southern European regions, through the identification of economic and environmental improvements achievable by companies in the leather industry and the related supply-chain by applying the industrial ecology principles and tools. The research we report here addresses three critical issues. First, we identify inter-organizational relationships among firms and other institutions inside the sector, giving a description of various forms of cooperative environmental agreements among firms in the slaughtering and leather tanning districts. Second, we investigate - with the support of social network analysis - the peculiar characteristics of the network structure inside the industry. And third, we investigate in a comparative manner the level of association between inter-organizational network structures and environmental performance at the organizational level.

Keywords: leather supply-chain, inter-organizational networks, environmental performance

Introduction

In the context of the EC-funded "Regional Framework Operation" ECOSIND, the research project "Cicle Pell: Industrial ecology in the animal-to-leather chain", was carried out, with the overall aim of identifying some improvements in the bovine leather supply-chain based on industrial ecology principles. Among the specific tasks of Cicle Pell was the analysis of the existing co-operation, if any, among organisations in the sectors being investigated, with a particular focus on environmental cooperation [1] [2]. To this aim we analyzed inter-organizational networks of both slaughtering and leather tanning industries in four different regional areas of two European countries: Spain and Italy. In more details, we identified the existing inter-organizational relationships among firms and other institutions inside the sector, as well as the nature and the frequency of such relations, to compare networks in order to identify major similarities or heterogeneous aspects among the different regions, and to investigate the occurrence of environmentally-aimed cooperative links. The present paper is structured as follows. We start with a brief description of the leather supply-chain, discussing about the importance of inter-organizational relationships in this sector. We then present the social network analysis methodology and the main results obtained from our survey. Finally, a brief discussion concludes the paper.

Background

The animal-to-leather supply-chain includes a variety of processes of different technological complexity, where relatively large amount of water, energy and chemical substances are generally used and significant amounts of wastes and by-products are generated. This may raise serious environmental and health problems for present-day slaughterhouses and tanneries, as well as it may cause a poorly efficient resource exploitation. On the other hand, such industries are increasingly kept under pressure by stricter regulation and more and more severe limitations have led companies, especially in the tanning industry, to look for new methods for minimising the release of waste materials and pollutants [2].

In particular, in the regional districts investigated we observe several factors of complexity for the animal-to-leather supply-chain. On the one hand, leather tanning firms import the raw material (hide or skin) from different origins (Asia, Africa, etc.), have strong competitors in less developed countries with law salaries and less

environmental constraints (like China or South America), and the environmental costs have an important effect on the leather final price. This activity has a long history in Italy and Spain, and most factories are small, and sometimes poorly technologically advanced. On the other hand, slaughter-houses don't have competitors in other countries, but they usually compete to each other. The environmental costs in this last case might be important, but the price of the final product appears not to be greatly affected. For these companies, changes in management possibilities for this kind waste and by-product have recently been and could be further introduced in the future. The factories are small and medium size (in Abruzzo most of them are very small).

In complex and turbulent environments, organizations frequently develop formal or informal relationships in order to work together to pursue goals, address common concerns, and/or attain mutually beneficial ends. In recent years, such inter-organizational collaboration has become a prominent aspect of the functioning of many different types of organizations. The number and significance of collaborative forms of organizing, including inter-organizational teams, partnerships, alliances, and networks, have increased tremendously. The value of effective collaborative relationships as well as the complexities and challenges they present have been recognized by many researchers [3] [4] [5], and they continue to be a frequent subject of scholarly and practitioner-oriented literature.

In the present paper, the term network is used to describe multiple-organizational relations involving multiple nodes of interactions. A network is a group of individuals or organizations, who, on a compelling or voluntary basis, exchange information and undertake joint activities and who organize themselves in such a way that their individual autonomy remains intact. A particular interesting type of network involves complex production relationships that benefit from being able to form and dissolve quickly. The participants therefore wish to protect themselves against opportunistic exploitation by their partners without having to suffer the delays and costs of formal contracting [3]. This means that there is some element of trust in the relationship.

Social network analysis provides tools and concepts for analyzing organizations as networks [6]. In the present study, we apply network analytical tools to analyze interorganizational cooperative ties between companies in the animal-to-leather supply-chain, with the objective of identifying the way in which the single node collaborate with others and for the functioning of the entire network.

Methodology

The study of the inter-organizational network is carried out by using the Social Network Analysis (Sna) methodology. Sna represents a method of collecting and analyzing data from multiple individuals or organizations that may be interacting with one another. In social networks, each actor (node) represents a person or social group, and each tie or edge represents the presence or absence, or strength of a relationship between the actors [6].

Network data refers to contacts, ties, connections, memberships and encounters matches that determine a relationship between an actor and another actor inside the network [7]. Network research focuses on relations and the patterns of relations rather than on attributes of actors. Depending on the purposes of the analysis and on the type of data collected, it is possible to examine, for instance, the number of actor to which one actor is linked, the total number of links in the network, the type of interactions among network members, the level of the relationships, and the extent or strength of each relationship. Analysis can be conducted using various software packages, the most common of which is UCINET [8].

In this paper, we use one-mode format to represent the inter-organizational network [6]. Following this basic representation of network structure, once they have been collected, the relational data are stored in the so-called "who-by-whom" matrix, or adjacency matrix, in which each actor appears twice, once in the rows and once in the columns of the matrix itself. The presence and the absence of a connection are respectively represented by values 1 or 0 in the relevant intersection cells of the matrix. In order to increase the analysis' information capacity, it is also possible to include the tie's frequency or the exchange frequency of the exchange relationship between two or more actors.

What can be done with these relational data once they are arranged in matrices? In the case of one-mode network data, an almost unlimited range of analytical techniques can be employed for both the individual network of an actor and the entire network structure. At the individual level, a first and very important concept of Sna is that of an actor's centrality within a network. An actor is locally central if it has a great number of ties with the other points of his surrounding environment, and it is globally central if it has an important strategic position in the overall structure of the network [6]. In this study, we analyze the main relational indicators aimed to define the strategic position and the preeminence of the nodes within a network.

To describe the entire structure of the network other quantitative measures can be employed (for a review, please see [6]). The following qualitative and quantitative characteristics of networks were investigated in our study:

the network size, the density, the cohesion and centralization. We analyzed all network data by using the UCINET 6 social network analysis program [9].

Data collection

In our research we drew up a sociometric questionnaire for single organizations within slaughtering and leather tanning industries. The questionnaire was comprised of 4 main sections:

- Section 1: general information of the company (name of the company, address, number of employees, annual sales in Euros, details about entrepreneurial activity);
- Section 2: information about presence/absence of collaborative ties among companies of a given industry localized in a specific geographical district;
- Section 3: information about the frequency of collaboration established among companies of a given industry localized in a specific geographical district;
- Section 4: information about other generic commercial and industrial types of links with other companies localized in a specific geographical district.

In particular, in Sections 2-4, single organizations were asked to give answer to several questions like the following: "With whom do you cooperate to get your work done?, With whom do you cooperate in order to respect environmental laws and rules?". The method was nominative, with a limited possibility of choice in the order of preference. This possibility of choice was limited to those actors localized in the same geographical area of that of respondents.

Network data consist of a square array of measurements. The rows of the array are the cases, or subjects, or observations. The columns of the array are - and note the key difference from conventional data - the same set of cases, subjects, or observations. In the present study, rows and columns represent single organizations involved in both slaughtering and leather tanning industries. Each cell of the array describes a relationship between the actors. In particular, we surveyed the following actors: slaughter-houses in the slaughtering industry; tanneries in the leather tanning sector; other actors directly tied to tanneries and slaughter-houses.

Among these actors, we were interested to investigate about three main types of relations, namely relations for cooperation, relations for environmental cooperation, and other commercial or industrial relations (with providers, customers, etc).

Overall, our analysis refers to two main tanning districts in Italy, i.e. Santa Croce sull'Arno (Tuscany), and Arzignano (Veneto), and to the Spanish district of Igualada (Catalonia), as well as to the slaughtering industry in the Abruzzo region.

We also use data on environmental performance in order to investigate the level of association between inter-organizational network structures and environmental performance at the firm level of analysis. We have temporarily limited this analysis to 23 slaughterhouses of the Abruzzo Region.

Analysis and Results

Our first goal was to give a description of the inter-organizational networks in the leather supply-chain at the regional level. We analyzed four matrices that respectively measure the overall number of cooperative relations among single organizations located in the above mentioned regions. The network measures showed in Table 1 sum up the main characteristics of the network structures across regions and sectors.

Table 1: Main characteristics of inter-organizational networks

Country	Italy			Spain
Region	Abruzzo	Tuscany	Veneto	Igualada
Size (n. nodes)	126	36	70	76
Density (%)	2.29	11.27	2.94	5.84
Centralization (%)	9.06	31.89	-	40.76
No. of Components	1	1	3	1
r Pearson Degree/Mean distance(km)	0.42	0.12	0.56	0.22

It must be noted a high level of variation that characterizes the dimension of networks: the network formed by the highest number of actors was found in Abruzzo (n=126), while the smallest network dimension was that of Tuscany (n=36). However, at least part of such differences could reflect the difference rate of response obtained.

Other normalized measures can be used to make a general comparison among networks. A first important measure is represented by the density of a network.

The density of a network is defined as the number of lines in a network divided by the maximum number of all possible lines, and it may give us insights into phenomena such as the speed at which information diffuses among the nodes, and the extent to which actors have high levels of social capital and/or social constraint. The network of Abruzzo, in spite of its dimension, is really sparse with the lowest density score (2.3%). This means that among the maximum number of all possible lines, only 2.3% of lines are present in the network. A quite similar result characterizes the interfirm network in Veneto. The networks of Igualada and Tuscany are on the contrary more dense with a density score of 5.84% and 11.27%, respectively.

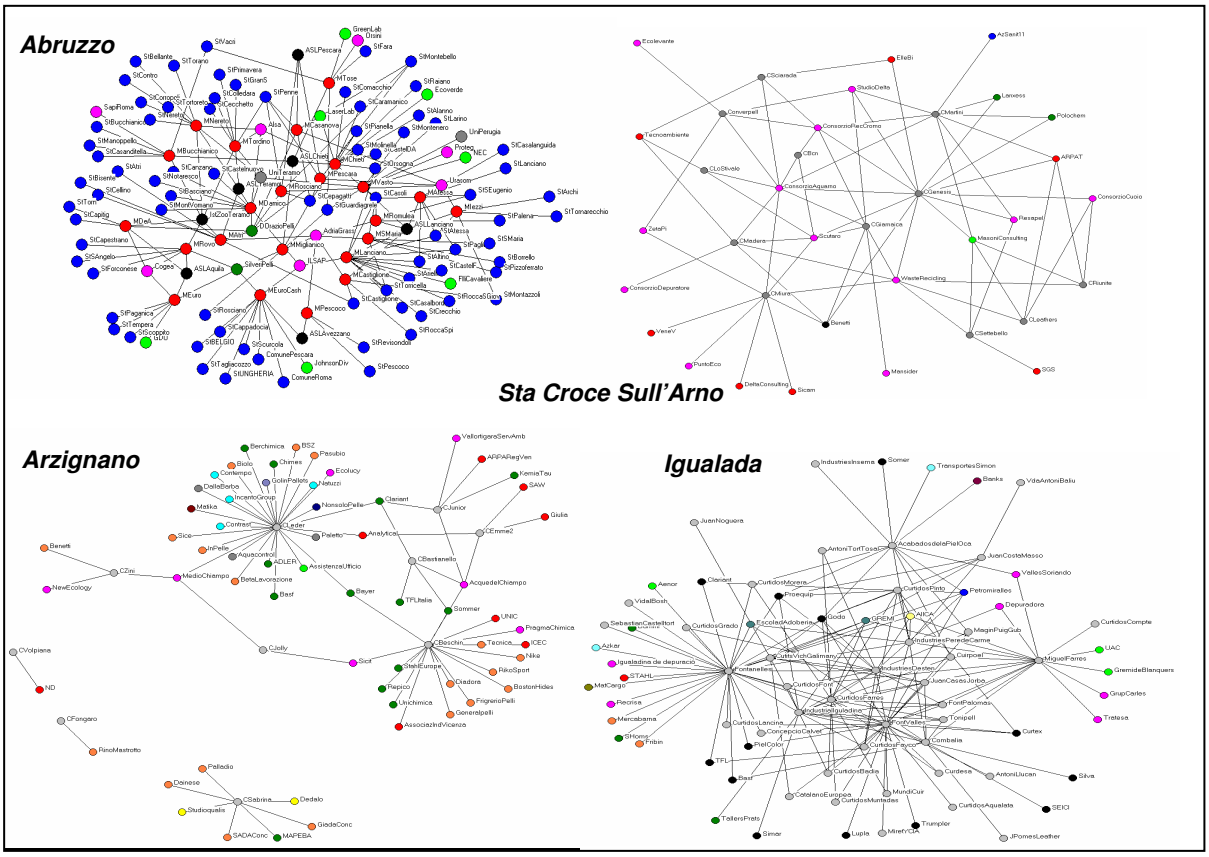

Figure 1: Network visualization of collaborative relationships in the leather supply-chain in four regions

Another important characteristics to investigate relates to the centralization of networks. Network centralization measures the degree to which an entire network is focused around a few central nodes. In other words, it represents an indicator of global centrality. The highest centralization index refers to the network of Igualada (~ 40%), followed by those of Tuscany (31%) and Abruzzo (9%). This means that in the first network, more that in the others, a large number of interfirm ties are grouped around a small number of actors. An important remark here relates to the network structure of the leather tanning industry in the Veneto region. In this case, the index considering centralization could not be computed since the graph is disconnected (Wassermand and Faust, 1994). We remind that a graph (i.e. a network) is called connected if every pair of vertices in the graph is connected. In an undirected graph, two vertices A and B are called connected if the graph contains a path from A to B. Otherwise, they are called disconnected. In Veneto the network structure shows the presence of three different components which represent three different groups of nodes not directly or indirectly connected. Overall, this shows a higher level of fragmentation – that means in general a lower level of cohesion - for the interfirm network of Veneto in comparison with networks of the other regions, which in turn are composed by one single component.

Finally, we considered a general measure that considers the level of correlation among the network degree of nodes and the mean distance (in kilometers) from each nodes surveyed and their alters. Network degree represents the number of nodes adjacent to a given actor in a graph, and that it is a widely used to measure actor centrality. This index could be seen as a general measure of the existing association between centrality of nodes in the network and their geographical distance from other nodes. In all regions investigated there are low levels

of correlation. In particular, the highest correlation was found for the nodes representing the network of Veneto (r = 0,56), while the lowest level was found in Tuscany (r = 0.12). Overall, such results suggest that the fact that nodes are more central inside their own industries does not reflect their geographical closeness to other nodes. Probably, other factors can better explain the reason why certain actors appears to be more central. The investigation of those specific characteristics of the most central actors highlighted in the previous analysis will help to shed light upon those factors that effectively influence actor centrality inside the network.
Our descriptive analysis , surveyed inter-organizational networks show large differences not only with reference to the different countries of investigation, but also across the different regions. In particular, across the three Italian regions here considered (Abruzzo, Veneto and Tuscany) we found the greatest differences for what concerns dimension, density, centralization and cohesion of the network.
Other than through a mathematical approach, social network analysis allows a graphical investigation of networks. Figure 1 shows four different sociograms that are graphic representations of the relationships representing environmental collaborative ties between organizations within the leather supply-chain. The network visualization for this figure is performed using NetDraw 1.0 as implemented in UCINET 6 software [9]. Overall, the sociogram graphically points out the various companies (nodes) and the existing collaborative ties between the various nodes of the network (relations). Besides describing the collaborative relations between the various structures, the figure also highlights the existence of particularly central nodes that stand out for the number of relations carried out within the network. At the same time, it is possible to single out several organizations characterised by a low number of ties with the other nodes. The observation of the picture explicates quite well the above mentioned differences of the four networks for what concern size, density, centralization, and number of components.

Table 2: Regression Coefficients: Equation to Predict of Environmental Performance^

Variables	2	3	4
Intercept	2.217**	1.212	0.882
Employees (n.)	0.934	-0.301	0.167
Volume of activity	-0.064	-0.331**	0.221
Network variables			
Degree (centrality)	-0.134	0.026	0.017
Betweenness (centrality)	0.173	-0.707	0.211
Eigenvector (centrality)	0.130	0.008	0.000
Density	0.638***	0.441	0.512**

^ Reference category is adoption of technologies of category "1"; ** denotes significance to 0.01, *** denotes significance to 0.05; N=23; Likelihood score = 498.3926

2) Relationship between the degree of cooperation of a network and its environmental performance

Our second goal of the analysis was to investigate about the relationship among network variables and environmental performance at the organizational level. We included in this analysis 23 slaughterhouses of the Abruzzo Region. We identified four different categories of technology used by slaughterhouses in their production cycle. The adoption of one of these different categories was used as dependent variable in our model[1]. The model also includes four different network variables, three measuring centrality and one that relates to density, and two attribute variables, i.e. the number of employees and the volume of activity performed in 2005. We used a multinomial logit regression to analyze such data.
The data show (Table 2) there are no differences among the categories representing the environmental performance regarding the centrality network indicators and number of employees. However, we find that the categories differ on density and volume of activity. Slaughterhouses adopting technologies of categories "2" and "4" tend to have a more dense network while slaughterhouses pertaining to category "3" are likely to have higher volumes of activity. There are no significant differences among the categories regarding network centrality indicators.

Conclusion

This report shows the results of a social network analysis relating to interfirm ties established among organizations involved in the slaughtering sector and in the leather tanning industry. In particular, the network structure within the slaughtering sector was investigated in Abruzzo, while those of the leather tanning industry refers to the two Italian districts of Tuscany and Veneto, as well as within the Spanish district of Igualada.

[1] A detailed description of such categories is available from the authors upon request.

Our findings give a first picture about the way in which firms involved in the animal-to-leather supply-chain establish interorganizational collaborative ties to cope with peculiar complexity of this sector. By using several network indicators, we highlighted the existing differences among the network structures of companies among different regional districts. Furthermore, we investigated whether the network structure –measure in terms of centrality and density- could have an impact on single firms' environmental performance. Our results shows that, among the variables investigated, only network density could significantly explain the adoption of the most advanced environmental technologies from slaughterhouses. However this is a preliminary survey, especially for what relates the limited number of observations included in the regression analysis conducted. In this direction, much efforts are also required in order to get the most suitable variable(s) for the environmental performance. Further works will be done in this area.

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