CONTRIBUTION OF SOCIAL NETWORK ANALYSIS FOR EVALUATING IMPACTS OF SCIENCE-BASED RESEARCH AND INNOVATION PROGRAM: THE EXAMPLE OF THE FARMERS' CONVERSION TO ORGANIC CROP PRODUCTION IN CAMARGUE

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INTRODUCTION

This paper aims to demonstrate the interest of performing a Social Network Analysis (SNA) for ex-post evaluating Impacts of Science-Based Research and Innovation program (ISRIP) in the agricultural sector. In the EU funded IMPRESA project[1] (Impacts of Research on EU Agriculture), the approach of "ISRIP Pathway Analysis" was developed to assess the role of agricultural research based innovation (Quiedeville et al., n.d.). The "ISRIP Pathway Analysis" approach is based on the Participatory Impact Pathway Analysis (PIPA); and the conduct of stakeholders' workshops (with researchers, funders, institutions, extension services, and farmers) is the guiding thread of it. The approach comprises a central workshop dedicated to the evaluation of the research program (set of projects) under review. In this workshop, stakeholders are asked to reconstruct the theory of change of the research program by identifying changes (outcomes) and defining the way they happened (via research activities, outputs, etc). The "ISRIP Pathway Analysis" approach includes a Social Network Analysis (SNA), among other complementary methods to PIPA, but the rationale of conducting a SNA needs to be further reflected. We explore this through the case of the transition to organic farming in Camargue, which was performed in the IMPRESA project as one of the six case studies conducted.

In the context of ex-post evaluating ISRIP, we made the hypothesis that SNA aids (as part of the "ISRIP Pathway Analysis" approach) to understand how new techniques or products are spreaded and thus to help draw conclusions on the impacts and role the research in the whole process. We concentrated ourselves on SNA, which is in line with the concept of innovation system (Lundvall 1992; Touzard et al. 2014) that challenged since many years the classical mode 1 of linear knowledge transfer by Gibbons et al (1994).

THE CAMARGUE CASE

The Camargue territory is situated in the south east of France over an area of some 145,000 ha. Rice is the main production cultivated and organic agriculture started in the eighteens. At that time no specific value chain was dedicated to organic products, but the trader SARL Thomas has given up to conventional farming in 1990 (it handled around 6,500 tons of rice) to actually concentrate on organic crop production. The co-operative SudCéréales also positioned itself on the organic market but marginally, and the firm BIOSUD has been founded in 2003 with the goal of organizing the organic value chain in a single common objective of negotiating and selling products through a specialized company. In 2000, the National Institute of Agricultural Research (INRA), the International Centre of Agricultural Research (CIRAD) and the French Centre of Rice (CFR) have launched a research program in order to develop organic crop production systems in Camargue. This research program was evaluated in the IMPRESA project.

METHODOLOGY

SNA INDICATORS

The SNA indicators of betweenness, clustering coefficient, density, and "degrees" were chosen to help analyze the impacts and role of the research in the Camargue case. We hypothesized that the identi-

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1   For more details, refer to: http://www.impresa-project.eu/home.html.

fication of actors with a high betweenness is of particular interest, as those actors are likely to be knowledge brokers (Haythornthwaite 1996). Indeed, "the betweenness of a point measures the extent to which an agent can play the part of a "broker" or "gatekeeper" with a potential for control over others" (Scott 2000). The clustering coefficient of an actor is the quotient of its level of connectivity among its neighbors on the total possible number of connections that may occur between those neighbors. Its calculation intended to define whether the different actors are connected to a structured organization; thereby to help understand the evolution of actors' position in the whole network and whether the research has played a role in it. More generally, we assumed that the clustering coefficient can aid to estimate how resilient and robust the actor network is as well as its capacity to support innovations. The density (average number of relationships among actors) could be seen as an economic performance indicator through enhancing information flow (Vurro, Russo, and Perrini 2010). Finally, the "degrees" allow examining the evolving strength of connectivity from one actor to another; and could help to understand how the research system has contributed to the change. The table 1 summarizes how SNA data were collected and analyzed. Three steps have been followed: (1) Face-to-face interviews; (2) generalization of the sample; and (3) calculation of SNA indicators.

order to ameliorate future research programs. However this approach may lack scientific rigor if the different information gathered would not be further explored and validated by identifying clear evidences (e.g. from reliable available documents, official statistics, etc). This is why the process tracing method was applied as part of the "ISRIP Pathway Analysis" approach in the Camargue case. In a nutshell, it intends to evaluate whether the first and second event of each pathway link actually occurred; if the link can be explained by an underlying mechanism; and if the second occurrence of the link was due to other factors. This procedure also applies to pathway links specifically related to relationships issues. Given the complexity of the procedure, the "ISRIP Pathway Analysis" approach provides the opportunity of organizing all the information in a so-called "table of links" (see table 2). The origin (first event) and destination (second event) of the pathway links are specified in the first two columns, whilst the other columns relate to underlying mechanisms and alternative explanations.

Table 1: Collecting and analyzing of SNA data

SNA steps	Target(s)	Explanations
Face-to-face interviews	Researchers from INRA and CFR Respondents from private traders 11 farmers (7 partial-organic and 4 organic)	We asked for useful relationships (information flow, financial exchanges, and collaborative ties) around organic agriculture An intensity score from 0 to 3 was set Six times periods were considered over the years 2000-2014
Generalization of the sample	The population (all organic farmers, researchers, extension services, and rice traders)	We did a simple transposition of the sample of 11 farmers, which was representative, to the population (35 farmers). The interest of generalizing the sample was to ensure that stakeholders are not under or over represented in the network.
Calculation of SNA indicators	Betweenness Clustering coefficient Degrees	Calculation of the indicators by the UCINET software (Borgatti, Everett, and Freeman 2013).

TABLE OF LINKS

The "ISRIP Pathway Analysis" approach is of participatory nature and actively involves stakeholders in the evaluation process of the research program and innovation under review. The rationale of this is mainly to increase the plausibility that stakeholders will use evaluation results in

Table 2: Blank table of links

Pathway links		Description of the underlying mechanism(s)	Alternative explanations of the mechanism(s)	Validity of the alternative explanations
Origin of the link	Destination of the link			
Example: Activity 1 (name to be specified)	Example: Output 1 (name to be specified)	*Specify the most relevant evidences as to how the first event of the link has led to the second occurrence*	*Specify the plausible alternative explanations to the link*	*Yes or no* *If yes, specify its importance*

Source: (Quiedeville et al., n.d.).

RESULTS

We have done five SNA tests on the basis of stakeholder's statements. Below we summarize the four more important ones (out of five).

TEST 1:
GROWING INFLUENCE OF INRA IN THE NETWORK.

The first suggestion made was that some research activities (mainly undertaken by INRA) have led to an increase of the influence of INRA in the network. The SNA has allowed to confirm this. The betweenness score of INRA has evolved from 370 in 1999 and 415 in 2006 to 542 in 2014. Furthermore, we can confirm the hypothesized underlying mechanism. In effect, we observed growing relationships between INRA and farmers, with an increase of around 80% in their bilateral "degrees" over the years 1999-2014. That said, these bilateral relationships started to increase in the year 2005, which means that the CEBIOCA project (the first research activity done about an agronomic diagnosis) did not play a significant role. First experimentations in farming plots and the participatory training sessions have boosted the interactions between INRA and farmers. One of the alternative explanations hypothesized was the increase in relationships between the neighbors of INRA, as it could also explain the growing centrality of INRA in the network. This hypothesis was validated, as we observed a growth of 60% of the clustering coefficient[2] of INRA (from 0.1 in 1999 to 0.16 in 2014). As a result, the SNA does not fully corroborate what the stakeholders claimed in workshops. It appears that the research and disseminations activities done by INRA were not the only factors explaining its growing influence in the network around organic farming in the Camargue.

TEST 2:
INFLUENCE OF CIRAD IN THE ACTOR NETWORK.

The second suggestion made was that some research activities have led to a growing influence of CIRAD in the network. The SNA has allowed to confirm the growing influence of CIRAD within the network. During the time span of the program, the betweenness of CIRAD has increased about 34% from 1999 to 2014 and the average "degrees" around 61%, whereas the average "degrees" only increased about 29% in the entire network. Furthermore, the hypothesized underlying mechanism was also confirmed. In effect, relationships between CIRAD and farmers were growing, which is revealed by an increase in the bilateral "degrees" about 45% (from 11 over the years 1999-2010 to 16 in 2014). However two alternative explanations were confirmed. The first is the increase in relationships between CIRAD and SudCéréales as well as between CIRAD and INRA. The second is the growing interactions between the neighbors of CIRAD. This is illustrated by a growth of 60% of the CIRAD's clustering score (from 0.2 in 1999 to 0.32 in 2014). This situation raises the complexity of the innovation network and the importance of the role played by complex interrelationships among various actors.

TEST 3:
STRUCTURING OF THE ACTOR NETWORK.

The third suggestion made was that the increasing influence of both INRA and CIRAD have developed the exchanges and links in the network about transition to organic farming. The hypothesized underlying mechanism i.e. INRA and CIRAD have become knowledge brokers for the transition to organic farming, was corroborated by their higher betweenness.

TEST 4:
ADOPTION PROCESS.

The fourth suggestion made was that the structuring of the network has contributed to the adoption of organic farming and to crop rotation development (useful incremental innovation to switch to organic farming). The main hypothesized underlying mechanism was the development of information sharing between INRA and farmers, which was confirmed by the previous tests done. A main alternative explanation was the possible presence of peer-to-peer exchanges between farmers. In fact, the vast majority of the farmers could not find any relevant relationships with their colleagues as concerns organic crop production.

With respect to impacts on the organic actor network, note that we observed an increase of 44% and 50% (since 2000) of the clustering coefficient and the density, respectively.

DISCUSSION AND CONCLUSION

The SNA approach contributed successfully in the evaluation of IS-RIP. Particularly, it has allowed the different hypothesized pathway links on relationship issues to be deeply examined.

The SNA could not tell by itself what the effects of receiving information on the actors are and if their behaviors have changed and through which mechanisms. We had to make the assumption that changes in actors relationships were correlated to the evolution of the innovation. We could set this assumption since we only considered relevant relationships for organic farming.

However, SNA was very interesting for confirming or contradicting stakeholders' statements on relationships issues. Therefore we see SNA as a good way to triangulate the different information collected and increase the plausibility that we draw accurate conclusions regarding the impacts and role of the research as well as on the way the innovation pathway occurs. Finally, the SNA suggests that research on Camargue organic crop production has implied the actor network to be both more resilient and likely to support development of further innovations towards sustainable food systems.

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2   Individuals with high clustering coefficients (central actors) are linked to actors who are well connected together.

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