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Collaboration is considered an effective solution to improve business strategies. However, SMEs often lack common principles and common forms of contractual coordination. Several policies implemented by E.U. have addressed the setup of a comprehensive SME policy framework, but European institutions seem to have focused more on organizational devices to conduct business activities rather than on contractual forms of coordination. In April 2009, Italy adopted a law in network contract to promote the development of inter-firm cooperation strategies to foster enterprises' innovation and growth. Even if this law represents a novelty in Europe and may offer new challenges and hints, it still presents some lacks in its formulation. The current research aims at presenting the Italian law for network contract and an comparison with other model of SME aggregations adopted in EU countries. A formal model to support the design of a SME network was proposed, by providing both an ontology-based model to help the definition of the contract in a structured way, and a basic workflow to identify the important phases of the network design, i.e., the feasibility study and the negotiation.

Keywords: SME aggregation, network contract, ontology, UML

1. Introduction

A lot of literature is available on the analysis of industrial networks (Antonelli et al. 2007, Bennett et al. 2009, Michaelidesa et al. 2012, Renna 2012). Individually, SMEs are often unable to capture market opportunities which require large production quantities and homogenous standards, and they experience difficulties in achieving economies of scale in the purchase of inputs, such as equipment, raw materials, finance, consulting services, etc. (Ceglie and Dini 1999). Through networking, individual SMEs can address the problems related to their size and improve their competitive position. Through horizontal cooperation (i.e. with other SMEs occupying the same position in the value chain), enterprises can collectively achieve scale economies and pool together their production capacities to satisfy large-scale orders. Through vertical cooperation (with other SMEs as well as with large-scale enterprises along the value chain), enterprises can specialize on their core business and give way to an external division of labour.

Collaboration represents an increasing tendency among small and medium enterprises (SMEs) and is considered an effective solution allowing the achievement of development strategies, either to improve production processes or to increase competitiveness based on innovation and quality (Villa 2002, Ferrari 2010). SMEs are the engine of the European economy, being the 99% of all European businesses, and have been the target of several policies implemented by E.U. institutions (Matt and Ohlhausen 2011). For example the "Small Business Act" adopted in June 2008, for the first time puts into place a comprehensive SME policy framework for the E.U. Member States (Borbas 2009). However, European institutions seem to have focused more on organizational devices to conduct business activities rather than on contractual forms of coordination. The absence of common contractual coordination forms and of common principles of European contract law could negatively affect the functioning of markets and hamper SMEs' growth (Ferrari 2010).

In Italy, a recent law defined the "business network contracts" to point out the strategic goals and mutual activities of SMEs that want to build a network. Network contracts can help SMEs overcome limitations due to their dimension without causing them to lose their legal independence, while also enabling them to collaborate with firms of different dimensions. Furthermore, the network contract overcome the limitation of clusters and districts to be composed only by enterprises sited in a specific geographical area.

Even if the Italian law represents a novelty in Europe and may offer new challenges and hints for future discussion at international level, it still presents some lacks in its formulation (Granieri 2009, Scognamiglio 2009). A fundamental problem is the lack of a formal representation of the ontology of the network contract, being only a descriptive summary of a mode of organization of the market that can be achieved through different negotiation. Another problem is that nothing is said with regard to property rights (e.g., the know-how gained during the technological innovation) and the distribution of profits. To address these problems we define a formal model to support the design of a SME network, by providing both a formal ontology-based model to help the definition of the contract in a structured way, and a basic workflow which identifies the important phases of the network design.

The rest of the paper is organized as follows. Section 2 describes the Italian business network contract, by presenting its weeks and potentialities, and proposes an ontology-based model to represent it in a more structured way. Section 3 focuses on the network contract design phases to correctly set up a SME network. Particularly, the phases of Feasibility study and Negotiation are addressed. In Section 4 a comparison between the Italian business network contract and other forms of SME aggregations in European countries is presented. Finally, Section 5 draws conclusions and discusses future works.

2. The model of the Italian network contract for SMEs

The Italian business network contract stated in the Law 99 of July 23rd 2009 (Gazzetta Ufficiale 2009), allows two or more enterprises to jointly perform one or more economic activities falling within their social scopes in order to increase their mutual innovation capacity and competitiveness in the market. The law does not force the enterprises to be of the same nationality, thus international networks are allowed.

The essential requirements of the network contract include (i) the statement of the strategic goal and common scopes to reach the improvement of innovative capacity and competitiveness for the network, (ii) the identification of a network program that contains the activities and investments needed for the implementation of the strategic goal together with the set of indicators useful to measure the network performances, and the rights and duties assumed by each participant, (iii) the establishment of a common fund managed by a management body composed by SME representatives, aimed at pursuing the strategic goal. The firms are also free to establish entry and exit rules, and closing conditions for the network.

This bare description can be structured and enriched in an ontology (Bruno and Villa 2012), represented in the form of a UML class diagram (Fowler and Scott 2000). A class diagram is a static model that describes the structure of a system by showing the system classes, their attributes, and the relationships among them. In the class diagram, classes are represented with boxes which contain the name of the class and its attributes. The classes are connected by binary associations, which are represented as lines. The two ends of an association are labelled with the number of objects of the class that participate in the association, called multiplicity (“1” for one instance, “1...N” for one or more instance). The UML class diagram of the Italian business network contract is reported in Figure 1.

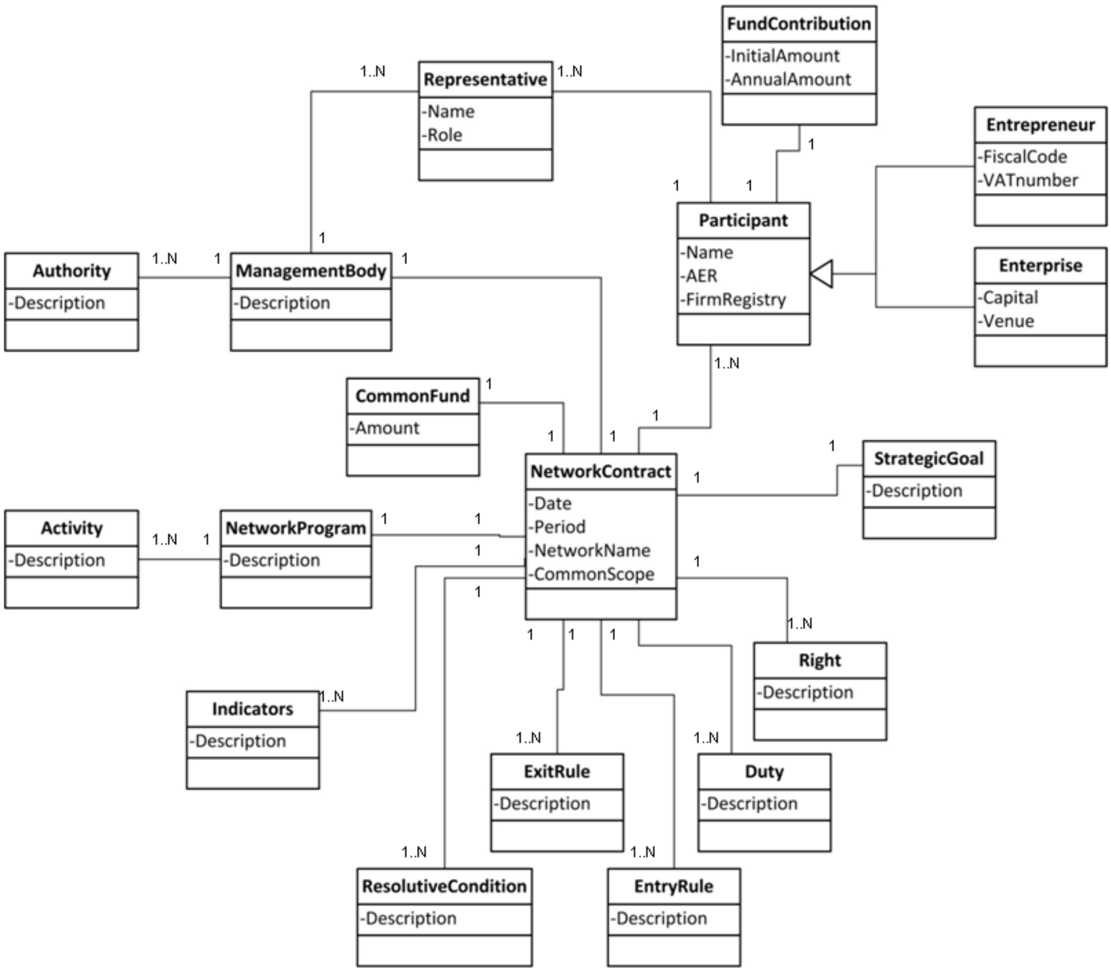

Figure 1. UML class diagram of the Italian business network contract.

The network contract is the central class which contains as attributes the details of the contract, i.e., the date in which the contract is signed, the period of life of the network, its name and the common scope of the SMEs that form the network. All classes representing the other fundamental concepts of the network contract are connected with it. The class named strategic goal contains the description of the objectives of the network. The class of participants, which is a generalization of the entrepreneurs and enterprises classes, contains the participant name, the firm register and the administrative repertory (REA) number in which the participant is registered. The class of common found contains the total amount of investments done by SMEs in the network, while the class of fund contribution stores the contribution of each SME to the common fund (an initial amount and an annual amount). Each participant can elect one or more representatives, which constitute the Management Body (or Management Committee) of the network contract. The representatives are characterized by their name and the role they play in the management committee. The network program class contains the description of the program of the network to reach the objectives described in the strategic goal and each activity under the program is described in the corresponding class. The indicators to measure the network performances, and the other legal concepts, such as rights, duties, entry rules, exit rules, and resolutive condition are represented by the correspondent classes.

The previously described UML diagram can be implemented in an ontology editor to allow the management of the model by computer software tools. An ontology formally represents knowledge as a set of concepts, properties and relationships within a domain, and has the aim of both allowing the clear separation of the domain knowledge (the model) from the operational knowledge (the instances) and enabling the reuse of the general model in different applications (Gaševic et al. 2006). Ontologies range from taxonomies and classifications to database schemas, and in recent years they have been adopted in many business and scientific communities as a way to share, reuse and process domain knowledge. We implemented the ontology with the Protégé software (http://protege.stanford.edu/). A screenshot of the ontology visualization is reported in Figure 2. The schema of the ontology is a direct representation of the UML diagram. The classes in the UML are concepts in the ontology with named relations between them having the cardinality restrictions and the names as defined in the UML.

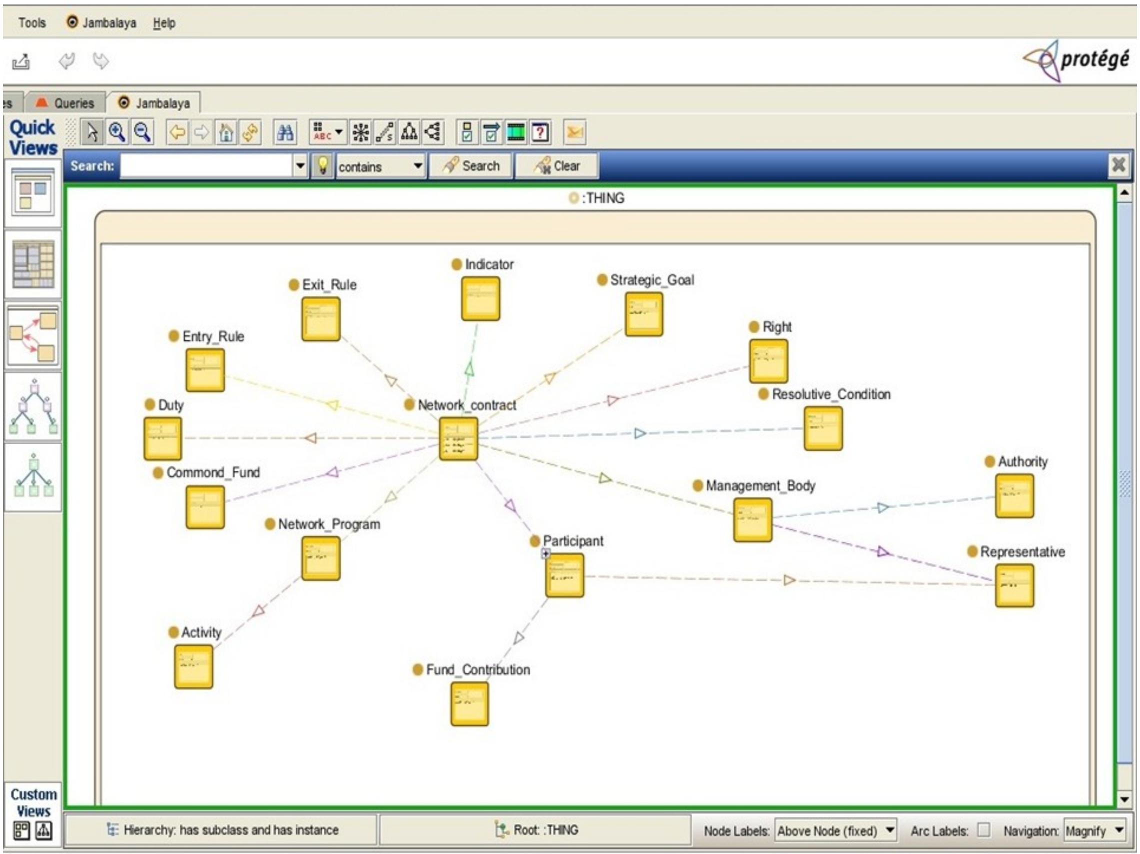

Figure 2. Ontology of the Italian business network contract realized in Protégé.

The presented model can be exploited by all the firms that want to build a network, to help them in the organization and the filling of the network contract. For each element the relationships with the other elements is formally defined. Each stipulated network contract can be represented as an instance of the ontology.

However, the design of a SME network is not limited to filling the network contract model, but it is a process composed by more complex phases, which are described in the next section.

3. SME network contract design

The basic workflow for SME network design is reported in Figure 3. The starting point of a SME network design is the agreement of a number of SMEs on a new common service that can improve their productivity as well as the quality of their products. Once this objective is considered of common interest, the participant SMEs that are to form the network perform a “network feasibility study”, with the scope of defining a preliminary network sketch to allow the evaluation of the design load as well as their respective involvement. The outputs of this phase are the base of the network, i.e., the strategic goal, the duration of the network, and the initial investments. Once these constraints are defined, participants can proceed with the “network contract negotiation”, which aims at balancing the global gain with individual SME financing possibilities. At the end of this phase, all the items described in the network ontology model in Figure 1 are defined, i.e., an instance of the network contract ontology is produced. Finally, for the defined time period, the participants remain connected in the designed network operation, under the control of the Management Committee, while the network performances are evaluated by means of the defined indicators. The two crucial phases of “network feasibility study” and “network contract negotiation” are detailed in the following.

Figure 3. Phases of the SME network design.

3.1 Network feasibility study

As above outlined, the feasibility study of the SME network design has the scope of defining a preliminary sketch of the main characters of the network design, such to allow the potential network partners to evaluate the design load as well as their respective involvement (Ravazzi and Villa 2009).

The network design problem here considered is the typical one to be approached by a set of SMEs aiming to build a common service: that means a given number $\boldsymbol{N}$ of SMEs will be involved in the future network, and that the SMEs are producing similar objects (thus, belonging to the same industrial sector). It is also considered that the development of the feasibility study as well as of the whole network design has to be managed by the above mentioned Management Committee, that receives the necessary contributions from the set of $\boldsymbol{N}$ SMEs which would be involved in the future network. A clear distinction between the "$\boldsymbol{n}$-th SME contribution", i.e. the contribution each SME gives to the common fund in order to compose the finance and resource reserve of the network design, and the "investment in the $\boldsymbol{n}$-th SME" decided by the Management Committee, has to take into account. The former ones are the transfers of money and resources that each SME attributes to the Management Committee to create the "initial capital" of the network. The latter ones are the investments that the Management Committee will decide to use in order to improve the productivity of the whole network and the quality of each SME.

The feasibility study needs to be supported by a specific formal model that could estimate the best network design gain in terms of the highest possible value increase of the network, depending on the investments the Management Committee would plan for each partner SME. Such a formal model is stated in terms of the following objectives and constraints, which formalize the reasoning for an assessment of the expected network design result.

Strategic goal of the network design. The SME network is expected to reach a production target p^* through an as effective as possible innovation of each n-th SME.

Each n-th SME is also expected to reach a minimum quality target q^* , which represent the quality of the network. To reach the production and quality targets, specific investments have to be applied in each SME. Said targets are expected to be assured for an a-priori decided "network life" H.

Resources to be applied to the design development. The investment to be planned by the Management Committee for application in the n-th SME innovation, denoted by dK_n, is the sum of two types of investments: the investment for the process innovation (dKP_n) and the investment for the product innovation in term of quality increase (dKQ_n):

$$dK_n = dKP_n + dKQ_n \tag{1}$$

Network design variables. The variables involved in the network design are the process innovation (dp_n) and the product innovation in terms of quality increase (dq_n). They are again linearly dependent to the investment dKP_n and dKQ_n respectively.

$$dp_n = \mu_n \, dKP_n \tag{2}$$

$$dq_n = \beta_n \, dKQ_n \tag{3}$$

where μ_n denotes the rate an investment gives rise to process innovation, and β_n the rate an investment gives rise to a product quality improvement.

Initial capital for the network design. The sum of contributions provided by the N SMEs, each one denoted by $dK_n°$, is the initial capital of the Management Committee, which must be used to yield the best improvement of the SME network:

$$K^o = \sum_n dK_n^o \tag{4}$$

where the right-hand-side term details the real budget of the network design, i.e., the common fund.

Constraints on the network design results. The expected production level for the whole SME network (P) and the expected quality level to be reached by each SME (q_n) are given by the following formula:

$$P = \sum_n p_n \geq p^*, \quad p_n = p_{0,n} + dp_n \qquad (5)$$

$$q_n = q_{0,n} + dq_n \geq q^* \qquad (6)$$

Value increase of the network. Goal of the Management Committee is to obtain the highest possible increase of value I of the SME network, to obtain the maximum yield from the initial budget through the most effective innovations applied to all SMEs. So, each process innovation will generate a value increase for the n-th SME, as well as each product quality improvement (respectively measured by multiplying the process and quality improvements by two constants, a_n and b_n, that measure the improvements in financial terms). On the other hand, the common found will be the real global cost of the network design.

$$I = \sum_n I_n - dK^o, \quad I_n = a_n\, dp_n + b_n\, dq_n \qquad (7)$$

In formal terms, the set of conditions (1)-(3) and (5)-(6) could be recognized as a typical LP problem, where the network increase of value (7) has to be analyzed by taking into account the set of constraints above mentioned.

However, a more deep analysis of the "network design problem" must be done, because – in practice – it refers to the problem of finding a "good" agreement among the N SMEs, taking into account the following:

- on one hand, each n-th SME contributes in the common found with proper financial amount and resources, according to its own investment possibility;

- on the other, the Management Committee will decide investments in each SME such to obtain the maximum increase of value for the network and a good increase of quality for each SME production.

This consideration suggests that a solution of the network design problem of really practical interest should be obtained by finding a good compromise between the desire of improvement of each SME and their respective contribution to the initial budget. The opens the following "negotiation step".

3.2 Network negotiation

Finding a solution for the network design problem, i.e. values for dKP_n and dKQ_n for each n, means to decide which innovations should be applied to each n-th SME. One could say that this reflects into a "gain" for the n-th SME itself. Indeed, the design gives rise to a "gain" for the whole network, that can be quantified by the increase of productivity and the improvement of quality over the whole network life:

$$G = \sum_n \{a_n p_n + b_n q_n\} H = \sum_n G_n H \tag{8}$$

While G is the global final "result" of the network design, each term G_n denotes the technological "advantage" or gain to be attributed to the n-th SME.

Taking into account the concept of "design result", the above stated problem can be approached as a "cooperative game", in the form of a multi-person bargaining problem. As known, the game theory can be divided in two main approaches: the cooperative and the non-cooperative games (von Neumann and Morgenstern 1944). The actors in non-cooperative game theory are individual players who may reach agreements only if they are self-enforcing, while in cooperative game theory, the actors are coalitions, group of players. Cooperative game theory looks for the possible set of outcomes, study what the players can achieve, which coalitions will be formed, how the coalitions will distribute the outcomes and whether the outcomes are robust and stable (Sosic and Nagarajan 2006). It attempts to answer how the total value is divided up among the players and how this answer will depend on their bargaining power (Marchi et al. 2009). A player's bargaining power depends on how much other players need him to form coalitions, that is his marginal contribution: in practice, the amount by which the created overall value will be reduced if this particular player leaves the game (Brandenburger 2007). There are several ways of solving a cooperative game: among them, the so called “core” and the “Shapley value”. The core is a solution concept that searches for the set of payoffs that no coalition can improve. The Shapley value prescribes a single payoff for each player, which is the average of all marginal contributions of that player to each coalition where the player is a member of (Serrano, 2007).

Considering the technological advantage or gain (8) together with the constraints the set of conditions (1)-(3) and (5)-(6), and looking at the problem as a collaborative game, it could be solved by searching for a set of innovations for the individual SMEs (the “players”) such to obtain a “good” value for the global gain (8). In case of maximization of the global gain, this reflects in pushing high innovations for the SMEs where the financial impact is high – according to (8) - as well as their rates of investments – as in (2) and (3). This solution, indeed, implies some practical defaults. Among them, the main defect is to generate a greatly unbalanced network, with some SMEs, already well organized and with greater quality level, again supported, whilst some others, not so equipped and assessed, not able to receive a good investment. In practice, this means an unsuccessful design. On the other extreme, if a solution of the investment problem is searched by planning a no gain for the network design, then an attribution of investments to SMEs proportional to their respective initial contributions results. In this case, the problem is split into N independent sub-problems, and no real meaning of network design remains.

These two considerations suggest that, in a practical situation, the above stated formal model should be used for clarifying the concept of network design, and any theoretically optimized investment must be followed by a "negotiation of contributions and investments", such to balance global increase of innovation with individual SME financing possibilities. According to the "cooperative game" view and taking into account of its "core" (as above mentioned), each SME represented in the Network Committee will try to have the best possible balance between the finance contribution (delivered for the common project) and the innovation actions (planned for the application to the SME).

4. Applying the SME network contract model to analyze SME aggregations in some European countries

The SME network contract and negotiation models above developed can be used as analysis criterion for comparing the different types and models of SME aggregations in some European countries. A summary of the main aspects concerning the organization of SME networks in some EU countries can be found in (Villa and Taurino 2011).

France launched in 2004 an industrial policy to support initiatives emerging from academic and economic actors within a region to develop dynamic networks to link firms and research institutions, the so called *Poles of Competiveness* (Boucher and Dolgui 2009). The poles are associations of companies, private and public research centers, and teaching institutes, collectively involved in a public or private partnership with a common development strategy. They aim at launching new projects resulting in innovative technological and organizational advances, increased efficiency and job creation: national and regional governments both contribute to the funding of clusters (see http://www.competitivite.gouv.fr). Each pole is represented by a coordination entity with a specific legal structure, usually based on the status of an association, which employs a permanent staff to elaborate the general strategies of the cluster, manage the communication with the other clusters, and evaluate the projects. This structure as well as its main characters, its strength and weakness, can be recognized by using the ontology and negotiation models here proposed. First, the French approach to the network contract is to use a well-established form, the association, thus avoiding any uncertainty about the partners' interactions; the same happens for the Management Committee, that is the association Board of Directors. Referring to the negotiation model of Section 3.2, in a pole of competitiveness there are N SMEs and an extraneous element (the government). If this last one will only transfer funding without participating in the management committee, then the network will result from a cooperative negotiation (or "game"). Otherwise, if the element "government" will participate in the committee, the negotiation degenerates since a member could influence all others without having operative tasks. In practice, as it generally happens, the government should contribute through plans, both with calls for projects (for new networks) and with an a-posteriori evaluation of the project results, without interfere in the committee activity. For instance, this is the typical way of doing of the European Commission, as in the recent *Small Business Act for Europe* (European Commission 2008).

In markets dominated by large multinational companies, the development of either virtual or outsourcing networks is frequent. Outsourcing networks typically link highly innovative de-verticalized leading firms with sets of highly functional suppliers who provided a wide range of production-related services (Heavey et al. 2009). These networks, widespread in Ireland, are highly flexible systems characterized by short-term contracts between participants to the network itself. In terms of the ontology model, the network contract structure is greatly simplified, because the enterprises aggregation is driven by the leading firm: the way the enterprises interact is typical of a supply chain. In presence of a leader, the problem of negotiation in terms of cooperative game disappears. The leader will try to optimize the global increase of value (7) of the network since the leader knows that its own parameters (see (2), (3) and (7)) will assure the maximum individual gain. However, the leader should take account that this optimization would give some gain also to weaker SMEs, in order to offer them some interest in the network constitution.

In UK there is not a unique definition of SME clusters. For instance, the UK Department of Trade and Industry defines a cluster as a concentration of competing, collaborating and interdependent companies and institutions, which are connected by a system of market and non-market links (see http://www.dti.gov.uk), while the Scottish Enterprise defines clusters as a group of industries and organizations linked by a common goal or practice (http://www.scottish-enterprise.com). These differences show a significant variability in promoting and also evaluating the cluster aggregations in the various UK regions (Villa and Taurino 2011). In practice, both clusters composed by set of industries linked through vertical relations (client-supplier) and clusters composed by industries linked by horizontal relations (common customers, technologies and market channels) can be found. While the former ones essentially are supply chains, the negotiation model of the latter can be based on a cooperative negotiation of the network gain (8), as above outlined.

The types of German clusters can be either created by government initiatives (top-down networks), or originated by some leading organization and supported by local political environments (top-down internally initiated networks), or created outside any public initiative (bottom-up networks). In practice, it can be found a mixture of these three scenarios, even if the first two are more frequent (Meier zu Köcker 2009). These two types of clusters – usually denoted “kompetenznetze” – are very similar to the French “poles de competitivité”: any consideration already done for the last ones can be referred to the German top-down networks. The last type (bottom-up networks) corresponds to the cooperative negotiation model: a cooperation-based aggregation with common strategic goal and network committee in order to manage the distribution of rates of the global gain to partners.

Another form of aggregation of different types of bodies, both enterprises and research institutions, is the Science and Technology (S&T) Park. It is a sort of *mediator* to facilitate the creation of spin-off companies and disseminate innovative technological achievements to regional SMEs (Agoti et al. 2009). To encourage the growth and the implementation of high-technology and innovation production, the S&T park provides services such as high-tech research installations, pilot laboratories, and incubators for new firms, and it facilitates the establishment of new companies and the innovation of products and services. Examples of important parks in Europe include the Cambridge Science Park in England, the Lindholmen Science Park in Sweden, the Sofia Antipolis Science Park in France, and the Patras Science Park in Greece. In terms of the proposed ontology, the S&T park is a typical aggregation of independent bodies whose “contract network” states the rules to use some facilities provided by local/national governments, and the general scope of the park. In practice, they are not aggregations with scope: then, the negotiation model could provide at most some suggestions for creating internal “coalitions”.

5. Some concluding remarks

Looking at the European industrial system, if one takes account that SMEs are supplying labour to about 100 million citizens, this makes reason of the importance of SMEs, the real backbone of the European economy. However, the globalization of markets of goods and of labour makes individual SMEs no more competitive. During the last decade, the European Commission has perceived this critical situations and has stimulating research on what could be the *antidote* of the crisis: the development of profitable SME aggregations in terms of either poles of competitiveness, network of competence, clusters or industrial districts. The proposed ontology model of the network contract and the related negotiation model wants to be further tools to support this innovation crucial effort. They are directed to SME managers, to counteract their innate individualism, and to local governments, to offer them a tool to analyze some characters of the their industrial systems. The outlined application of the ontology and the negotiation models to different types of SME aggregations in some European countries can justify its usefulness, as well as an it will be done by their on-going application in a new collaboration between Politecnico di Torino and the National Federation of Craftsmen, just starting.

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