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An ontology-based model for SME network contracts

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Abstract. Even if collaboration is considered an effective solution to improve business strategies, 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. However, 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, by highlighting both its potentialities and its defects. 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. In this way, the network rules and criteria for controlling the network members' contributions are defined. Mathematical tools derived from performance optimization were exploited.

Keywords: SME integration, network contract, ontology, UML

1 Introduction

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 [5]. However, SMEs usually show a traditional individualistic attitude [2]. This means facing the marketing, technological innovation and purchasing problems alone. On the contrary, being an independent node of a networkcould lead many advantages to a SME: (i) more complex products can be realized by integrating skills of all the network nodes, (ii) higher manufacturing volumes can be obtained by cumulating node capacities, (iii) fluctuations of market demand volumes can be handled better by sharing workload peaks and shortages among the nodes, and (iv) there is no need of spending resources in hard competitions with the other SMEs [9, 13].

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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 [12]. 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 [1]. 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 [5].

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 [8,11]. 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 intellectual property rights, such as the know-how gained during the research and development for technological innovation.

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, i.e., the feasibility study and the negotiation.

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 highlight the points that are not explicitly addressed by the law. Section 3 focuses on the network contract design phases to correctly set up a SME network. In this way, the network rules and criteria for controlling the network members' contributions are defined. Mathematical tools derived from the performance optimization were exploited. Finally, Section 4 draws conclusions and discusses future works.

2 Italian business network contract

The Italian business network contract of the Law 99 of July 23rd 2009, published under number 136 in the Ordinary supplement of the Gazzetta Ufficiale on July 31st 2009, allows two or more enterprises to jointly perform one or more economic activities falling within their social objects 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 the statement of the *strategic goal* and *common scopes* to reach the improvement of innovative capacity and competitiveness for the network, 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, 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 *resolutive conditions* for the network.

This bare description can be enriched and structured in an ontology, represented in the form of a UML class diagram [6] in Fig. 1. 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 [7].

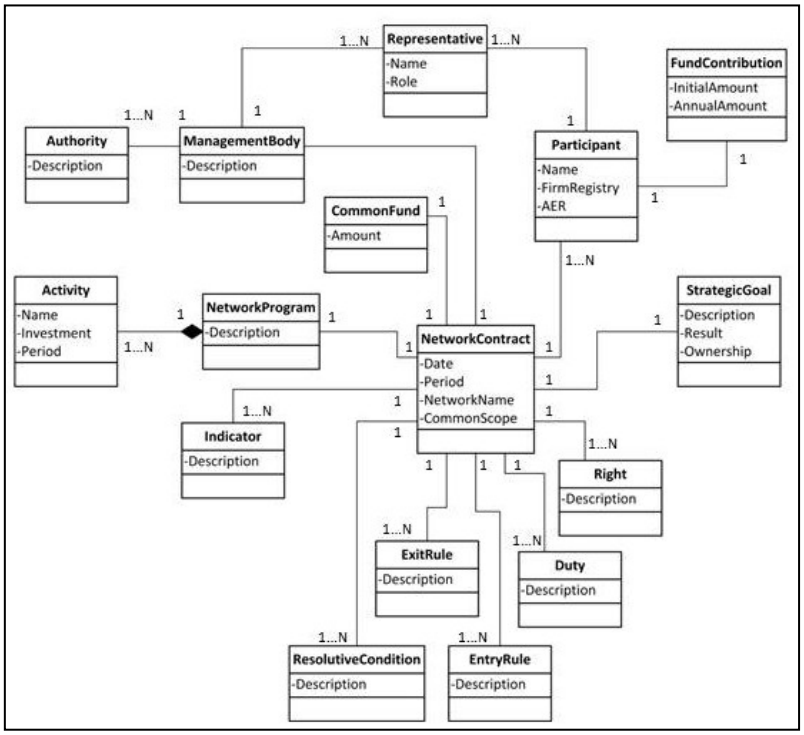


Fig. 1.UML class diagram of the Italian business network contract.

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 ele-

ment the relationships with the other elements is formally defined. Furthermore, some additional attribute were explicitly added, even if they are not present in the original law. For example, in the Activity class, the investments and the time period should be specified, while in the Strategic goal class, information about the expected result and its ownership should be provided in addition to its description. Each stipulated network contract can be represented as an instance of the ontology. However, the design of a SME network is not limited to defining the network contract, but it is a process composed by several phases, which are described in the next section.

3 SME network design phases

The basic workflow for SME network design is reported in Fig. 2. Initially, the participants that are to form the network perform a Network feasibility study, with the scope of defining a preliminary 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 Fig. 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 Network operation, under the control of the management body, while the network performances are evaluated by means of the defined indicators. The phases of Network feasibility study and Network contract negotiation are detailed in the following.

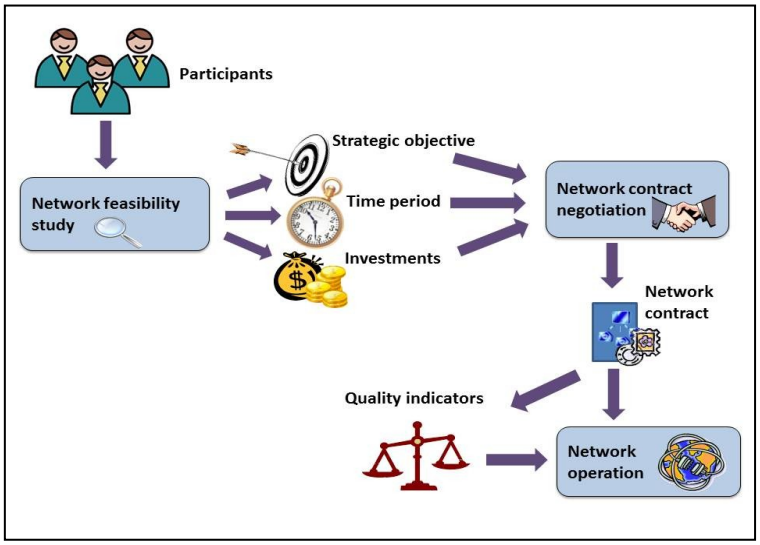


Fig. 2. Phases of the SME network design.

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 [10].

For sake of clarity, the assumption that a given number N of SMEs would be involved in the future network, and that the SMEs are producing similar objects (thus, belonging to the same industrial sector), is adopted. 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 body, that receives the necessary contributions from the set of N SMEs which would be involved in the future network. A clear distinction between the "n-thSME contribution", i.e., the contribution the SME gives to the common fund in order to compose the finance and resource reserve of the network design, and the "investment in the n-th SME" decided by the management body, will be used in the following.

The feasibility study needs to be supported by a specific formal model that could estimate the network design gain, depending on the investments the management body would plan for each partner SME. Such a formal model is composed by the following objectives and constraints.

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 quality target q_n^* , by applying a specific investment.

Resources to be applied to the design development. The investment to be planned by the management body for application in the n-th SME innovation, denoted by dK_n, is the sum of the 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 (r_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.

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

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

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.

Cost of the network design. The sum of all investments planned by the committee for the N SMEs will define the final cost of the network design (i.e., the amount of the

common fiund), C, that will be bounded by the sum of contributions provided by the N SMEs, each one denoted by $dK_n°$.

$$C = \sum_n dK_n \leq \sum_n dK_n° \tag{4}$$

where the right-hand-side term specifies the real budget of the network design.

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:

$$P = \sum_n p_n \geq p^*, \quad p_n = p_{0,n} + \varphi_n r_n = p_{0,n} + dp_n \tag{5}$$

$$q_n = q_{0,n} + dq_n \geq q_n^* \tag{6}$$

Gain of the network design. The network design is expected to have a gain, G, resulting from the innovations applied to all SMEs, even if in different forms and amounts according to the initial state of the SME itself. So, each process innovation will generate a gain for the n-th SME, as well as each product quality improvement (respectively measured by the products of the process and quality improvements by two constants, a_n and b_n, that measure the improvements in terms of financial income), whilst the SME contribution will be the real individual cost for participating in the network design.

$$G = \sum_n G_n, \quad G_n = a_n dp_n + b_n dq_n - dK_n° \tag{7}$$

The set of conditions (1) to (7) can be easily recognized as a typical LP problem, where the network gain (7) has to be analyzed by taking into account the set of constraints (1) to (6).

3.2 Network contract negotiation

In principle, the LP-stated network design problem should be solved by maximizing the gain (7). This reflects in pushing high innovations for the SMEs where the financial impact is high – according to (7) - as well as their rates of investments – as in (2) and (3). This theoretical 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 contributions results. In this case, the problem is splitted into N independent sub-problems, and no real meaning of network design remains.

These two considerations suggest that the above stated formal model should be used for clarify the concept of network design, and perhaps to obtain an optimized investment strategy, even if unbalanced, but it must be followed by a “negotiation of

contributions and investments", such to balance global increase of innovation with individual SME financing possibilities. To this aim, the negotiation can be viewed as a "game", where each SME representative in the management body tries to have the best possible condition in terms of finance contribution (to be delivered) and of innovation actions to be applied. Looking at the Theory of Games, each participant can bring some influence to bear upon the out-come of a certain event and no single participant by himself can determine the outcome completely [4]. The special feature of the game under consideration is that a "cooperative solution" must be searched, and that some suggestions for an agreement among the SMEs can be given by the solution of the formal model above discussed.

4 Conclusions

Recently, the European Commission has decided to extend the outreach of the *Enterprise Europe Network* - the business and innovation support network for SMEs - to enable more European SMEs to profit from the fast-growing markets in Asia, Latin America and Eastern Europe [3]. With this aim, a contact office has been opened in Japan and the presence in China was doubled. The network was also expanded in southern Mediterranean countries, with further enlargement foreseen in the near future. The network was established to help SMEs to find potential partners in European and world markets and to turn research and innovation into profits. As mentioned in the introductory section, a similar decision has been taken by the Italian government, with the specific goal of promoting agreements among SMEs to create networks.

However, in both these cases and also in regulations adopted in other European countries, the aim of the legislation is mainly to offer support services for commercialization, only in rare instances to give criteria for SMEs cooperation [12]. It seems that cooperation could emerge in an instinctive manner. This is not the case of most of SMEs, whose owners are often jealous of their own enterprise and their knowhow, even they are poor. Owners and managers' individualisms are the first obstacle to cooperation, followed by the lack of practical supports (rules and criteria) to activate effective cooperation.

This paper tries to build a bridge between individualism and the need of SMEs networking, by introducing a new tool for SMEs network designers composed by the following items: (i) an ontology of the network contract for organizing a SME network, (ii) a model for a-priori evaluation of the cost and the gain of the network design, and (iii) some hints for understanding how the potential partners of the network contract can provide financial contributions and human resources for the network design execution.

Looking at the current versions of Italian laws and E.U. recommendations, point (i) will give help to formalize the network design contract, point (ii) will support in estimating how a contract management committee could decide investments, and point (iii) will give suggestions to the network partners about the negotiation of contributions and their utilization for the design development.

An application of these three points is currently under development in cooperation with a Regional Government of North-West Italy and a small group of SMEs used as test subjects.

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