70 A PROCEDURE FOR THE ANALYSIS OF INDUSTRIAL NETWORKS

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This paper gives a presentation of a procedure for the analysis of industrial networks. An appropriate meta-model, specifically dedicated to SME networks, is introduced to describe the interactions among firms. The importance of considering both scientific studies and real industrial systems to make a proper analysis of a network is put in evidence, introducing two significant investigation tools. After a description of a logical arrangement of available information, a procedure useful to fully analyse an industrial network, using both data/information from existing SME networks and technical/scientific reports, is presented.

1 INTRODUCTION

Industrial networks and clusters of Small and Medium Enterprises (SME) represent the European way of aggregating enterprises to compete in a worldwide business market, leaving at the same time autonomy to each SME (Albino and Kuhtz, 2004; Picard and Toulemonde, 2003; Rosenfeld, 1995; Verwaal and Hesselmans, 2004).

Many theoretical contributions have conceptualized the distinctive features of these forms of industrial development, based on affiliation of small and medium sized firms in geographically delimited areas. Firms located in regional industry clusters (called also industrial districts, ID) are generally characterized by some distinctive features: (i) within the district there is a division of labor among firms, which promotes high levels of flexibility and productivity; (ii) high degree of specialization in one or few complementary industries; (iii) horizontal competition and vertical cooperation: the spatial concentration and strong complementarities among different units turn competition into a connective force among agents; (iv) a distinctive milieu that includes the local institutional infrastructure; (v) common marketing strategies.

The academic literature on the performance of ID has been mostly either of qualitative nature or too specific (not looking at the network as a whole).

Some papers concern the comparison of the performances of firms with respect to their belonging to a district. Signorini (1994) compares the financial and economic ratios of some firms belonging to the district of Prato to the average of woolen cloth manufacturers located outside the province. Fabiani and Pellegrini (1998) analyze the profitability and productivity ratios of firms belonging to IDs in comparison with a control sample of similar firms. These and other studies (Molina-Morales, 2001) confirm the hypothesis of positive externalities for SMEs belonging to IDs (in terms of ROE, ROI, etc.), but they are mainly concerning ID performance from economic point of view.

ID performance must not be restricted to economic and financial perspective; an industrial district, in fact, is defined as "a socio-territorial entity, characterized by the active co-presence of a community of people and a population of industrial firms" (Becattini, 1990). This is the reason for which it is necessary to consider also the performance of an ID from the social viewpoint, in order to better understand the influence that the district has on the population into which it is immersed and to comprehend the effects on social's welfare. Paniccia (1999) analyses these concepts in her research, focusing on the interactions between the performance of IDs and population's welfare.

Another component it is necessary to take into account is the governance. A comprehensive review of different roles that governance should have in an ID is presented in Alberti (2001). Albino *et al.* (1999) investigate the relationship between the number of leading firms in IDs and the quantity of information shared. Lin *et al.* (2005) examine the relationships between supply chain features and organizational performances, on a qualitative point of view.

Regarding the operational structure component, a wide literature on Supply Chain performance analysis exists (Akif *et al.*, 2005; Abu-Suleiman *et al.*, 2005; Klejinen and Smits, 2003). Furthermore, some ascertained tools can be used, as an example the SCOR model (Supply Chain Council, 2006) or the Balanced Scorecard (Kaplan and Norton, 1992; Kaplan and Norton, 1993; Kaplan and Norton, 1996; Brewer and Speh, 2000). The difficulty of applying these tools to IDs consists in the lack of 'aggregated' KPIs, as those usually disposable from IDs.

In the last years the majority of SME clusters faced a significant reorganization. Among the possible reasons for their crisis there is the lack of investments in innovation, due to the lack of an effective governing board able to boost innovation to SMEs. Except for some cases, industrial clusters have not been able to evolve into "networks". These issues might originate in the problem that SMEs do not know how to operate and effectively manage in a "network of SMEs".

In this context, the Coordination Action CODESNET (CA project n° IST-2002-506673, http://www.codesnet.polito.it) was born with the goal of giving an organization and interpretation of data and information collected from the industrial systems of European countries and concerning networks of enterprises for the sake of improving the ID knowledge about network management.

2 A META-MODEL FOR ANALYSIS OF INDUSTRIAL NETWORKS

In order to give a formulation useful for network analysis and evaluation, a conceptual model of a DESNET (DEmand and Supply NETwork) can be stated in terms of a graph of partially autonomous firms, that means firms which agree to be collaborative together, to have a high rate of reciprocal transactions concerning components and products, to share information and common services, to define together common industrial strategies (as in case of joint projects to search for a new market, to develop either a new technology or a new product, and to organize new logistic services).

In formal terms, a *meta-model* of a DESNET has been proposed (Villa, 2006), where the term 'meta-model' means a model integrating the most important components of a SME network, connected by the critical links and interactions. The meta-model of a DESNET contains the following components (see Figure 1):

1. an **Operation Structure** (OS), representing the graph of the logistic connections among the firms. It refers to the graph of interactions linking the enterprises together, through flows of parts, information & controls, money; each node of this graph is an autonomous enterprise, and plays the role an of individual decision-maker (DM) but included into a group of companion DMs;
2. an **Organization Arrangement** (OA), describing the management architecture which drives the DESNET behavior (i.e., the DESNET governance), and the information pattern which links the firms together;
3. the **Interactions with the Socio-Economic Environment** (ISEE) within which the DESNET operates, that means the interactions with the markets of materials and products, and with the financial market and the labor market. In principle, its scope is to make as strong as possible the presence of the industrial network in the markets of final products, labor, finance, etc..

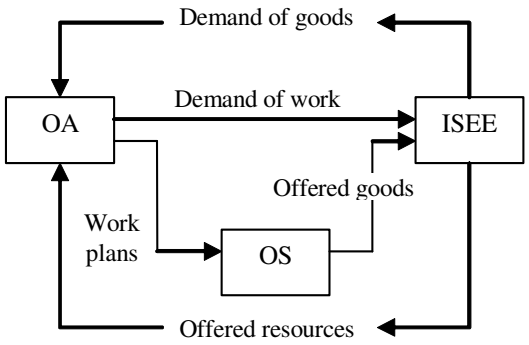

Figure 1 – The conceptual model of a DESNET

To make the above described meta-model an analysis tool, each component must be formally described by specific models, either descriptive or prescriptive.

3 COLLECTED DATA FOR THE ANALYSIS

A useful representation of each meta-model component can be obtained by considering qualitative and quantitative descriptions of existing SME networks, by collecting public data and information on their main features and characteristics, and then by using these data/information representations as examples for an analysis based on comparisons among the several industrial bodies. In the CODESNET approach, since the scope is to offer information both to industrial people and to university researchers, the descriptions of the components must be stated in a standardized form, which must summarize the most important analysis drivers and performance indicators. Two standardized formats represent a way for a conceptual organization of data and information. They have been called V-LIB and V-LAB:

- **V-LIB** (Virtual Library): scientific reports and papers presenting networks' models and discussing problems of network design and management;

- **V-LAB** (Virtual Laboratory): descriptions of existing SME networks, each one presenting a strong characteristic in either the OS, OA, or ISEE.

Each component of the meta-model has been detailed in three main issues that represent some questions that need an answer in order to give a complete and useful description of the ID. This set of typical main issues, concerning SME network management or evaluation, is selected and used as key-driver in the search within the data archive and the model catalogue. Each main issue plays also the role of "analysis viewpoint" for an industrial user.

The main issues representatives of the meta-model have a central role in the interaction of V-LIB with V-LAB and vice versa. Their central position is evident looking at Table 1.

Depending on which main qualifying attributes of the analyzed enterprise network are recognized in the V-LAB format, either proper models (for network simulation, design or performance evaluation) or methods (for network management) or procedures (for network innovation and skill improvement) can be found in some catalogued scientific papers, summarized in V-LIB formats.

Among all V-LIB and V-LAB documents available on CODESNET web portal, a subset of particularly interesting and useful papers has been selected and analyzed. The selection has been done on the strength of the importance and the completeness of information and data available on the documents.

Table 2 and Table 3 show a conceptual organization of the information collected in the V-LIB and V-LAB formats, respectively.

In Table 2, for each selected V-LIB, the numbered Main Issues identified in the scientific paper are described. In the fourth column the type of paper content is specified; the notation introduced is (A) for algorithms and methods, (B) for case study, (C) for survey. In the other columns, the most relevant topics approached in the paper are specified and the related V-LABs are listed.

From the other side, it is also important to have a reverse procedure to connect enterprises networks to one or more papers described through the V-LIB. This reverse path is shown in Table 3, where the list of the selected V-LAB formats is shown. Each V-LAB is associated to one or more CODESNET Main Issues and is summarized by its most qualifying attributes.

These two tables describe the connections between V-LAB and V-LIB lists, which are proposed to the end user when analyzing elements of either the Virtual Laboratory or the Virtual Library. This work has required a logical procedure, which will be explained in Sections 4 and 5 in order to facilitate the understanding and the analysis.

Table 1 – V-LIB and V-LAB correspondence with CODESNET main issues

V-LAB Main attributes of an enterprise network	CODESNET **Main issues**		**V-LIB** Main topics
a. Type b. Logistics	OS	1. how production operations & volumes are distributed among the enterprises	I. Model
		2. which different skills are employed in the different enterprises	
		3. which logistic network is used	
c. Leading firms d. Governance	OA	4. how management responsibilities are attributed to each enterprise and how information are transferred & managed	II. Organizational chart
		5. how internal agreements, or control mechanisms, are negotiated	
		6. which organization chart or coordination strategy is selected to assure best efficiency/effectiveness	
e. Personnel skill level f. Innovation programs	ISEE	7. how commercial agreements with external bodies are negotiated for max profit for the network	III. Skill competence profile IV. Innovation plans
		8. how a network innovation program is decided by partners (and negotiated with financiers)	
		9. which dynamic evolution of the network can be forecast	

4 LINKING V-LIBS AND V-LABS

In order to obtain an accurate association between V-LIBs and V-LABs, a preliminary analysis and classification of V-LIBs is useful. This V-LIBs evaluation is performed according to the informative levels summarized in Figure 2:

1. identifying the main issues among the nine questions;
2. analyzing the paper content, understanding which features the paper discusses;
3. evaluating the completeness and usefulness of information and of data;
4. if they are adequate, the V-LIB can be inserted in the data base; otherwise, the considered V-LIB has to be improved.

Table 2 – Selected list of V-LIB formats, with the most relevant topics

					Most relevant TOPICS				
#	Selected V-LIB list	Authors	Main Issue	Type of paper	I. model	II. Organiz. chart	III. Skill competence profile	IV. Innovation plans	Related V-LAB
9	Collaborative networks: a new scientific discipline	Camarinha-Matos L. M., Afsarmanesh H.	4 , 6	C		X			7, 8, 29, 35
12	Competence Profiling and Problem Solving in Virtual Networks	Edelmann C., Wagner K.	2	C			X		7, 9, 29, 38, 53, 54
13	Constructing a typology for networks of firms based on activities complementarity and competences similarity	Burlat P., Besombes B., Deslandres V.	1	B			X		29, 37, 38, 50, 53, 54
32	Framework for outsourcing manufacturing: strategic and operational implications	Momme J.	5 , 7	A	X				13, 34
33	A framework for comparing outsourcing strategies in multi-layered supply chains	Abdel-Malek L., Kullpattaranitun T.	5 , 7	A	X				13, 34, 66, 68

Table 3 – Selected list of V-LAB formats, with the most qualifying attributes

			Most qualifying attributes						
#	selected V-LAB list	Main Issue	(a) Type	(b) Logistics	(c) Leading firms	(d) Governance	(e) Personnel skill level	(f) Innovation programs	Related V-LIB
7	District 21 - Suzzara	2, 6, 8	2-stage SC 3500 SMEs			Political committee	skills in steeling and manufacturing activities	collaboration with universities	9, 12, 34, 35, 36, 53, 72
13	Automotive District Stuttgart	5, 7, 8	multi-agent	outsourcing	2-3 leading firm (OEM)				16, 32, 33, 52, 56, 96
34	Shoes District of Verona	1, 5, 8, 9	Flexible SC, 524 SMEs	outsourcing		Support agency		collaboration with res. centre, R&D	32, 33, 36, 69, 72, 81
35	BIO cluster district – Bioindustry Park	4, 6, 8, 9	Scientific park 344 companies			Regional system integrator	importance of high competence, skills	innovation	4, 9, 36, 65, 72, 76, 103, 107
37	Evonet	1, 2, 8	flexible SC 6 SMEs			managerial center	different skills in mechanical engineering		13, 20, 27, 34, 48, 69, 70, 76, 77, 96

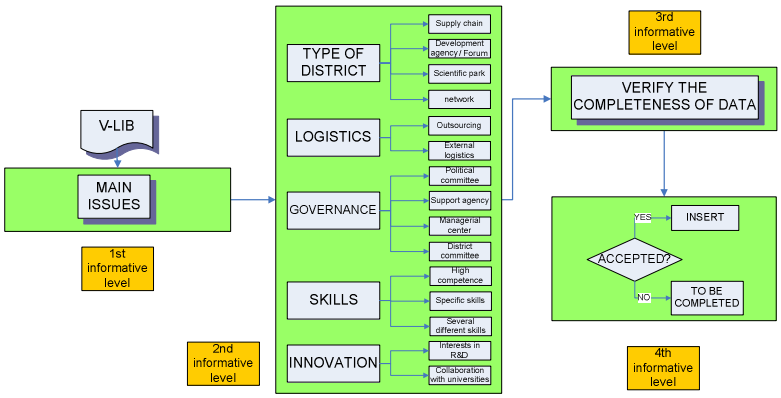

Figure 2 – Steps necessary for V-LIB classification

The most qualifying attributes of each industrial network have been extracted from each selected V-LAB (Table 3). From this information, it is possible to understand the characterizing features of each district. Combining together Tables 2 and 3, it is possible to find for each industrial network its related V-LIBs, looking at the weak and strong points of the district, and associating them proper articles included in the list of the selected V-LIBs.

This association is performed in three steps: 1) consider only the V-LIBs belonging to the main V-LAB issues; 2) among the filtered list of V-LIBs, search for scientific papers having appropriate topics, according to the V-LIB classification; 3) analyze the content of each paper to verify the association.

Let us consider, for instance, the Shoes District of Verona (V-LAB n. 34). It is a flexible supply chain, composed by 524 SMEs. From the logistic point of view, outsourcing is used for the management of the distribution. Coordination is assured by a support agency. There is a relevant cooperation with Universities and other research centers; so, an interest in R&D comes out from this information. The main issues associated to this district are the categories 1, 5, 8 and 9.

The first step for the association consists in filtering V-LIBs, using the four categories the V-LAB belongs to. Among this filtered list, look for scientific papers with appropriate topics. In the Shoes District case, its V-LAB shows as interesting topics: “Model”, “Organizational Chart” and “Innovation Plans”. Regarding the V-LIB classification, it is necessary to look for papers that relate to: supply chain, outsourcing, support agency, interests in R&D and collaboration with universities. From the list of V-LIBs belonging to the main issues 1, 5, 8, 9 and concerning these topics, some appropriate papers are associated to the Shoes District. Particularly (for the complete list of V-LIBs, see http://www.codesnet.polito.it):

V-LIB n. 32–33: concerning outsourcing;
V-LIB n. 36–81: concerning R&D and innovation;
V-LIB n. 69–72: about coordination and collaboration in a supply chain.

5 CONCLUSIONS

This study provides a logical procedure useful to arrange the available information on industrial networks and to facilitate the integration between actual industrial systems and scientific studies.

Even though the data collected within CODESNET Project are constrained to be public (in order to allow their open diffusion through Internet), their analysis could produce useful suggestions. As a matter of fact, the outcome of this approach could be a starting point for the performance evaluation of IDs management and for benchmark identification.

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