BOTTOM UP APPROACH TO COOPERATION IN TECHNOLOGY INNOVATION

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Introduction

Most of approaches to favour technology innovation made by public agencies concern the creation of structures making promotion of innovation, helping transfer of technology or making calls of proposals with defined conditions to obtain financial aid in which it may be named a *top down approach*. In this paper we describe a completely different approach, coming from our experience, that creates by itself structures, studies, R&D projects among firms and that we consider a *bottom up approach*. Such approach has a certain number of limitations but presents also some interesting advantages in respect to top down initiatives. Most of our experience in bottom up approach comes from the development of cooperation in R&D among firms producing taps and valves existing in two Italian industrial districts in the provinces of Novara and Brescia in what we call the Ruvaris Project. Certain aspects of formation and working of such network have been reported previously by A. Bonomi and P. Marenco (2007). We have in this article interpreted the formation of structures and processes using some concepts and models elaborated in the field of the complex systems and in particular in what we name here the ACLE Model, acronym of the main elements: *A*gent, *C*atalyst, *L*eader and *E*co-technician used by S. Kelly and M. A. Allison (1998) in their description of restructuration of Citibank, and the generative relationships model elaborated by D. Lane and R. Maxfield (1995, 2006) studying the business development of two companies of the Silicon Valley. We start the article with a brief description of the history of the Ruvaris Project. After we present the interpretation of the development of the projects using the ACLE Model followed by a description of the generative relationship model and its interpretation in generation of studies carried out in the project. Finally we discuss strength and weakness of the bottom up approach and possible generalization to other cases of promotion of technology development in a territory

In order to understand our descriptions it is necessary to define what we intend for structure and process of a general system in our discussions. In our view a system is composed by a structure and processes occurring within. A structure may be composed by spatial, organizational or temporal elements while processes are the activities occurring among the various elements of the system. For example a system such as an industrial districts has a structure composed by the firms of the district and processes constituted by various types of activities occurring among the firms. A method may be also considered a system and its structure is composed by elements constituting the temporal sequence of steps that should be used to apply the method while processes are the activities necessary to go from one step to the next one.

History of the Ruvaris Project

The Ruvaris Project is an experience we participated and followed for more than 15 years concerning a bottom up process of formation of cooperative R&D in taps and valves industry in Italian industrial districts existing in the provinces of Novara and Brescia. The origin of the project may be considered a meeting occurred in March 1996 between an entrepreneur of such industry and the director of Tecnoparco del Lago Maggiore about a problem of corrosion of valves in the

relatively acid drinking water existing in Sweden with the aim to verify how the Tecnoparco could help to solve this problem. Such meeting was followed by a second one between the same director and a consultant in the field of technology innovation. In such second meeting it was discussed the fact that tap and valves industry could have much other common important problems to be solved by R&D and that these problems could be faced promoting a cooperation for R&D projects in order to share competences and costs. The idea was to transfer to industrial districts the so-called multi-client method of participation to projects and studies as made by research organizations on a world wide base for large companies.

It is useful to describe in a certain detail how it consists the multi-client method practiced by contract research organizations. Such method is schematically reported in Fig.1. The starting of a multi-client study or R&D project necessitates the combination of three factors: the initiative of a consulting and research organization, the existence of a global technological problem fitted to be solved by a study or a R&D project, and the presence of potential clients composed by great companies sharing the problem. Such conditions allow the application of the multi-client method consisting in preparing, preliminary notes, specific detailed proposals containing objectives, scope, program, duration and cost of the study or project, and contacts with potential clients and organization of launching meetings. When the minimum number of clients is reached there is the constitution of the multi-client group and study or project may start. At the end of the project or study the client group is dissolved and the organization takes in consideration the launching of other multi-client studies. Multi-client studies are normally open to any company wishing to participate and are carried out under the responsibility and management of the research organization in a typical top down approach to industries. When considering industries of districts they are much smaller and possible financial support for participation is much lower than in the case of large companies joining a typical multi-client study. However, small and medium enterprises (SMEs) in districts are numerous and problems for studies and research are more specific, conditions that might make possible the realization of a multi-client project in such environment, Consequently it was decided to organize some meetings with taps and valves district industries to discuss their technology innovation problems and verify the possibility to generate cooperation in the frame of a bottom up approach.

During the period April – December 1996 a series of meetings was organized by Tecnoparco del Lago Maggiore with firms of both tap and valves districts of provinces of Novara and Brescia to discuss the problems. From such meetings emerged an interest to carry out a cooperative study concerning possible substitution of traditional materials and galvanic surface treatments for taps and valves in contact with drinking water. In the period January – June 1997 a multi-client proposal for the study was prepared and adhesion promoted among the various districts firms. In July 1997 it was decided to start the study with ten participants and in September 1997 we had further 13 participants for a total of 23 adhesion to the study. It should be noted that budget of the study was calculated for a minimum of 20 adhesions. Starting with a lower number of participants than the minimum one is a normal practice in multi-client studies as the starting has a strong attractive effect for new adhesions. In December 1997 there was the presentation of the results of the study and delivery of the report. The study presented three interesting subjects for R&D projects and one in particular concerning the development of a brass treatment eliminating the lead existing on the surface in order to avoid contamination of drinking water was considered of great interest. During the period January – June 1998 there was e series of meetings to discuss how to implement the results of the study. As a few technologies of leaching lead from brass were already existing, some contacts were taken with suppliers of such technologies in order to build up a consortium plant to prove industrially the validity of the technology. In fact such approach was eventually dropped by suppliers as not corresponding to their development strategies. Another possibility was to use of

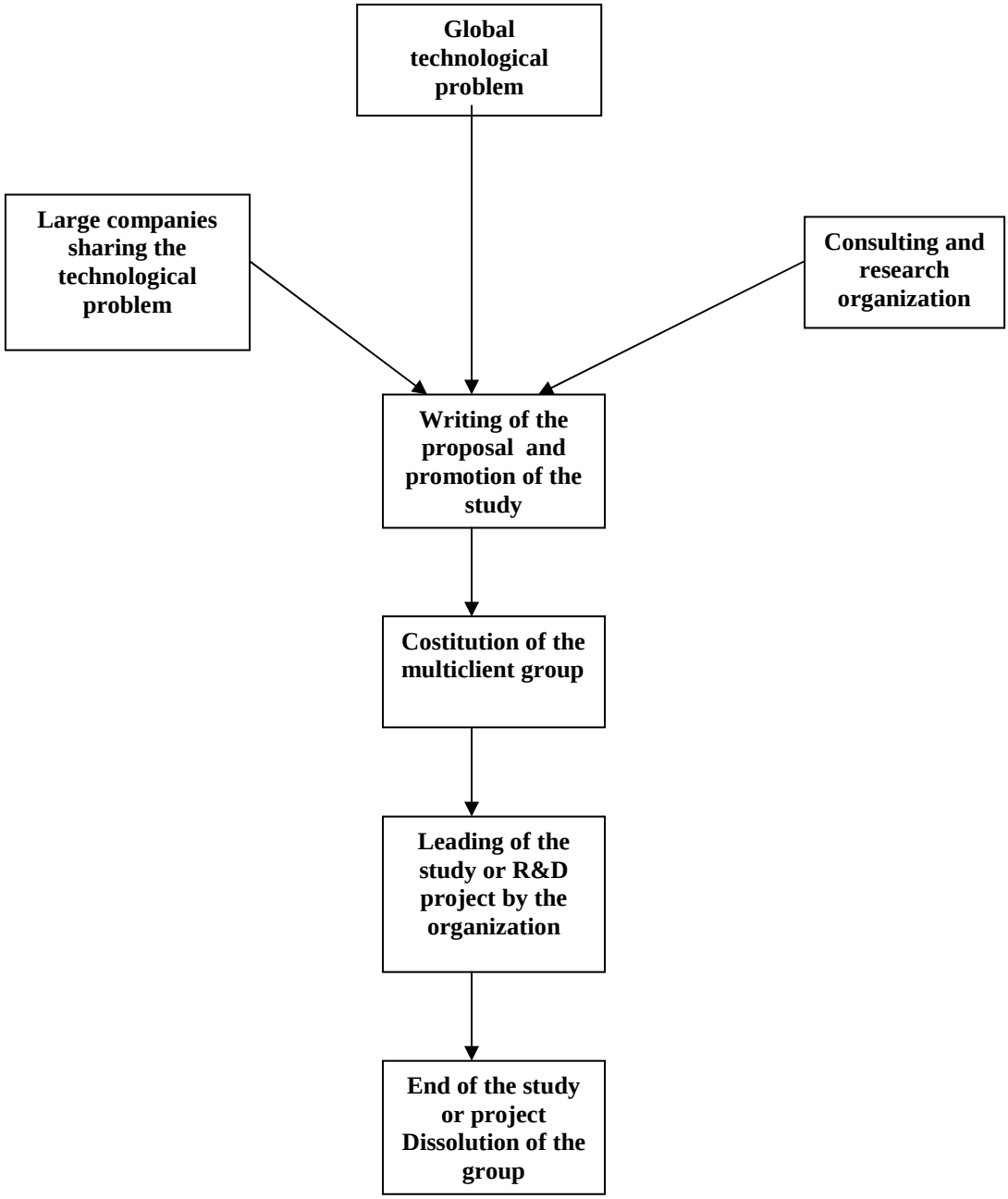

Fig.1. Schematic view of the multi-client method structure for studies or projects

facilities of Tecnoparco del Lago Maggiore to develop a new technology but this alternative was readily abandoned as available laboratories and experience were not suitable for development of such type of technology. At this point emerged from industrial part the idea to build up a company able to carry out the development of a leaching technology, possibly improved in respect of available ones, using facilities and experience existing in districts firms. Finally, n June 1997 we had the foundation of such company named Ruvaris S.r.l. and associating six companies of both Novara and Brescia districts. The R&D activity of the company lead to the realization of a first demonstration treatment plant in September 1999 followed by a second industrial plant in September 2000. Presently there are more than ten plants existing in Italy and other countries. A US patent was granted at first in September 2001 followed by extensions to other countries. During the years period 2000-2004 Ruvaris Srl was interested in developing activities concerning testing of tap and valves in complying various certification rules of various countries about contamination of heavy metals in order to validate and improve its technology. In January 2005 there was a renewed interest in R&D activities and Ruvaris Srl promoted a second study concerning the identification of other R&D projects interesting tap and valves industry. The study launched in May 2005 reached the number of sixteen participants at the moment of starting of the study in July 2005 and a total of 19 participants in December 2005. In February 2006 there was a final meeting to discuss the results of the study and the final report was delivered in April 2006. The study indentified six interesting R&D projects, the most important concerned the development of free cutting brass without lead content. At the same time during the meetings arose the interest to carry out a continuous R&D activity through a consortium allowing a much higher number and open adhesion of members than in the case of Ruvaris Srl. In April 2006 the initiative to transform Ruvaris S.r.l. in a consortium for cooperative R&D collected 19 adhesions and transformation of the company was finalized in June 2006. Presently there are 25 companies in the consortium, both from districts of provinces of Novara and Brescia, and the present activity includes the running of four main R&D projects. The consortium has a light structure including a board of directors and president elected among the representatives of the firms participating to the consortium, a director coordinating the activity and external relations, and an assistant following administrative work and existing research projects. There is also a technical and scientific committee composed by representatives of the firms and external consultants to evaluate and promote R&D activity. R&D work is carried out in external research laboratories and in facilities of firms that may be member or not of the consortium following the type of testing to be done.

The ACLE Model in bottom up approach

The ACLE model was developed by S. Kelly and M.A. Allison (1998) in the ninety years during the restructuration of Citibank with the aim to supply a new management method based on an alternative to directive hierarchical management and consisting in a network of autonomous agents under the responsibility of a leader and the presence of two additional figures composed by a catalyst triggering business and an eco-technician consulting expert in complex systems operating through typical bottom up processes. Although such model was essentially developed for restructuration and management of companies, we would show in this article that it could be also applied to bottom up processes of aggregation of firms around R&D projects in particular in industrial districts where there are basic common technologies and products as described previously for the Ruvaris Project.

We may start our discussion looking to the agglomeration phenomena of firms that correspond to the autonomous agents of ACLE model. In Fig. 2 we have reported the increment with time of number of participations to the two cooperative studies carried out in the frame of the Ruvaris

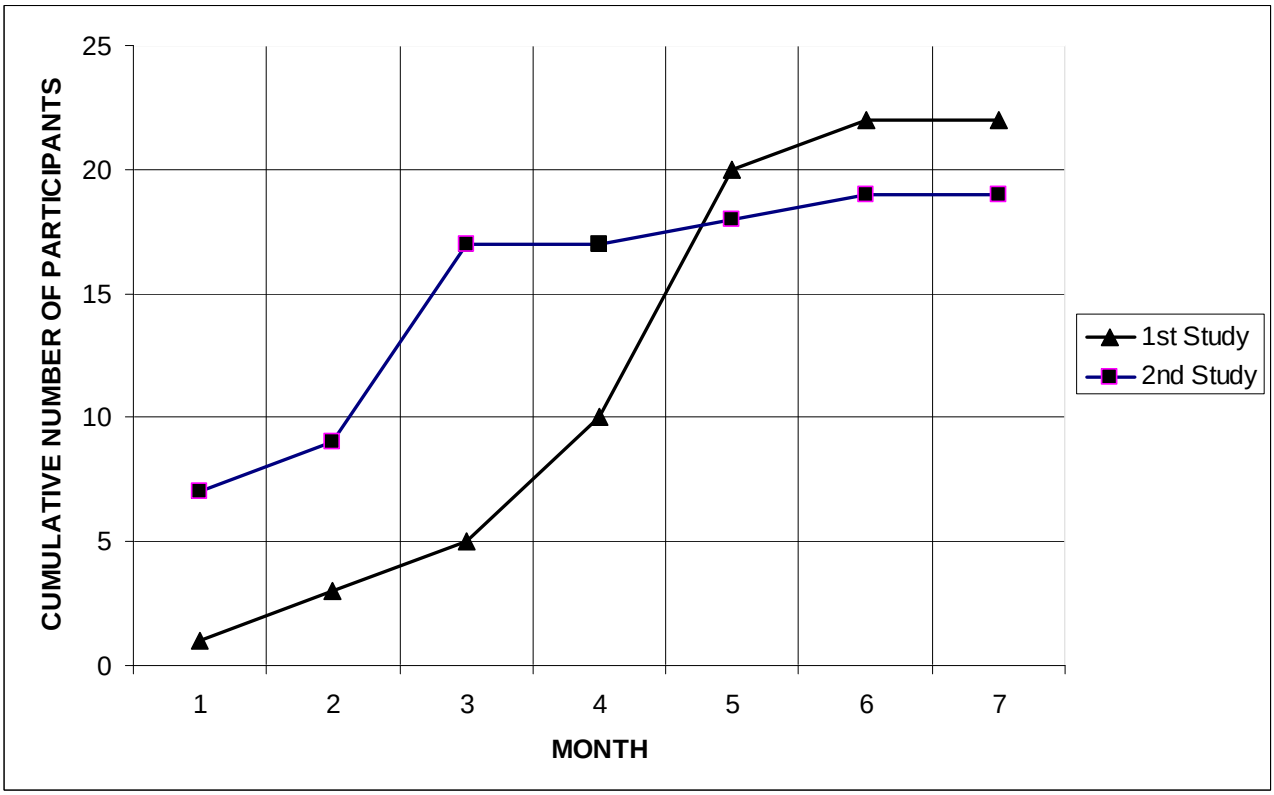

Fig. 2. Agglomeration effect on firms participating to studies in the Ruvaris Project

Project respectively in 1996 and 2005. It is clear from the S shaped curve of agglomeration of participants there is an autocatalytic effect in the creation of the cooperative group of firms. We think that the triggering of a successful agglomeration effect may be explained in term of the ACLE Model with the presence of specific individual figures in the system. We report here the definition of such figures, as proposed by S. Kelly and M.A. Allison (1998,: and their specific role in the bottom up approach to cooperation:

Autonomous agent: a thinking conscious decision-making being taking responsibility for those decision, definition that well corresponds to independent firms that decide to cooperate.

Leader: an autonomous agent who is responsible for consolidating a vision, encouraging an open communication and a robust decision-making network to realize it. Such definition in our case correspond typically to an entrepreneur or manager of a participating firm that is willing to promote with his knowledge and outstanding figure the coagulation of potential partners and management of the formed network of firms.

Catalyst : a figure using specific triggers expertise and effective communication to enable self-organization processes and to increase rate of change within specific activities. In our case he corresponds to a figure that takes the initiative, backed by an external organization, to make contacts , organize meeting, and favouring the agglomeration of firms around a cooperative activity helping also through effective communication to maintain the cohesion of the group.

Eco-technician : a consultant figure with expertise in various aspects of complex systems analysing structures and processes and supporting the action of leaders and catalyst in finding the good practice necessary to their role. In our case he correspond to the figure that has elaborated the transfer of multi-client method used by international research organization to the world of SMEs and industrial districts to generate cooperation in the field of R&D.

Looking to the history of the Ruvaris Project, the director of Tecnoparco del Lago Maggiore acted as catalyst continuing further his catalytic presence as director of Ruvaris Srl and after of the consortium. The consultant suggesting the transfer of the multi-client method to the case of industrial districts acted as eco-technician and followed the whole evolution from foundation of Ruvaris Srl to the present consortium. During the history of the Ruvaris Project there was a succession of industrial figures as leaders: in particular during the first phase promoting meetings this figure was assumed by the entrepreneur that had the first discussion with director of Tecnoparco, followed by other entrepreneurs during the creation and managing of Ruvaris Srl and still others during formation and management of consortium. During the promotion of a bottom up process of aggregation of firms around a R&D activity the emergence of the leader figure among entrepreneurs or managers of the firms is the most critical factor of success. In fact autonomous agents, or firms in our case, are naturally existing as potential elements for cooperation, catalyst and eco-technician should be initially present to trigger the process, the leader of the process should emerge from contacts and meetings in order to realize a valid cooperation of firms. The necessity of an industrial leader figure in cooperation of firms has been observed also in other cases. For example A. Ricciardi (2010) cited the importance of a leader entrepreneurial family in the formation of a consortium of firms in the fashion and textile district in the province of Verona. Such consortium was created to develop local trade-marks, promotion of commercialization activities and general innovation of products and processes. The formation of cooperation among SMEs is relatively common for typical firm activities such as trade marks, central buying of products, common storage of materials, marketing and commercial promotion. Differently from the case of the Ruvaris Project such cooperation may arise spontaneously under the initiative of one or

more entrepreneurs. The difficulty to generate spontaneous cooperation of SMEs in R&D projects may be explained by the fact that such activity is neither well known nor a diffused way to make innovation in SMEs, especially when technological innovation has some radical character and need research laboratory.. In such case the presence of a catalyst and an eco-technician is important for triggering a cooperation. In their initial action catalyst and eco-technician necessitate generally the backing of some organization that may be for example a public agency, an industrial association or a research laboratory. In the case of Ruvaris Project the Tecnoparco del Lago Maggiore assumed such backing role. In Fig. 3 we have reported a schematic view of the bottom up approach occurring in the case of the Ruvaris Project that has an analogous structure of the schema reported in Fig. 1 for the multi-client method. In similar way the bottom up approach needs three elements to start the process that in this case are the action of a catalyst with an eco-technician and the emergence of a leader willing to promote. The multi-client method is a typical top down approach in which the contract organization chooses the topic for the study, makes a proposals and carry out under its responsibility the study the company participating acting as simple clients. In the case of our bottom up approach the agglomeration of firms around a cooperation may precede the definition of specific cooperative R&D projects and may start actually with a cooperative study to identify such R&D projects. In fact the only likeness existing between the multi-client method and our bottom up approach is in writing proposals and sharing the cost of the studies while the most important differences are in the important exchange of experiences occurring during technical meetings, that practically does not exist in multi-client meetings with large companies, and the fact that there is a continuous cooperation instead of dissolution of the group of companies at the end of the multi-client study.

The generative relationship model in the bottom up approach

During the bottom up approach to cooperation there are some important relations among agents, leaders, catalyst and eco-technician concerning identification of cooperative studies and R&D projects Such studies or R&D projects emerge generally from meetings or direct interviews between catalyst or eco-technician and industrial partners represented by entrepreneurs or managers of concerned firms. Such type of activity, that is an important aspect in the formation of a network of R&D cooperation, may be described using the model of generative relationship elaborated by D. Lane and R. Maxfield (1995, 2006) studying the development of two innovative firms of the Silicon Valley: ROLM in 1975 and ECHELON founded as start up in 1990. Innovative ideas are often considered as the results of individual creativity, however D. Lane and R. ;Maxfield observed that such generation may be also the results of suitable relations of two or more individuals, that not necessarily belong to the same organization, but interact in reaching some common objectives. These generative relations may be described in a general model and innovative ideas may involve various fields concerning for example marketing, commercialization and products or process innovations and, in our case, the generation of R&D projects. These authors defined a certain number of elements and how they interact to generate innovation that are presented below:

Agent: any individual or group of individuals that interact in the system constituted for example by firms, firms departments, representative agents, brokers, clients, researchers, interviewers, etc.

Artefact: any product, process or service designed, produced, exchanged by agents, including projects, financial instruments, communication means and so on.

Attribution: any interpretation that an agent has about himself, the other agents and the artefacts

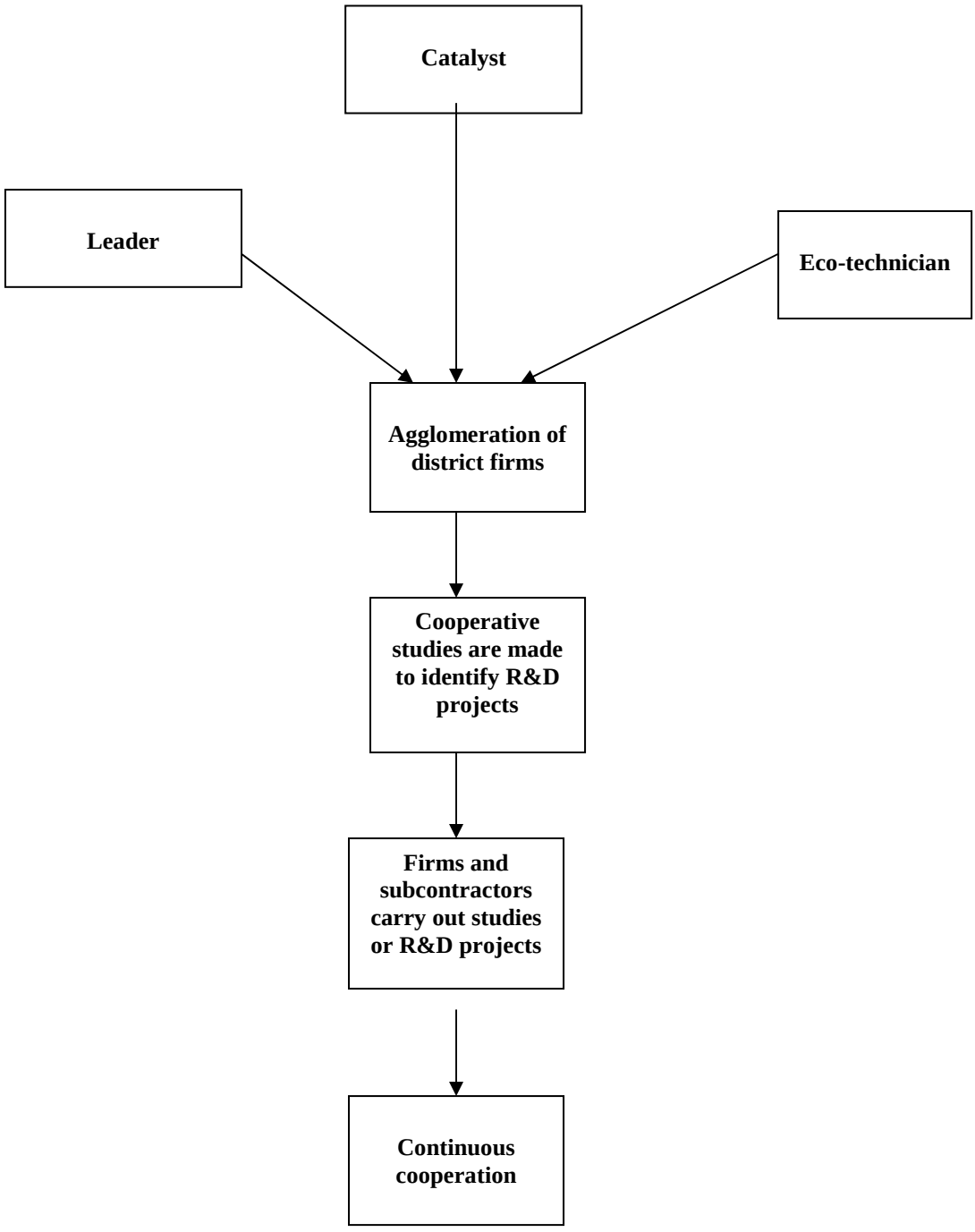

Fig. 3. Schematic view of bottom up structure in the case of the Ruvaris Project

Relations space: structured set constituted by agents operating for the same activity and ideas that they have on artefacts. The structure of this space is constituted by the types of relations existing between agents and artefacts.

Generative relation: relation among agents or also artefacts that is able to induce changes among the parts concerning attributions about agents or artefacts in measure to create new entities (innovations)

The generative process is essentially the following: at the beginning of the relation the agents, that typically do not belong to the same organization, have quite different ideas about an artefact and its attributes. In the generative relation the agents converge in the space of relations toward a common artefact owning shared attributes and resulting in agreed innovation. Considering the specific case of the Ruvaris Project we may consider the case of an interviewer, for example the eco-technician, that discuss with an entrepreneur or a manager of a firm with the aim to define a possible cooperative study or R&D project. We may note that such situation is practically the same when a researcher tries to define a R&D project with a firm manager in order to obtain a research contract. At the beginning the interviewer presents the envisaged study or R&D project and the other party elaborates his own attributes for the exposed artefact. In the case of studies or R&D projects attributes are for example objectives, working programs, duration, costs, benefits, strategic interests, etc. Of course such attributes may not be necessarily the same for the interviewer and the other part and it is normally the task of the interviewer to lead discussions trying to converge to common attributes for the artefact, and new useful ideas for this purpose may emerge by both parts. When successful the generative relation results in common ideas and agreement of the artefact, that may lead to its realization, in our case the study or the R&D project. The changing and converging of attributes of the artefact represents the innovation generated by the relation. There are important implications in leading such type of generative interviews. It is important in fact that at the beginning of the relation there is some defined artefact and not simply description of strength, competences or past experience of its own firm or research laboratory. It is not uncommon that an initially discussed artefact would be deeply modified during the generative relation but it is essential to trigger discussions and convergence of attributes also to a possible completely new artefact. Simple presentation of competences may not generate and converge discussion on any mutual interesting artefact attributes. In the Ruvaris Projects there is an example of such type of evolution by use of the generative relation. In fact the discussions in the initial meeting was about a valve corrosion problem but further it converged to a more important problem of materials and surface treatments and finally to a specific problem of treating brass to eliminate contamination of drinking water with lead.

Strength and weakness of the bottom up approach

As any intervention the bottom up approach has its strength and weakness. Probably the most interesting strength concerns the ability of such approach to generate effective structures and processes in complex systems such as networks of firms in industrial districts. Top down approaches in this case have the inconvenient to introduce structures that are not necessarily well adapted to such complex badly known network. As we defined in the introduction, we call here system any structure with its functioning processes either emerged by a bottom up process or introduced by a top down approach. Another interesting aspect of bottom up approach not often considered is the robustness of the emerged system. We use here a definition of robustness as discussed by E. Jen (2003) in complex systems Robustness means resistance to any perturbation coming from the environment in which the system operates. In our case perturbations may be situations of economic crisis, external strong competitive attacks, appearance of new ruling norms,

etc. Bottom up systems are naturally robust and resist better to any external perturbation as they emerge as consequence of a selective process of Darwinian nature among various possibilities randomly discussed during meetings and selected on the base of a large existing experience. In the top down approach the system is in fact designed to resist to a limited number of perturbations, but that reasonably cannot be all possible perturbations, and its robustness is deeply limited by resistance to perturbations for which it was not designed to resist. Of course that does not mean that all top down introduced systems would fail and all bottom up emerged systems would resist to any perturbation, but such favourable aspect should be considered when carrying out bottom up emergence of structures.

Concerning limitations of the bottom up approach an important one may be the long time necessary to have the emergence of structures in the system. Such long times in our case may be the consequence of long times in taking decisions from a large number of firms or difficulties in finding a suitable leader for the agglomeration and establishment of a network. In the specific case of the Ruvaris Project it takes about ten years from the preliminary meetings to create a company and finally transforming it in a consortium. It should however be noted that such process was not helped by any public aid beside what done at the beginning by Tecnoparco del Lago Maggiore in supporting the starting process. Even the first study carried out was practically entirely financed by participating firms. The availability of public aid financing a deeper activity of contacts and meetings would had surely an accelerating effect on the agglomeration processes but normally such type of activities are not included in any call of proposals for public aid to R&D. Another limitation observed specifically in the Ruvaris Project concerns strategies about choice of R&D subjects for technological innovation. As the consortium is a bottom up structure born in the frame of an industrial district and finally managed by entrepreneurs of SMEs composing the district, it could arise some difficulties in establishing good strategies in R&D, activity in which SMEs are not particularly experienced. That could make delays and uncertainness especially concerning possible support of radical innovations that have high return of investment but also high risk of failure and that should necessarily have medium or long term supported R&D.

Possible generalization of the bottom up approach to other cases

Our bottom up approach, as applied to the case of Ruvaris Project, may be generalized considering the approach as a transfer method from some external practice to a specific case operating in a very different situation, practice, that in our case, was the multi-client method for studies and R&D projects. What we have done in fact was the identification of some processes in the practice that could be used to catalyse the bottom up approach. In our case it was the organization of suitable meetings able to agglomerate interest and to make the emergence of a leader able to advance and manage the process of emergence of a suitable operational structure. Promotion of generative relations during the meetings was also another important factor of success of such approach. Then a bottom up approach in the Ruvaris Project may be considered a transfer operation in which there is not a simple transfer and adaptation of a structure, but use of selected suitable processes of the original structure to emerge a nearly completely new structure. In our case the use of a top down approach transferring the multi-client method, would mean that Tecnoparco del Lago Maggiore should had to take the initiative to make a study proposals and carry out R&D projects for tap and valve industry in its laboratories, under its responsibility and management, that in fact it was not possible as Tecnoparco did not have such capabilities. We present here two possible examples of further applications of bottom up approaches concerning in one case the question of transfer of good practices in promoting science to business bridging between universities and industry and the other one, not involving actually any transfer of practice, concerning the spreading of radical technological innovations, such those that may be generated by nanotechnology, in favour of SMEs.

Promotion of relations between scientific research and business activities is carried out in industrialized countries in various ways such as independent laboratories for contract research, research centres dedicated to specific technical sectors or also specific national agencies charged to promote such relations. For example in Switzerland there is a federal agency called Commission for Innovation and Technology (CTI) that is charged to promote such relations between federal polytechnics, professional universities and industry through a coordinated regional networks including special offices for transfer of technologies, promotion of spin off and coaching of start up companies generated by R&D projects. In Italy there is not any centralized structure of such type and most of R&D support is regionalized and promotion of such relations is carried out by a multitude of small organizations of various type. It would be useful to improve the work of such organizations but it would not be suitable to do for example any transfer and adaptation of centralized structures, such as the Swiss CTI, because of the strong difference in the environment they would operate. However processes occurring in the CTI network could be studied and selected to be used in a bottom up approach making the emergence of some structure among the numerous involved agencies enabling the improvement of their work.

Nanotechnology, differently from genetics, robotics or ITC, is not concerned by specific type f industries but have a very broad spectrum of potential applications interesting almost all industrial sectors. Normally nanotechnologies may be divided, depending by the process, in top down or bottom up technologies. For example the extension of photolithography to production of electronic circuits of nanometric size is a typical top down process. On the other side the growth of carbon nanotubes or other nanometric material on a support or in a medium is a typical bottom up process. It is generally recognized that top down technologies demand high investment in R&D and for production plants justified by large consumer markets, such as that of ITC, and consequently they are suitable only to large companies. On the contrary bottom up technologies may ask much lower investments in R&D and production plants as they may cover small market niches and are well suitable also for small enterprises. Italian SMEs, with their experience in niche markets, is an example of well suitable type of industry for bottom up technologies but for various reasons they do not have an easy access to research and competences existing in Italian universities in the field of nanotechnologies. It is possible to imagine a bottom up approach able to improve applications and diffuse bottom up nanotechnologies. In this case the bottom up approach does not involve transfer of practices but does exploit emergence if innovations from meetings and generative relations. There are various agents that can be involved in such process: first of all university researchers in nanotechnologies that may be interested in industrial applications of their results, agencies for promotion of R&D activities and, of course, SMEs and their possible associations. If it would be possible to organize meetings among such agents in order to develop suitable generative relations, we could have the emergence of leaders and a new structure able to reach these objectives. In fact, the more potentially successful nanotechnologies for SMEs are not necessarily those immediately apparent from research in a technology push action, neither necessarily new ideas of applications coming from SMEs in a market pull situation, but they could emerge by an organized network and generative relations among the various agents interested in such activity.

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