The Influence of Communication Frequency with Social Network Actors on the Continuous Innovation Adoption: Organic Farmers in Germany

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Paper prepared for presentation at the 131st EAAE Seminar 'Innovation for Agricultural Competitiveness and Sustainability of Rural Areas', Prague, Czech Republic, September 18-19, 2012

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Abstract: This study investigates previously experienced farmers' adoption behavior of Agri-Environmental Measures (AEM) in Central Germany. We consider organic farmers as previously experienced with AEM as they already have practiced the environmental management standards for organic farming. The logit model is used to explain the influence of communication frequency on the probability of adoption of other environmental measures as a continuous innovation. Social network analysis is carried out to investigate the role of attitudes towards information sources. Our findings demonstrate the influence of communication frequency with interpersonal network actors (agricultural organizations and neighborhood farmers) on continuous innovation adoption in three ways: First, the communication frequency of organic farmers with both agricultural organizations and neighborhood farmers does not influence the original farmer's decision to adopt AEM. Second, a higher education level of frequently communicated neighborhood farmers increases the probability of farmers' AEM adoption, while the innovativeness of frequently communicated farmers does not. Third, inside the population of frequently communicated organic farmers, formal information sources (agricultural organizations) are considered as more important information sources about agricultural issues than are informal sources (other farmers).

Key words: Interpersonal communication network, communication frequency, innovation adoption, agri-environmental measures

1 Introduction

Agri-Environmental Measures (AEM) are the key instruments of European agricultural and rural policy. To reinforce environmentally friendly farming practices, significant parts of the Common Agricultural Policy (CAP), as well as national funding, are dedicated to supporting agri-environmental (AE) practices. This AE support is paid annually to farmers, who decide voluntarily to carry out their activities in a manner that goes beyond usual good farming practices and is deemed environmentally beneficial (Article 248(4) of the EC Treaty). Most importantly, since 2005 these supports have introduced cross compliance conditions linking direct payments with standards concerning the environment, food safety, and animal and plant health. These voluntary and cross compliance measures promote adoption through raising awareness of the importance of the environment amongst farmers. Within this context, more farmers adopted AEM.

To explain the adoption behavior, many studies have investigated the farmer's decision-making process by focusing on innovation and the adoption of technology. The study done by Ryan and Gross (1943) is generally accepted as the starting point of research on innovation diffusion in rural areas; their study describes "diffusion" as a process that aims to reduce uncertainty among potential users. According to Rogers (2003), adoption begins with sharing information with potential users through two main channels: mass media and interpersonal communication channels. Interpersonal communication channels represent information sharing by people in a face-to-face situation.

In the research field of innovation adoption, there is an increasing number of studies that recognize the importance of social networks, particularly the influence of interpersonal communication channels on farmer's behavior (Conley and Udry 2001; Bandiera and Rasul, 2006; Matusche and Qaim, 2009; Hartwich, Fromm and Romero, 2010). The main research works in this field have highlighted the importance of the interpersonal communication network actors on information support. Only few studies on the adoption of AEM were published that investigate the influence of being previously experienced on environmental

practices (Vanslembrouck, Van Huylenbroeck and Verbeke, 2002; Defrancesco et al, 2008). To our knowledge, the influence that communication frequency with a network has on continuous innovation behavior[1] actors has not yet been studied.

This study investigates the adoption of AEM to illustrate the adoption of innovation among previously experienced farmers. We consider organic farmers as being previously experienced with AEM as they already practice the environmental management standards for organic farming. In our study, a closer look at organic farmers located in Central Germany is carried out. The main aim of the study is to contribute to understanding the influence different aspects of communication with interpersonal communication actors has on adoption decisions. First, we analyze the influence of communication frequency with interpersonal network actors on the continuous adoption of AEM among organic farmers. Second, we study the influence of communication partner characteristics such as education and innovativeness on AEM-adoption decisions. Third, we analyze the question of whether there is a correlation between communication frequency and considering the communication partner as an important source of information on agricultural issues.

The paper is structured into six sections. In the following section, we develop the research framework on the role of interpersonal communication networks in adoption behavior. Detailed information on the studied data set is provided in the third section. Sections four and five describe the methods applied (logit model and social network approach) and the results, respectively. The results are discussed and conclusions are derived in the last section.

2 Review

Adopting AEM is a complex decision process. Previous studies show that many factors can influence the process of adoption, for example: characteristics of farm and farmers (Crabtree, Chalmers and Barron, 1998; Wynn, Crabtree and Potts, 2001; Polman and Slangen, 2008), the influence of a person that promotes innovation (Chatzimichael, Genius and Tzouvelekas, 2011), environmental influences (Morris and Potter, 1995; Sutherland et al, 2012), the design and requirements of policy measures (Dupraz, Latouche and Turpin, 2009; Beckmann, Eggers and Mettepenningen, 2009; Fraser, 2012; Vanslembrouck, Van Huylenbroeck and Verbeke, 2002), and communication networks (Lowe and Cox, 1990; Black and Reeve, 1993; Morris and Potter, 1995; Skerratt, 1998; Deffuant et al, 2001; Prager, 2007).

Environmental conservation can be seen as an innovation by farmers (Black and Reeve 1993; Deffuant et al, 2001). Valente (1995) defines diffusion of innovation as the "spread of new ideas, opinions, or products throughout a society, thus diffusion is a communication process in which adopters persuade those who have not yet adopted to adopt." This definition is mostly used in the adoption of AEM studies as an idea that shows the relevance of innovation diffusion theories.

Interpersonal influence is defined by Cartwright (1965, p.3) as the "modification of one person responses by the action of another." In that perspective, interpersonal influence is one of the most important variables explaining the importance of communication flows in the diffusion of innovation in rural areas.

Interest in studying interpersonal communication started in the early 1950s with Barnes (1954). The main aim of subsequent studies was to analyze how relations between actors influence their behavior. The concept of interpersonal network was broadly applied in studies on innovation diffusion. Indeed, a number of studies were published analyzing who influences whom within the community about innovation adoption (Rogers and Beal, 1958; Coleman et

[1] In the study we accepted the concept of continuous innovation as a continuous improvement on AE farming practices by adopting the definition of "continuous innovation builds on previous knowledge without massive amounts of new knowledge," (Sonnino et al, 2009).

al, 1966; Valente and Rogers, 1995; Nutley, Davies and Walter, 2002; Albronda, Langen and Huizing, 2011). An interpersonal network unites actors who frequently communicate in ways that allow them to achieve a common purpose (Chassagnon and Audran, 2010).

Studies that recognize the importance of communication networks have analyzed the social influence of communication network actors by providing information in rural areas. In the context of delivering information to potential adopters, some studies point out that interpersonal communication channels[2] (oral, visual, written, etc.) most likely influence attitudes about innovation adoption in rural areas (Thomas, Ladewig and McIntos, 1990; Daberkow and McBride, 2001; Deffuant et al, 2001). Longo (1990) found out in his study on the influence of different communication channels in Brazil that while media created awareness about agricultural innovation, interpersonal information become important when transferring more (adoption promoting) technical information.

To clarify the importance of interpersonal communication channels, aside from the network approach, a number of studies on social capital investigate factors that influence a farmer's decision about collaborative activities (Morris, C. et al, 1995; Potter, C. et al, 1998; Wilson and Hart, 2000). In the social capital literature, greater participation in agricultural organizations is the important index that shows higher levels of social capital (Beugelsdijk, 2003; Sobels, Curtis and Lockie, 2001). Social capital could lead to lower transaction costs and influences the behavior of farmers (Polman and Slangen, 2008).

In addition to the presented approaches on the importance of communication network actors on the adoption of innovation in the agricultural sector, we also considered literature on the influence of communication frequency on innovators in other sectors (Lewicki and Bunker, 1996; Harhoff et al, 1999; Paruchuri, 2010; Chassagnon and Audran, 2011). The main studies in this field stress the role of repeated collaboration and cooperation between network actors to increase innovativeness. Based on the previous studies, the following assumption is derived for this study: high-frequency communication with interpersonal network actors is an important approach for understanding new ideas that reduce uncertainty.

Thus, our first tested three hypotheses are:

H1: The higher the interpersonal communication frequency on agricultural topics, the higher the probability of adoption of other AEM by organic farmers.

H1a: The higher the interpersonal communication frequency with agricultural organizations, the higher the probability of adoption of other AEM by organic farmers.

H1b: The higher the interpersonal communication frequency with other farmers on agricultural topics, the higher the probability of adoption of other AEM by organic farmers.

Studies on the adoption decision of AEM show the important influence of neighborhood farmers' attitudes, not only for passive adopters – those who enter AEM mainly for financial reasons – but also for active adopters – those who voluntary adopt AEM for both environmental protection and financial reasons (Deffuant et al, 2001; Defrancesco et al, 2008). A study by Deffuant et al (2001) on decision-making found that for France, Italy and the UK, given categories of "family" and "colleagues" are the most-cited answers by AEM adopters as being factors that influence their decisions (relative to the categories of institutions, other and nobody). Defrancesco et al (2008) carried out a study in Italy and found a positive influence of neighboring farmers on the opinion of AEM for both passive and active farmers.

[2] We use the definition of interpersonal communication as a "process of message transaction or transmission between people to create and sustain shared meaning." Examples for each interpersonal communication channel are given as: oral communication (speaking face-to-face or on the phone), written communication (e-mails, letters, instant messaging and texting), and visual communication (body language or sign language).

Research on characteristics of innovation promoters (Kautz and Larsen, 2000; Rogers, 2003; Nutley, Davies and Walter, 2002; Guerin 2001) points out that promoters, characterized as having higher status or being more innovative (called also opinion leaders), have a vital role in the adoption of innovation. The following hypotheses on regularly communicated farmer's characteristics are tested:

H2: The higher the education of regularly communicated farmers, the higher the probability of adopting other AEM.

H3: The higher the innovativeness of regularly communicated farmers, the higher the probability of adopting other AEM.

In addition to the frequency of interactions between actors and the characteristics of informing actors, attitudes towards identifying actors as interpersonal information sources can be seen as a complementary process when understanding innovation adoption. Weimann (1982) defines the strength of communication links by a measure composed of contact frequency and contact importance. A relation is defined as strong if actors have high rates for both contact frequency and contact importance. The relationship between contact frequency and contact importance is tested using the following hypotheses:

H4: The higher interpersonal contact frequency with interpersonal communication actors, the higher the probability of considering that actor as an important source of information.

H4a: The higher participation frequency in agricultural organizations, the higher probability of considering that actor as an important source of information.

H4b: The higher communication frequency with other farmers on agricultural issues, the higher probability of considering that actor as an important source of information.

3 Data

The dataset available for the analysis consists of 52 organic farmers located in Central Germany. The data were collected during face-to-face interviews with farm managers within the EU-funded FOODIMA Project (EU Food Industry Dynamics and Methodological Advances) in 2008. The survey provides farms' and farmers' characteristics and interpersonal communication relations (formal and informal network). The descriptive statistics for the data used for estimations are given by the two-sample t-test results in Table 1. In that table, variables related to characteristics of regularly communicated farmers (age, education, farm size and innovativeness) represent the average number of three different regularly communicated farmers given by respondents.

Table 1. Characteristics of Organic Farmers (n=52), Central Germany, 2008 (two-sample t-test results)

Variables	Mean AEM Adopters (n=16/30%)	Mean Non-Adopters, (n=36/70%)	P-Value
Farmer/Farm Characteristics			
AGE	51.60	48.41	0.413
EDUCATION	15.87	16.05	0.784
FARM_SIZE	212.47	142.61	0.39
FARM_SOIL_Q	2.47	2.88	0.054*
FARM_INCOME	2.31	2.91	0.193
CONVERSION_Y	1993	1996	0.037*
Interpersonal Networks			
Informal Network			
NETWORK SIZE	7	9.73	0.526
AGE_RCF	45.14	47.5	0.272
EDUCATION_RCF	16.84	15.46	0.077*
FARM_SIZE_RCF	270.76	173.90	0.372
INNOVATIVENESS_RCF	7.071	6.96	0.861
COMMUNICATION_FREQ	50	58.08	0.256
Formal Network			
MEMBERSHIP	0.82	0.85	0.79
PARTICIPTION_FREQ	1.94	1.85	0.758

Significance levels: * = p < 0.10, ** = p< 0.05
Description of variables:
AGE: Age of surveyed farmer (years).
EDUCATION: Education of surveyed farmer (years).
FARM_SIZE: The sum of arable and grass land: Total Land (ha).
FARM_SOIL_Q: German soil value for farmland (Bodenwertzahl 1-100) (Ordinal Scale 1-5).
Low=1 for "< 25", 2 for "26-45", 3 for "46-65", 4 for "66-85" and High=5 for "> 85".
FARM_INCOME: Share of income from farm activities (Ordinal Scale 1-4).
1 for "<50 %", 2 for "=50%", 3 for "<50%" and 4 for "=100%".
CONVERSION_Y: Year of conversion to organic farming.
NETWORK_SIZE: Number of regularly contacted farmers by surveyed farmers.
AGE_RCF: Age (year) of farmers regularly contacted by surveyed farmers.
EDUCATION_RCF: Education (year) of farmers regularly contacted by surveyed farmers.
FARM_SIZE_RCF: Farm size (ha) of farmers regularly contacted by surveyed farmers.
INNOVATIVENESS_RCF: Innovativeness of regularly contacted farmers, this score reported by surveyed farmers (Ordinal Scale 1-10); 1 for "hardly accept an innovation" and 10 for "easily accept an innovation".
COMMUNICATION_FREQ: Communication frequency with other farmers (%); 0 for "not at all" and 100 for "very frequently".
MEMBERSHIP: Membership in agricultural organisations that are relevant for or involved in agri-environmental programmes (1=Member, 0=Non-Member).
PARTICIPTION_FREQ: Participation frequency in agricultural organisations' events (Ordinal Scale 0-4) 0 for "not at all" and 4 for "very frequently".

Additionally, adopted AEM by surveyed organic farmers in Central Germany between 2000-2008 is given by the division of states in Table 2.

Table 2. List of Additional Adopted Agri-Environmental Measures (AEM)
Germany, 2000-2008

1. Saxony-Anhalt
Crop diversification (Fruchtartendiversifizierung)
Mulch seeding (Mulchsaat)
Nature conservation (Naturschutz)
Land cultivation adapted to market and location (Markt-undstandortangepasste Landbewirtschaftung, MSL)
2. Saxony
Cultural landscape program (Kulturlandschaftsprogramm, KuLap)
Environmental protection, Forestry (Agrarumwelt Maßnahmen und Waldmehrung, AuW)
Nature conservation (Naturschutz)
Environmentally friendly crop production (Umweltgerechter Ackerbau)
3. Nordrhein Westfalen
Solid manure program (Festmistprogramm)
Wetland protection (Feuchtwiesenschutz)
Diversified crop rotation (Vielfältige Fruchtfolgen)
Grazing dairy cows (Weidehaltung v. Milchkühen)
4. Thuringia
Cultural landscape program (Kulturlandschaftsprogramm, KuLap)

4 Logit Model

4.1. Method

A number of studies on AEM adoption analyze the choice problem using a logit or probit model. These studies consider the adoption decision to be a dichotomous problem (1=adopters and 0=non-adopters) for estimation (Crammer, 1991; Crabtree, Chalmers and Barron, 1998; Wynn, Crabtree and Potts, 2001; Vanslembrouck, Van Huylenbroeck and Verbeke, 2002; Polman and Slagen, 2008; Hurle and Goded, 2007).

The difference between a logit and probit model lies in the distribution function of the error term. While in the logit model errors are assumed to follow the standard logistic distribution, in the probit model errors are assumed to be based on standard normal distribution. Having applied both models, the choice of which to use in the study is derived by the results of models' (R-squared) explanatory power (Collet, 1991). Since the R-square is lower in the probit model, an error term can be assumed to be distributed logistically, and the logit model is selected for analysis. The employed dependent variable is described as:

Yi =1 is assigned to organic farmers that adopt a minimum of one other AEM by the survey date.

Yi =0 is assigned to organic farmers that did not adopt any other AEM by the survey date.

The logit model used in this study is specified as:

$$Yi = \beta\ Xi + ui \qquad \textbf{(1)}$$

Where β = vector of parameters, Xi = vector of independent variables, ui = error term.

To estimate the probability of organic farmer i adoption of other AEM, our research uses the following variables: characteristics of farms and farmers and the characteristics of interpersonal networks. The characteristics of farms and farmers are used as control variables. Based on the results of previous studies on the influence of farmers' characteristics (Bonnieux, Rainelli, and Vermersch 1998; Vanslembrouck, Van Huylenbroeck, and Verbeke

2002), we include age and educational level as the estimation variables. For the farm characteristics, by taking into account the results of studies that investigate the importance of farm characteristics (Wynn, Crabtree, and Potts 2001; Polman and Slagen 2008), variables for farm size, the share of income coming from farm activities and farm soil quality (expressed in German Agricultural Land Grades) are included. To test the influence of being an experienced adopter on the acceptance of additional AEM, the number of years of experience in organic farming is used. The characteristics of formal and informal networks are included in the interpersonal network characteristics. The influence of communication frequency with other farmers and the characteristics of farmers with whom others regularly communicate about agricultural issues are tested (age, education and innovativeness as perceived by surveyed farmers). Finally, in the formal network, the degree of attachment to agricultural organisations (farmers' associations) and participation frequency in these organisations' events is considered.

The probability of being an adopter is given by:

$$\Pr(Y_i = 1 | X_i) = F(\beta X_i) = \exp(\beta X_i) / 1 + \exp(\beta X_i). \quad \textbf{(2)}$$

Tested independent variables are:

$$X_i = (\text{AGE, EDUCATION, FARM\_SIZE, FARM\_SOIL\_Q, FARM\_INCOME, CONVERSION\_Y, AGE\_RCF2, EDUCATION\_RCF, INNOVATIVENESS\_RCF, COMMUNICATION\_FREQ, MEMBERSHIP, PARTICIPATION\_FREQ}). \quad \textbf{(3)}$$

To avoid the multi-collinearity between tested independent variables in the model, we checked this potential problem by applying two common used tests. Firstly, using the approach by Menard (2002), we calculated the variance inflation factor (VIF) by constructing an ordinary least squares (OLS) regression with the same variables in the equation. Results show the mean VIF value of 1.49. As the accepted upper critic limit is 10.0 (Chatterjee and Hadi, 2006), we consider that there is no correlation between variables. Secondly, we checked the pairwise correlation coefficient between explanatory variables. Inside the total coefficient values of the model, the indication of values ranged from 0.003 to 0.41. No coefficient values larger than 0.5 indicates weak correlation between variables. Relying on the results of two tests, we conclude that there is no multicollinearity problem in the model.

4.2. Results

Table 3 reports the results of the logit model estimation for Adopters and Non-Adopters of other AEM within the group of organic farmers. Due to missing values, the total number of observations decreases to 43 farmers. In the model, a likelihood ratio test is used to compare the fit of null and alternative models, which is 18.11 with nine degrees of freedom (LR chi2 (12): 18.11).Tested predictors were treated as significant when p-value was lower than 0.10.

Adoption of other AEM by organic farmers is significantly influenced by a farmer's age, farm soil quality, conversion year and education of regularly communicated farmers. A positive coefficient sign for the age variable reveals that adopting AEM increases with the increasing age of an organic farmer. The negative sign for soil quality means that farms located in less favored areas have a greater likelihood of adopting other AEM.

Table 3. Results of Logit Analysis,
Adoption of Additional Agri-Environmental Measures (AEM) by Organic Farmers

Parameters	Coef.	Std Error	P>|z|
Farmer/Farm Characteristics			
AGE	.135	.080	0.093*
EDUCATION	1.756	1.300	0.177
FARM_SIZE	.001	.003	0.649
FARM_SOIL_Q	-2.11	1.244	0.090*
FARM_INCOME	-1.515	1.349	0.261
CONVERSION_Y	-.160	.096	0.095*
Interpersonal Networks			
Informal Network			
AGE_RCF	-.180	.091	0.050**
EDUCATION_RCF	.609	.337	0.071*
INNOVATIVENESS_RCF	-.038	.295	0.896
COMMUNICATION_FREQ	.018	.022	0.410
Formal Network			
MEMBERSHIP	-.722	1.643	0.660
PARTICIPATION_FREQ	.715	.588	0.224
CONSTANT	310.995	190.038	0.102

Number of Observations: 43 / LR chi2(9): 18.11/ Pseudo R2: 0.3436
Significant levels: * = p < 0.10, **=p<0.05
Used dummy variables[3]:

FARM_INCOME=0 for “=45% or <45% share of income from farm activities”, FARM_INCOME=1 for “=46% or>46%”.
FARM_SOIL_Q= 0 for “<45 or =45 Bodenwertzahl” (German soil value for farmland),
FARM_SOIL_Q =1 for “=46 or >46 Bodenwertzahl”.
EDUCATION=0 for “<16”, EDUCATION=1 for “17 or >17 years of education”.

With respect to interpersonal communication, both hypothesis H1a (The higher the interpersonal communication frequency with agricultural organizations, the higher the probability of adoption of other AEM by organic farmers) and H1b (The higher the interpersonal communication frequency with other farmers on agricultural topics, the higher the probability of adoption of other AEM by organic farmers) were rejected (Table 3). Communication and participation frequencies are found to be insignificant when explaining the adoption behavior of organic farmers in Central Germany.

[3]Additional to the given description variables in table 1, here we provide three dummy variables created by the user in order to estimate the results of predictors’ interactions.

Regarding H2 (The higher the education of regularly communicated farmers, the higher the probability of adopting other AEM), a positive sign of estimates for the education variable of regularly communicated farmers confirmed that farmers that communicate regularly with more educated farmers have a greater likelihood of adopting AEM. Thus, H2 was corroborated.

Hypothesis H3 (The higher the innovativeness of regularly communicated farmers, the higher the probability of adopting other AEM) was rejected. Innovativeness of regularly communicated farmers is not a significant variable for explaining the adoption behavior of organic farmers in Central Germany. Finally, we conclude that it is not interpersonal communication frequency that increases the probability of adoption, but the attributes of regularly contacted actors in the network.

5 Social Network Analysis

5.1. Method

In addition to modeling the effect of communication frequency and communication partner characteristics in the acceptance decision by using logit analysis, the relationship between contact frequency and contact importance was examined using Social Network Analysis (SNA). "Social network analysis in general studies the behavior of the individual at the micro level, the pattern of relationships at the macro level, and the interactions between two," (Stokamn, 2001, p. 509). In a network, social entities are referred to as actors that are discrete individual, corporate, or collective social units (Wasserman and Faust, 1994). SNA allows a number of analytical tools to measure the relational aspects of social structure. In our study, we use an ego-centered network and reciprocity analysis, respectively.

An ego-centered network is defined as a network (personal network) that consists of focal actors (called ego) and a set of nodes (called alter) to whom the ego is directly connected (Wasserman and Faust, 1994). There are several approaches that allow us to study the relations in ego-centered social networks. Our study uses personal interviews where each respondent (alter) reports to whom (ego) it is tied (Burt 1984, 1985). While here alter represents organic farmers, two interpersonal communication actors (agricultural organizations and other farmers) represent egos in the network. The measurement of such personal, ego-centered networks can be found in studies from fields such as anthropology, psychology, medicine and sociology (Bott, 1957; Wellman, 1993; McCarty et al, 2001).

Ego-centered networks are mostly used in studies on social support that refer to social relations that help to increase an individual's well-being (Wasserman and Faust, 1994). In our study, we use the reference definition of Cohen and Wills (1985), which distinguishes between four types of support: instrumental, informational, emotional and social support. Our study focuses on informational support that refers to social relations providing assistance with knowledge, information and skills (Cobb, 1976). The objective of this study is to examine the degree of reciprocity within the informational social support in the organic farmers' network.

Reciprocity means that a positive action of one individual provokes a positive action towards that individual (Katz and Powell, 1955), and is mostly studied using the question of "How strong is the tendency for one actor to choose another, if the second actor chooses the first," (Weiligmann, 1999). Several studies have interpreted the strong tendency of reciprocity as the stability of a social system (Gouldner, 1960; Allen, 1977). The stronger the tendency of reciprocity in the social network, the stronger will be the social ties and cooperation in interpersonal networks (see the literature review of Chassagnon and Audran, 2011). In our study, a reciprocity analysis is carried out with the Ucinet software package to answer the question, "How strong is the contact importance with the second actor for the first actor if the

first actor has high communication frequency with the second actor?" The examined social network indices are detailed in Table 4.

Table 4. Indices used to measures interpersonal communication structure

Indices	Definitions and Measure
Network Level	
Network Size (n)	Number of actors in the network.
Isolator	Actors that have neither in nor out-degree ties with a single actor.
Relational Ties	Social ties that link actors to the other actors.
Ego-Centered Network Level	
Connectedness	A ratio between the number of actual ties and the maximum number of possible ties that an actor could have.
Undirected Actors	Actors that are connected to and from ego actor.
In-Neighborhood Actors	Actors with a tie to ego.
Out-Neighborhood Actors	Actors with a tie from ego.
Out-degree ties	Ties from ego to out-neighborhood actor.
In-degree ties	Ties from in-neighborhood actor to the ego.
Connectedness	A ratio between the number of actual ties and the maximum number of possible ties that an actor could have.
Undirected Actors	Actors that are connected to and from ego actor.
Reciprocity Analysis	
Reciprocity	Proportion of dyads (actors) that are reciprocated.
Non-Symmetric In-Neighborhood Ties	Proportion of ego's incoming ties that are not reciprocated.

In the ego-centered network measures (table 4), all alters that represent farmers are undirected actors. While an in-neighborhood actor represents farmers that have high contact frequency with the studied ego, an out-neighborhood actor represents farmers that attach high contact importance to the ego actor. In the reciprocity analysis, proportions of the employed measure are given for each of the studied egos by considering the ties to and from that ego. A result for reciprocity gives the proportions from 0 to 1. If the value is equal to 1, this can be interpreted as a high tendency to make reciprocal choices. If the value is equal to 0, then there is no tendency to reciprocate. The non-symmetric in-neighborhood ties represent the proportion of farmers that have a high contact frequency with the ego, but did not cite the contact as an important information source.

In the interpersonal communication network, we incorporate reciprocity by assuming that farmer A is more likely to give importance to the information coming from farmer B if farmer A has already cited B as an actor that he communicates with frequently. Regarding that assumption, to test hypothesis H4, the average number of in-degree ties is accepted as the minimum expected number of reciprocal ties in the network. We then created a binary data as: 1 = farmers that have both in-degree and reciprocal ties; 0 = farmers that have in-degree ties but not reciprocal ties. The binomial probability test is used by the expected probability of success with 0.5. We test the statement of "at least 50% of population is coded as 1." If the probability is smaller than the significance level of 0.05, the hypothesis is rejected for the observed network.

After clarifying the study concept for the organic farmers' interpersonal communication network, we identify the role of actors in the communication structure. As opposed to network analyses that focus on characteristic of actors, network role analysis asks the question of "How do relationships link the entire sum of actors throughout the network," (Wasserman and Faust, 1994). Based on the literature on communication roles and information exchange patterns, we distinguish between informal and formal communication structures (Allen, 1977). While a formal communication structure is formulated within the organizational structure, channels and rules, an informal communication structure works within social affiliations (Kilduff and Brass, 2001). In the examined network, we refer to the constructed ties between ego of an agricultural organization and surveyed farmers as formal networks, and ties between the ego of other farmers and the surveyed farmers as an informal network. A contact matrix that illustrates whether or not there exists any relation among actors has been designed for both networks. In the study, 50 organic farmers were surveyed with a contact matrix; due to missing values we eliminated 2 farmers from the matrix. Two main types of relations were considered: frequency of communication and importance of information sources. Measures that are used to construct communication structures are given as follows:

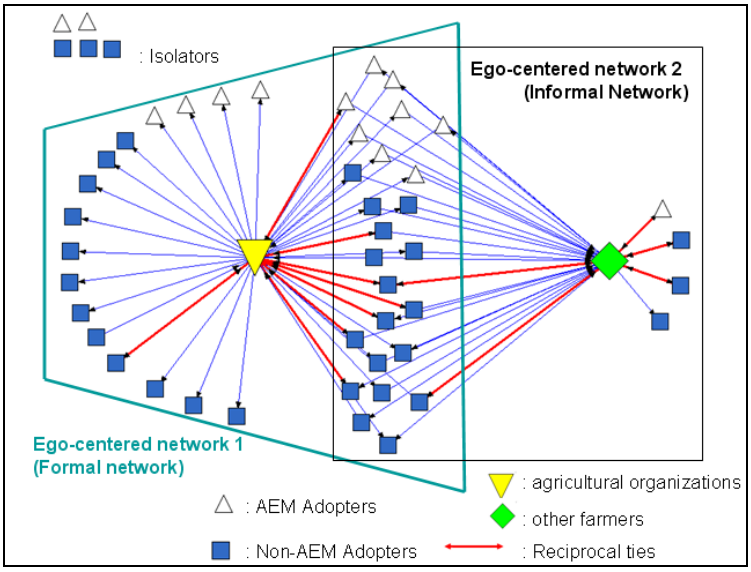
Communication frequency: Information exchange in the communication structure could be measured by several methods (Kyriazis and Massey, 2008). In our study, we use the amount of communication to represent the intensity of all available information flows. The question "How often do you communicate with other farmers on agricultural issues?" was asked of survey participants to describe their informal communication frequency. Additionally, the question "How often do you participate in the agricultural organization's events?" was asked of farmers to define formal communication frequency. For both questions, the degree of frequency was ranked on a percentage scale, in that the higher percentage indicates a higher frequency of communication. In the contact matrix, the threshold level of having high contact frequency is constructed by translating the top-half of the communication and participation frequency percentages (>50%) of farmers into 1's and the other half into 0's (≤50%).

Importance of information source: Information sources in rural areas are examined by several studies focusing on either the use of information (Ortmann et al., 1993), factors that influence attitudes toward information sources (Gloy, Akridge and Whipker, 2000), or information preferences of farmers (Pompelli et al, 1997; Schnitkey et al, 1992). In our study, we consider the importance of information from socio-informational network actors ranked by farmers. Farmers were asked to rate the importance of 15 information sources under three main titles: other farmers, agricultural organizations and media. The question posed was "What is the importance of the listed information sources on agri-environmental issues for you?" The degree of importance was ranked on a percentage scale that summed up to 100. Regarding the distribution of rankings in the matrix, a high percentage of responses (more than 33%) were translated into 1, and a low percentage (less than 33%) into 0. For the purpose of the study, the source of media was eliminated from the network, as this does not represent interpersonal communication.

5.2. Results

Figure 1 shows the information exchange in the structure of interpersonal communication network (n=52) for a sample of organic farmers in Central Germany in 2008. In the presented network, we observe organic farmers (n=50) who have a high communication frequency and/or contact importance with ego-central networks (n=2), as well as an interpersonal information source of agricultural organizations and other farmers.

Figure 1. Interpersonal Communication Network of Organic Farmers, Central Germany, 2008



Source: *FOODIMA Survey*

The figure shows that the number of reciprocal ties is far below the number of in-degree ties (ties from alters to the ego). For the whole network, hypothesis H4 (The higher the interpersonal contact frequency with interpersonal communication actors, the higher the probability of attributing importance to that actor as a source of information) is rejected with the significance level of $p < 0.05$ using a binomial probability test. The state of relationship between the variable of high contact frequency and high contact importance cannot be explained by a stable equilibrium of either reciprocity or mutuality.

In the further analysis on differences between informal and formal communication structures, the following hypotheses are tested by using ego-centered network analysis:

H4a: The higher participation frequency in agricultural organizations, the higher probability of considering that actor as an important source of information.

H4b: The higher communication frequency with other farmers on agricultural issues, the higher probability of considering that actor as an important source of information.

Table 5 shows the characteristics of both studied ego-centered networks. Regarding the study question, contact matrix relations are designed with a star network structure, where all actors connect to a central actor. Hence, as expected, the proportion of actual ties to the possible ties that are given as connectedness is low for both the formal and informal network. Additionally, standard deviation provides low variance between actors in terms of the distribution of ties. It means that population in the both of the ego-centeraled network represent a homogeneous group that deviates low from the mean.

The whole network consists of 83 ties representing high communication frequency (in-degree ties from actors to two ego nodes) and high contact importance (out-degree ties from ego nodes to actors), with the division of 49 formal and 34 informal communication ties. This could be interpreted as those formal ties being more important than informal ties in promoting information exchange. In the informal network, the ego node of other farmers is an actor that provides information exchange mostly with actors that also have support from formal ties (Figure 1). The strength of informal ties in promoting information exchange lies not in the high number of ties, but in their number of reciprocity with the actors that have only one informal tie.

Table 5. Ego-Centered Network Analysis of
Organic Farmers (n=50), Central Germany, 2008

Characteristics	Formal Network	Informal Network
Connectedness	0.019	0.013
Std Dev	0.137	0.115
Sum of Ties	49	34
Undirected Actors	41(82%)	29(58%)
In-Neighborhood Actors	15(30%)	20(40%)
Out-Neighborhood Actors	34(68%)	14(21%)
Reciprocity	0.19	0.17
Non-Symmetric In-Neighborhood Ties	0.46	0.75

Source: *FOODIMA Survey* (Percentages within the parentheses show the proportion of related actors to the total number of whole network level alters that represent farmers (n=50)).

In the study, the percentage of undirected actors is given by the number of actors that are linked to both ego networks. The proportion of undirected actors varies between the two considered ego networks. While 82% of actors are connected to formal networks, 58% of actors are connected to informal networks (Table 5). The reason for more connected actors in the formal network is mostly the high group size of out-neighborhood actors. These actors represent farmers that place high importance on information distributed by agricultural organizations. In the formal network these actors are both AEM Adopters and Non-Adopters. Comparing to the informal network, we observe more AEM Adopters in the formal network (Figure 1).

As we can observe from the proportion of non-symmetric in-neighborhood ties, the reciprocity analysis based on in-neighborhood ties provides different results for the ego networks. Relative to the informal network, in the formal network, the proportion of an ego's in-degree ties that are not reciprocated is lower (0.46). This could be interpreted as follows: 46% of farmers that cite high participation in the agricultural organizations do not report these organizations as being a source of information on agri-environmnetal issues, which is highly important. A binomial probability test was used to test the statement "At least 50% of in-neighborhood ties are symmetric," for the two ego-centered networks. While for the formal network, Hypothesis H4a is accepted, for the informal network H4b is rejected with a significance level of $p < 0.05$. We conclude that at least half of the farmers who cited themselves as a frequent participant in agricultural organizations also place importance on the information distributed by these organizations. However, with the assumed success of 0.5, in the informal network, high communication frequency with actors is not the measure that provides the high degree of importance of that contact as a source of information.

6 Discussion and conclusions

This paper investigates whether significant differences exist between AEM adopters and AEM non-adopters amongst farmers previously experienced with environmental practices. The central aim of this research is to illustrate the relationship between interpersonal actors, communication frequency, and the adoption of AEM. Organic farmers from Central Germany that had practiced similar environmental management standards are examined by using Rogers (2003) diffusion of innovation as a theoretical basis. The logit and social network analysis was included to explain the influence of communication frequency on the probability of adopting other environmental practices as a continuous innovation, as well as the role of attitudes towards information.

Previous studies on the adoption decision did not investigate the adoption behavior of previously experienced (innovator) farmers. The studies considering conventional farmers' decision making on AEM adoption found that friends and colleagues opinion are the most important sources of information (Retter, Stahr and Boland, 2002; Drake, Bergström and Svedsäter, 1999). Furthermore, Polman and Slangen (2008) studied farmers' AEM behavior in the Netherlands, Belgium, France and Italy. The results show that farmers' (without the division of being experienced or not) participation in agricultural organization events focusing on improving farming practices frequently has a negative impact on the acceptance of all types of studied AEM. Our analysis shows different results. The employed logit models show that the frequency of participation in agricultural organizations' events, as well as communication with other farmers, has no (positive or negative) effect on AEM adoption.

Beside our results, these differences can be assumed to arise from being an experienced or inexperienced farmer, and by the expectation that farmers have regarding the received information. Organic farmers, similar to other economic actors, make their decisions after communication with their social network actors, and after having collected sufficient information about the beneficial points of the considered action. At that point, attitudes towards information coming from network actors guide their behavior towards or against continuing innovation. The survey conducted by Prager and Nagel (2005) in Germany shows that farmers especially contact agricultural organizations when they are looking for information on the application, scheme requirement and responsibility issues of AEM. Regarding the study on informal sources of information by Deffuant (2001), the most frequently discussed subjects between farmers are "weather", "price" and "whether to adopt AEM." Experienced farmers possess the basic knowledge on AEM adoption already and need to update formal information on political innovations (e.g. new measures or requirements).

Additionally, the result for regularly communicated farmers' characteristics is important in terms of the contribution to studies on innovation promoters. A high education level of regularly communicated farmers is found to be a significant determinant of an organic farmer's participation in AEM.

The results of the reciprocity analysis reveal that more than half of the active participants in agricultural organization events rate the information received from organizations as important. The main implications of this finding emphasize the importance of considering the frequency of participants' perceptions on agricultural organizations in the policy design. High frequency participants are important actors that help to improve information exchange within agricultural organizations. Formal information exchange has to be considered in the context of its high capacity to influence the frequent participants. Findings also confirmed that informal information flow is not the central, but a complementary information source for frequently communicated organic farmers. Additionally, results suggest that the high contact frequency with interpersonal network actors cannot be seen as a measure of high contact importance as a source of information on agricultural issues for farmers.

The number of observed organic farmers is rather small in our study. Three limitations and further research interests could be defined. Firstly, the present study does not focus on one type of AEM adopted by organic farmers. We included all accepted AEM by organic farmers without any division regarding their requirements. Secondly, investigations on the influence of network actors on organic farmers' behavior could be confirmed using an extended dataset with more actors. In this paper, we limited the studied actors on formal and informal interpersonal relations, and excluded the influence of the socio-informational media network on actors. Thirdly, in addition to our study on the relationships between high communication frequency and attitudes towards an information source, it would be interesting to complete the relationships by determining the differences between less frequently communicated farmers.

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