A FCMs approach to promote new business formation in rural areas under uncertainty conditions

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1. Introduction

The promotion of new business formation is generally hindered by several kinds of uncertainties, such as technology, market dynamics and economic constraints. In rural areas, in particular, one of the most relevant causes of uncertainty impeding the success of investments is represented by the lack of active involvement of local stakeholders. In fact, the scarce concentration of financial and human capital available at local level requires the sharing of a common vision capable of attracting such scarce resources into the new investment. The lack of public interest or acceptance may determine the unexpected failure of very promising projects. In this case, uncertainty is not only related with the unavoidable risk of the investment, but originates from the difficulties of achieving the common willingness to cooperate in the project as a mean to pursue individual expectations.

In order to mitigate this kind of uncertainty, a key factor is represented by the acquisition of relevant knowledge on local people's expectations towards the new investment and the convergence of their vision. Divergence of expectation may determine the failure of the project (Geels and Smith 2000; Smith et al. 2005). This approach is coherent with the Cork Declaration, where it is stated that the "... rural development must be local and community driven..." (European Commission, 1996), implying the active involvement of stakeholders in planning, monitoring and evaluating processes, rather than a mere ex-post communication. The basic assumption underlying the so-called participatory approach is that those who live and work in the system targeted of the rural development policy, may be better informed about the best strategies to foster the local economy, that could not be captured by third parties (analysts or policy makers). Therefore, local stakeholders are supposed to be capable of identifying the best actions and, probably the more effective ones.

The aim of this paper is to propose an integrated methodology enabling policy makers to acquire the relevant knowledge from local stakeholders about key elements that may hinder or foster new business formation in rural areas. This knowledge is the basis for the formulation of suitable policy action plan aimed at managing the uncertanty related to project failure since the early stage of the project. The proposed methodology is based on Fuzzy Cognitive Maps (FCMs), which is a semi-quantitative method capable of drawing a clear structure of the causal relationships existing among the most relevant stakeholders' perceptions (expectations and fears). Since the cognitive map is based on a numerical representation, social network analysis can be applied to investigate the knowledge structure, and also to perform simulations of alternative policy actions (Ozesmi and Ozesmi, 2004; Coban and Secme, 2005).

An empirical exercise referred to the introduction of a bio-refinery industry promoted by local development agencies operating in the Apulia region (South of Italy) is presented in the second part of the paper. The results show that even in case of lack of complete information, but with a vague description of the investment features, stakeholders are capable of expressing their perceptions (expectation and fears) and to converge towards a common vision. The analysis performed through the FCMs provides a list of sensitive issues that could support the design of the policy action plan.

The paper is structured as follows. In Section 2 a review of the theoretical backgrounds on the participatory approaches on rural development strategies is presented. The methodology is illustrated in section 3. Section 4 focuses on the empirical exercise, while in section 5 results are presented. Concluding remarks and some policy implications are proposed in Section 6.

2. Participatory approach on rural development strategies

The concept of "participation" in academic literature refers to the involvement in planning and decision-making of those involved in, affected by, knowledgeable of, or having relevant expertise or experience on the issue at stake. The idea of public participation *per se* is not new. Since their first introduction in the 1970s, participatory methods and techniques have largely been applied to support international development and conservation projects in developing countries. The general framework is represented by the Capability Approach, developed by Amartya Sen within which the participatory methods were developed (Kumar Duraiappah et al., 2005). In addition, public participation has also been included as a legislative requirement in natural resource and environmental management plans in developed countries. They are widely applied in the field of environmental management and sustainable development, such as in Agenda 21, where the concepts "integration", "participation", and "information" are the key factors for the achievement of sustainable development (Giupponi et al., 2008).

So far, multiple participatory approaches have been developed in different contexts, including the so-called participatory modeling methods (Maru et al., 2009), that incorporate the perspectives and priorities of the local people in decision-making, policy development and project implementation[1].

In practice, participatory methods are conceived to structure group processes in which non-experts play an active role in order to articulate their knowledge, values and preferences (van Asselt Marjolein and Rijkens-Klomp, 2002). The growing adoption of these methods reflects a continuing belief in a bottom-up approach in which participants becomes agents of change and decision-makers.

Some scholars (Thrupp et al., 1994; Giupponi et al., 2008) argue that participatory methods have many advantages such as facilitating planning of strategies and activities that better meet the needs of people, enabling local people to express their views and planners/policy makers to gain better understanding of local needs and to develop interdisciplinary interaction and integrated views, tending to contribute toward "sustainable development" objectives, enhancing democratic processes and equity in planning and decision-making. The overall advantage relies on the reduction of conflicts and therefore on a higher public acceptance and effectiveness[2].

The literature on participatory methods is abundant. A valuable literature review on this topic can be found in van Asselt Marjolein and Rijkens-Klomp (2002). In particular, some methods aim to uncover a spectrum of options and information, to enable a group to disclose information and to articulate tacit knowledge or to test alternative strategies in a permissive environment. Other methods have the explicit aim to define or single out one perspective, option or strategy. Such methods enable a group to reach an informed decision

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[1]A full review of the various methodologies for public participation is beyond the scope of this paper, but a synthesis of the main approaches at various depth of public involvement is reported in Dalal-Clayton and Bass, 2002; Kumar Duraiappah et al., 2005; Giupponi et al., 2008.

[2]For a more complete view on advantages of participatory approaches see Thrupp et al. (1994).

on an issue. The first goal can be summarised as mapping out diversity, while the latter consist on the attainment of the consensus (van Asselt Marjolein and Rijkens-Klomp, 2002).

Regarding the most recurrent techniques in literature, it is possible to distinguish among the followings: focus groups, scenario analysis, scientists stakeholder workshops, policy exercises, participatory modeling, citizens' juries, consensus conferences, and participatory planning (van Asselt Marjolein and Rijkens-Klomp, 2002).

In particular, a specific form of participatory approach is Participatory Modeling in which the formalization of a model is the medium for representing and communicating ideas. This approach assumes that the engagement of non-scientific knowledge, values and preferences will improve the quality of development strategies formulation by considering a wider range of perspectives and options that would not be captured by scientists and policy makers (van Asselt Marjolein and Rijkens-Klomp, 2002; Voinov and Brown Gaddis, 2008). The formalization of this model is carried out by experts with the direct involvement of stakeholders by means of various techniques such as cognitive mapping, causal loop diagrams, creative system thinking and brainstorming, etc. (Giupponi et al., 2008).

In this paper, the proposed integrated approach is based on the combined use of cognitive mapping, social network analysis and neural networks simulations.

3. Methodology

A large variety of tools and methods are available to tackle the complexity in economic studies (artificial neural networks, genetic algorithms, non linear equation systems and agent based modelling). With the specific reference to new business formation in rural areas we adopted the FCMs

FCMs is a participatory method rather easy to be adopted, since it is understandable also by non-professionals, it has a high level of integration (needed for the complex issues related to rural development), it can be performed in a short time, and gives a system description. The main advantages of FCMs, with respect to other semi-quantitative methods or qualitative modeling methods are described in van Vliet et al. (2010). In particular, we will focus on some specific aspects. First of all, FCMs are easy to build from the knowledge of participants (Coban and Secme, 2005). They are very powerful in dealing with dynamic systems (since their structure is based on variables and mutual relationships existing among them) and allow drawing a comprehensive picture of the elements of the problem under analysis. Secondly, FCMs deal with qualitative information which can be obtained at local level, allowing the researcher to overcome the lack of reliable quantitative data. Thirdly, although the method does not provide any prediction in quantitative terms, it is suitable for providing support for long run simulations performed by identifying the most relevant variables affecting the whole system (Ozesmi and Ozesmi, 2004).

Basically, FCMs can be conceived as semi-quantitative models describing how a given system works (Ozesmi and Ozesmi, 2004). In technical terms, FCMs are signed fuzzy digraphs made of variables (e.g. concepts, events, project resources) with causal relations among them. The idea behind this logical structure is the fuzzy logic, which is a general name for logical theories that attempt to apply the principles of logical thinking on fields where the classical logic seems inappropriate. Cognitive maps have been introduced for the first time by Tolman (1948) as an application for psychology research. Later, FCMs have been applied in several fields, such as anthropology, to represent different social communities in human society (Hage and Harary, 1983), to study the relationships among benthic organisms (Puccia, 1983), or to model policy scenarios (Axelrod, 1976). More recently, Ozesmi and Ozesmi (2004) built a model to study the effects of institutional changes on a lake ecosystem, based on the perception of local stakeholders. Coban and Secme (2005) modelled the effects of privatisation policies on the distilled alcohol sector of Turkey, based on the perceptions of the employees of alcohol factories, civil servants, and other social groups.

In this research we used an integrated approach based on the following methodological steps:

a. Building the social cognitive map with a participatory approach;

b. Analyzing the structure of the social cognitive map by means of social network analysis;

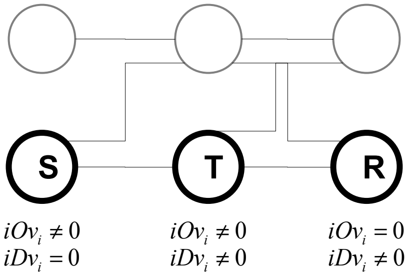
c. Simulating different policy scenarios by means of neural network.

3.1 Building the social cognitive map with a participatory approach

In order to draw the cognitive map involvement of stakeholders is required. As highlighted by van Asselt and Rijkens-Klomp (2002), stakeholders can be involved in two fundamentally different manners, indepth interviews, where stakeholders are questioned individually, and focus groups, where the emphasis is on the added value of discussing issues in a group setting. According to **Stewart and Shamdasani (1990), who** argue that this method is most appropriate where relatively little is known about the issue, in this research we adopted the focus groups technique. A focus group is a planned discussion among a small group (4–12) of stakeholders facilitated by a moderator and designed to obtain information about preferences and opinions in a non-threatening environment. In focus groups scientists play the role of facilitator or observer.

In the building of a social FCMs, the participant are asked to identify individually some relevant variables related to the issue under investigation. Then, a participatory discussion section is carried out on the relevance of each variables mentioned. Once the participants reached a sufficient consensus on the meaning of each concept, they were asked to code the concepts expressed into a concise form in order to achieve a compromise between the preciseness required by the logical definition of concepts, and the unavoidable vagueness of natural human language. Finally, participants were asked to specify the causal relationships among every variable and their intensity according to three increasing degrees: weak, moderate, and strong. The final outcome of the participatory meeting was the FCM in graphical form, representing the starting point for the network analysis (see Figure 1).

Figure 1 – An example of FCM with three types of variables



Note: S senders; T transmitters; R: receivers.

3.2 Social Network Analysis on cognitive maps

In order to analyze the structure of the social cognitive map we used the social network analysis (SNA) (Wasserman and Faust, 1994). It is based on the graph theory and is considered the key technique in organisational studies. The first step is to apply a scoring method to transform the value attached by the interviewees to the relationships between the variables indicated, in a real number in [-1,1] (Kosko, 1986). The second step is representing the map in the form of the so called *adjacency matrix* (Harary et al., 1965) formed by the intersection of the variables identified by stakeholders. The structural features of this matrix can be analysed by means of punctual and network indexes.

The punctual indexes allow to understood the role of each variable. Specifically, it is possible to distinguish three types of variables (Coban and Secme, 2005; Lopolito et al. 2010): (1) senders (also called forcing functions, or givens, or tails), which send stimulus toward other variables (positive out-degree) but do not receive it (zero in-degree); (2) transmitters, which both receives and transmits relations, they are the connecting fabric of the system; and (3) receivers (also called utility variables, or ends, or heads) that have a positive in-degree and zero out-degree.

The network indices describe the features of the whole network features. The most basic are the number of variables (N) accounting for the whole dimension of the system; the number of connections (C), describing the total interaction activities among variables; the density, that is calculated as the ratio of the number of connections present (L) to the maximum possible, it varies between 0 (no connections are present) and 1 (all possible ties actually exist); the index of complexity, calculated as the ratio of the number of receiver to transmitter variables (R/T). Complex maps will have larger ratios, because they define more utility outcomes and less controlled forcing functions.

3.3 Neural network simulations

The simulation is carried out using the auto-associative neural network method (Reimann, 1998). This methods does not concern the structure of the system but its outcomes and dynamic. Following this method, the value of each variables (C_i) in an iteration (t) can be computed as:

[1] $$C_i^t = f\left(\sum_{j=1}^{n} C_j^{t-1} w_{ji} + C_i^{t-1}\right)$$

where C_i^t and C_i^{t-1} are respectively the value of the variable C_i at end of the iteration and at its beginning, C_j^{t-1} is the value of concept C_j at the beginning of the iteration, w_{ji} is the corresponding weight between variables C_j and C_i, and f is a threshold function that transforms the result of the multiplication in the interval [0,1] wherein concepts take values (Yaman and Polat, 2009). Usually it is used the logistic function that assumes the form 1/ $(1+e^{-1x})$. As pointed out by Ozesmi and Ozesmi (2004), this non-negative transformation allows for a better understanding of activation levels of variables and allows a qualitative comparison among them. The simulation starts attaching a specific value (usually 1) to the initial state of C_i. The iteration is repeated until the system does not converge to a fixed point (i.e. steady-state). Different policy scenario can be also compared trigging the variables that can assume the role of policy instruments in order to evaluate their influence on the rest of the system. Several policy mixes can be ran clamping the value of different variables.

4. Case study

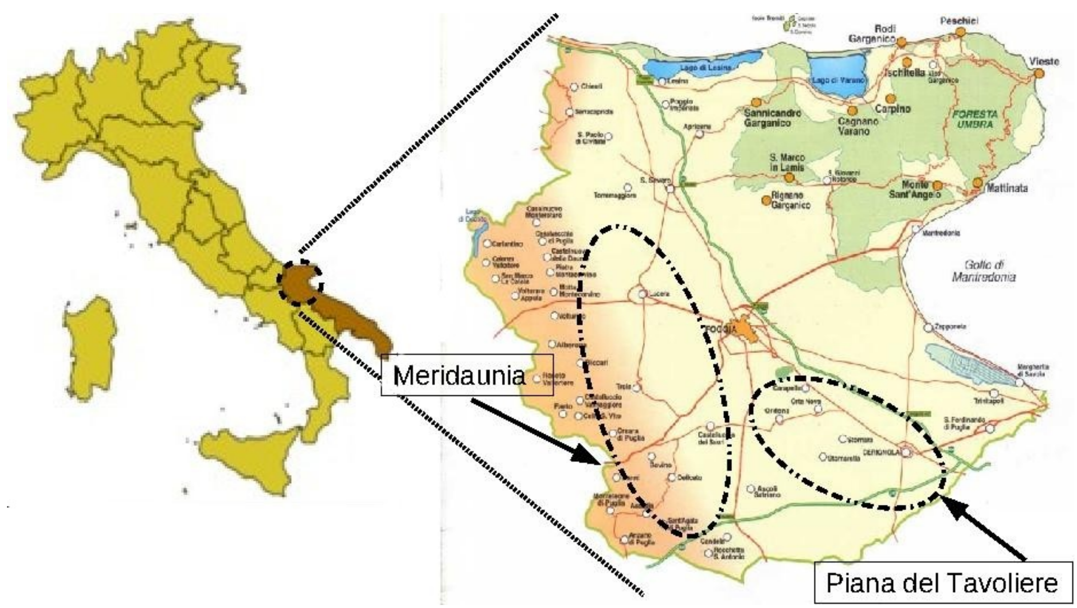
The province of Foggia is an administrative district in southern Italy, covering an area of 7.741 km², with about 640,000 inhabitants. The population density is about 83 inhabitants per km². During the period 2001-09 the demographic trend has been negative (-1.3%) per cent. The territory shows a low level of income per capita, much lower than the national average. This area is affected by three main problems: a low employment level, lack of international openness, and territorial imbalances.

This is a farming area, with 500,000 hectares devoted to agriculture, with 30,000 farms. The main crop is represented by cereals and, in particular by durum wheat. Another relevant crop is represented by tomato. The tomato industry is one of the main manufacturing activities of the province which is the leading national territory.

In this context, the promotion of a new business based on bio-refinery industry appears as a promising opportunity, due to the abundance of raw materials from the agricultural sector, and the growing demand of green products (e.g. ecological packaging, substitutes of plastic, biofuels).

The investigation was conducted in January 2011, in collaboration with three local development agencies: the Province of Foggia, the Meridaunia Local Action Group (LAG), and the Piana del Tavoliere LAG.

Figure 2 – Location of Foggia (Southern Italy)



The Province of Foggia was chosen because it has competencies on planning and land management on administrative NUTS level III “Foggia”.

Therefore, from its involvement in the study we expect to acquire an overall vision about the rural development strategies for the whole territory.

On the contrary, we considered the two LAGs since they are public-private subjects, representing the spectrum of interests and positions of stakeholders operating on a restricted area, which is likely eligible to host the bio-refinery settlement.

In particular, the Sub-Appennino Dauno LAG is located in a mountainous area, characterized by a severe emigration flow and aging of the current residents. The main activity is the agriculture, particularly based on the cultivation of wheat and on the rearing of goats and sheep.

The Piana del Tavoliere LAG operates in a flat and fertile agricultural area devoted to intensive cultivation especially wheat, tomatoes, grapes, olives, artichokes, peaches. These agricultural commodities have stimulated the development of the a flourishing and prosperous food processing sector.

The focus groups have been conducted with qualified members of the local community, representing the interests of the most involved categories: farmers, industrial entrepreneurs, consumers, environmental groups, political parties, scientists, extension services, and journalists. The number of participants have been the followings: 10 in group 1; 9 in group 2; 7 in group 3. The discussion was conducted with a broad introduction aimed at providing the basic definition of the bio-refinery industry, followed by a brainstorming of the most relevant issues related to its (eventual) settlement in the area of study, and an open discussion about the relationships existing among these concepts. The overall duration has been approximately of about 1.5 hours.

5. Results

5.1 Stakeholders' perceptions on bio-refinery industry

The focus groups allowed us to draw the three different cognitive maps. Although the graphical representation is rather clear and immediate, a synthesis of the features of each map is performed through a social network analysis tool, whose results are presented on Table 1.

Table 1 – Key social network features of the FCMs

Characteristics	**Foggia (n=10)**	**Bovino (n=10)**	**Cerignola (n=7)**
No. of variables	27	17	14
senders	5	3	3
transmitters	11	10	10
receivers	11	4	1
Complexity: Ratio No. of receiver / No. of senders (R/S)	2.20	1.33	0.33
No. of connections	34	28	24
Density	0.047	0.097	0.122

Group 1 (Foggia). The map is formed by 27 variables, which are classified into 5 senders, 11 receivers and 11 transmitters, and 34 weighted links. The low density of the network (0.048) means that stakeholders represent only a small part of the possible connections. Since receivers are much more numerous than senders, a high degree of complexity emerged (2.2). Another feature of this map is the great number of transmitters, which play a relevant role in spreading the stimulus produced by senders to the whole network. The insight is that local system is unstable and that it can be easily changed.

Group 2 (Bovino). There are 17 variables, three of which are senders, 10 are transmitters and four are receivers. These are closely connected (28 connections) denoting a system with a relatively high density (0.097) equally distributed among the variables. This denotes a stable system, resistant to exogenous pressures. The network shows a medium level of complexity (1.33) due to the fact that senders and transmitters are balanced.

Group 3 (Cerignola). The system is formed by 14 variables, which are closely interconnected (density = 0.12). The degree of complexity is the lowest (0.33), with three senders and only one receiver. However, the system has 10 transmitters and 24 connections. This structure allows the propagation of a stimulus to the whole system.

On the whole, the three groups identified 41 variables concerning economic, social and environmental issues (table 2). Among these, four have been mentioned from all the three groups. These are the following:

Technological innovation. It fosters innovation and human capital enhancement. It is conceived as a transmitter by all the three groups, and it is one of the most central variables influencing the rest of the system for groups 2 and 3. It is directly affected by the fostering of the bio-refinery, and in the perception of groups 2 and 3, by public information and research.

Table 2 - Variables identified by stakeholders

N.	Variable	Foggia	Bovino	Cerignola
0	*Development of bio-refinery industry*	x	x	x
1	*Technological innovation*	x	x	x
2	*Transport costs (and collection)*	x	x	x
3	*Induced industrial development*	x	x	x
4	*Job opportunities*	x	x	x
5	*Public information*	x		x
6	*Enhanced use of regional agricultural vocation*	x	x	
7	*Participatory in public decision making (Social Capital)*	x	x	
8	*Valorisation of residues and wastes*	x		x
9	*Agricultural sector profitability (diversification)*	x	x	
10	*Environmental pollution*		x	x
11	*Research*	x	x	
12-41	*Others*	x[a]	x[b]	x[c]

Note: Specific variables for each group: (a) Subsidies for bio-refinery; Competition between food/non food crops; Geographic dispersion of biomass; Availability of biomass from spontaneous species; Industrial diversification; Economies of scale; Land use change; Market distortions; Concerns towards the new industry; Biomass supply from dedicated crops; Consumer goods prices; Territory's reputation; Loss in residents' well-being; Dispersion of bio-refinery plants; Concentrated bio-refinery settlements; Loss in competitiveness of firms not involved; Technological transfer; (b) Human capital; Environmental protection laws; Scarce accessibility of available biomass; Marketing of bio-refinery products; Environmental awareness of local population; Competition from foreign biomass sources; Local value added; (c) Concerns about soil fertility; Social and cultural inertia (habits and beliefs); Development Agency; Bonding social capital; Extension; Local development.

Cost for collection and transport of biomass. It is one of the most important variables that can hinder the development of the bio-refinery project. It is viewed as an external threat by groups 2 and 3, but is considered modifiable by group 1.

Induced industrial development. These variables includes all the industrial activities that can be activated by the new project. It is conceived as an effect by group 2, while group 1 and 3 conceive it as a transmitter that can be stimulated and can stimulate other parts of the system at the same moment.

Job opportunities. It is the most cited social impact of bio-refinery development project. It is perceived as relevant by all the groups and is considered a receiver for group 1 and a transmitter for groups 2 and 3. In these latter cases, job opportunities is among the most important aspects affecting the demographic trend, that is one critical aspect in rural areas.

Other important variables cited twice are public information, enhanced use of regional agronomic vocation, participatory in public decision making (social capital), valorisation of residues and wastes, agricultural sector profitability (diversification), environmental pollution and research.

5.2 Policy simulation

The scope of simulation is to find, for each group, the variables susceptible to play as affective policy tool. In this study we assume that, in order to foster development in rural areas based on new business formation, the main policy objective is the development of bio-refinery. To this purpose, we used a FCMs simulator[3] to measure the impact of the strengthening or weakening of each variable forming the map, on the bio-refinery development (Ozesmi and Ozesmi, 2004; Coban and Secme 2005) for the three groups observed. The results of the simulation are summarized in table 3.

Table 3 – Identification of policy measures

Foggia	Bovino	Cerignola
- Subsidies for bio-refinery (+++) - Competition between - food/non food crops (+++) - Availability of biomass from spontaneous species (+++) - Enhanced use of regional agronomic vocation (+++) - Economies of scale (+++) - Geographic dispersion of biomass sources (*) (+++) - Concerns towards the new industry (*) (+++) - Public information and stakeholders training (++) - Technological innovation (++) - Participatory in public decision making (++)	- Environmental protection laws (++) - Marketing of bio-refinery products (++) - Transport and gathering costs (*)(++) - Scarce accessibility of available biomass (*) (++) - Technological innovation (+) - Human capital (+)	- Transport and gathering costs (*) (+++) - Concerns about soil fertility(*) (+++) - Social and cultural inertia (habits and believes)(*) (+++) - Bonding social capital (*) (+++) - Public information (+++) - Valorisation of residues and wastes (+++) - Development Agency (+++) - Extension (+++)

Note: (*) Policy action consisting on the weakening of the variable

As reported, for each area a characteristic action plan has emerged. Specifically, the group of Province of Foggia seems more oriented to the economic management of the project. Indeed, the most part of the drivers emerged relates to financial (subsidies) or natural resources (Competition between - food/non food crops; Availability of biomass from spontaneous species; Enhanced use of regional agronomic vocation; Geographic dispersion of biomass sources). Also Economies of scale are viewed as exerting an

[3] The software used in this work is FCMappers (http://www.fcmappers.net). FCMappers is a non registered network founded by Michael Bachhofer and Martin Wildenberg.

important role on bio-refinery development (+++). Some technological (innovation) and social (concerns, participation, information) issues are also considered with a minor role.

In the case of Bovino, one of the most important concern relates technological divide. Indeed innovation and human capital have emerged as possible drivers. May be this group is particularly aware of the local technological gap. Also the role or law and marketing are considered.

In the case of Cerignola, the central role is played from social issues (concerns, social inertia, bonding social capital, information). Other specificities are the role of local development agencies, and the importance of the extension services that can exert their influence on social issues.

6. Concluding remarks

In this paper we stressed the relevance of knowledge gained from local stakeholders' perceptions to reduce the uncertainty related to the introduction of new business in rural areas. This view is coherent with the Cork Declaration which emphasizes the participatory approach to pursue a bottom-up model to foster an effective and sustainable socio-economic rural development. Policy makers are enabled to select the most suitable and acceptable action plans. This is particularly important in rural contexts where local resources are limited and interdependent (i.e. no actors have sufficient power to unilaterally determine the success of the new project) and the risk of dispersion due to the uncertainty of the novelty is high.

The empirical exercise we conducted, has demonstrated the suitability of the integrated adoption of FCMs and Social Network Analysis, as a tool to map the stakeholders' perceptions and to identify the more appropriate policy action plans fitting the needs of the local communities.

The semi-quantitative nature of cognitive maps allows stakeholders to express their perceptions by interacting each other through natural language. In addition, the numerical representation of the cognitive map provides the basis to mathematically identify the most sensitive drivers and to simulate policy scenarios for the project deployment.

Considering that EU strongly emphasizes the role of the involvement of the local communities, of which LEADER Programme represents one of the most successful experiences, the proposed methodology seems to provide an operative tool supporting local development agencies (e.g. Local Action Groups) in the design of local development strategies.

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