How social capital affects willingness of farmers to accept low-carbon agricultural technology (LAT)? A case study of Jiangsu, China

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Abstract

Purpose – Low-carbon agricultural technology (LAT) extension is a key strategy for the agricultural sector to address climate change. Social capital, which consists of social networks, trust and norms, can play an active LAT extension role. This paper aims to analyze the mechanism of the role of social capital in the process of LAT extension.

Design/methodology/approach – Questionnaire data from six counties in Jiangsu, China, were used to measure social capital and analyze its effect on LAT extension using logistic regression. Data from 27 interviews were used to analyze the LAT extension experiences and problems.

Findings – LAT is mainly deployed by the government to farmers and distributed among them. In this process, the village officials who form parts of the government's composition and the villagers play a dual role that facilitates a close link between them and the farmers and ensures LAT integration. However, social norms did not play a significant role in the process.

Practical implications – Farmers' acceptance of LAT is based solely on the trade-off between local networks' benefits and trust in local villagers and village officials. LAT-related laws and technical measures, thus are essential to strengthen LAT practices' authority and incorporate LAT-based agricultural production as the norm of production behavior.

Originality/value – This paper provides an insight into the process and essence of farmers' acceptance of LAT, which provides theoretical lessons for the LAT extension in China and indeed other developing countries.

Keywords Social capital, Environmental communication, Agricultural technology extension, Low-carbon agricultural technology, Jiangsu China

Paper type Research paper

1. Introduction

The emissions of greenhouse gas emissions (GHG) from agriculture are second only to the industrial sector, with its effects on climate change confirmed by numerous studies (Bai *et al.*, 2019; Zhen *et al.*, 2017). Most importantly, previous studies have indicated that the emissions of methane and nitrous oxide are expected to rise by up to 30%–60% by 2030, with most of the increment occurring in the developing countries (Alexandratos and Bruinsma, 2012; Norse, 2012). Given the limited reduction potential, methane and nitrous oxide emissions from agriculture are, thus expected to account for an increasing proportion of the total GHG emissions reduction (Gernaat *et al.*, 2015; Harmsen *et al.*, 2019). As a result, the extensive use of low-carbon agricultural technology (LAT) needs to be taken into account more seriously now and in the future, especially in developing countries.

Generally, LAT mainly comprises the following three principles:

(1) To reduce the increase of GHG emissions caused by land-use change, e.g. restoring deforested and degraded land (Goh *et al.*, 2017; Newton *et al.*, 2016);

(2) To reduces GHG emissions in agricultural production (Norse, 2012); and

(3) To increase the carbon sink, e.g. establishing an integrated ecosystem of agriculture, forestry and animal husbandry (Sá *et al.*, 2017).

Based on these three principles, many countries with large agricultural sectors such as Brazil and Indonesia. have launched the LAT extension strategy. Research estimate that the continuation practices of LAT in these countries can significantly reduce GHG from the agricultural sector and increase carbon sinks over the next decades (Carauta *et al.*, 2018; Sá *et al.*, 2017).

The extension of LAT is also critical for the Chinese Government to fulfill its emission reduction commitments under the *Paris Agreement* (Dou, 2013; Zhen *et al.*, 2017). Carbon emissions from the agricultural sector in China rose from 148.6 million tons (MT) in 1995 to 241.1 MT in 2017, with an average growth rate of 2.8%, accounting for about 30% of total GHG emissions (Xu *et al.*, 2020; Chen *et al.*, 2020). However, China's situation is somewhat different from that of other developing countries mentioned above. Smallholder farming remains the main form of agricultural production despite the Chinese Government's constant attempts to increase the share of family farms and cooperatives in agricultural production (Shen and Shen, 2018). Compared to larger farms and cooperatives, LAT is much harder to reach among small farmers (Stringer *et al.*, 2020). For this reason, increasing farmers' acceptance of LAT has been studied intensively over several decades.

While farmers' innovation and its diffusion effects are often mentioned (Wu and Zhang, 2013), various research confirm the critical role of government in LAT extension. For instance, empirical studies in several regions have demonstrated the effectiveness of government-provided technical training and shown an increasing farmers' acceptance of LAT (Guo *et al.*, 2015; Pan *et al.*, 2017). Over the past decade, the Chinese Government has been promoting LAT in a desperate effort and made some achievements. In this process, how local governments intervene in the LAT extension in a rural society where smallholder operations are predominant is still not well studied. Besides, rural China is a social system made up of blood ties and geographical links, which heavily influence individual behavioral decisions (Tang *et al.*, 2019). Little is known about how the social system disseminates LAT-related information and ultimately influences farmers' willingness to accept LAT.

The paper addresses this research gap. In Section 2, the paper first analyzes the policy practice and LAT extension system in China, then establishes a theoretical analytical framework to analyze factors that influence LAT acceptance using social capital theory. The case areas, data sources and methods are presented in Section 3. Section 4 details the result of the data analysis.

Section 5 is the discussion, the paper combines the quantitative analysis results with the interview material to analyze the mechanisms in which LAT is introduced from the outside and then diffused amongst the farmers. Finally, Section 6 is the conclusion, where the paper makes policy recommendations in response to the issues identified in the study of LAT extension.

2. Policy analysis and theoretical model building of the extension and acceptance of low-carbon agricultural technology

2.1 The policy practice and low-carbon agricultural technology extension system in China

The LAT extension forms part of the agricultural technology (AT) extension system worldwide and China is no exception. There are two main types of AT extension systems. One is government-led, with participation from the research and education sectors and the other is led by non-governmental organizations (NGOs) (Aker, 2011; Benson and Jafry, 2013). China falls into the first category. In general, China has established a five-level LAT extension system at the national, provincial, municipal, county and village or township levels. These five levels, in turn, involve various departments such as the Ministry of Agriculture and Rural Affairs, the Ministry of Education and the Ministry of Science and Technology (Cheng *et al.*, 2016).

Although China's LAT extension system involves multiple levels and sectors, the central government generally sets policies and provides financial support using various forms of LAT projects. The higher government (including several agriculture-related sectors) allocates appraisal indicators and funds to the lower government. The local governments (village and town-level governments) submit project implementation plans to receive financial support. As the technology providers, the research and education sectors can apply funding for research and extension projects from all levels of the government (Figure 1).

Therefore, the LAT extension in China has always been a government-led system. While the research and education sector can work directly with farmers or enterprises, such cooperation is mainly about technological research and experimentation. Under this system (Figure 1), local governments promote LAT to farmers through organizing training, demonstrations, etc. The LAT extension system is essentially the same across China. However, there are some regional differences in the effectiveness of LAT extension. As noted above, quite a few areas have had successful LAT extension practices (Guo *et al.*, 2015; Pan *et al.*, 2017), but some areas have also been less effective. Several scholars attribute this to differences in economic or technological levels between regions. This paper attempts to analyze the transmission pathways of LAT from the social capital perspective and factors that influence farmers' willingness to accept LAT.
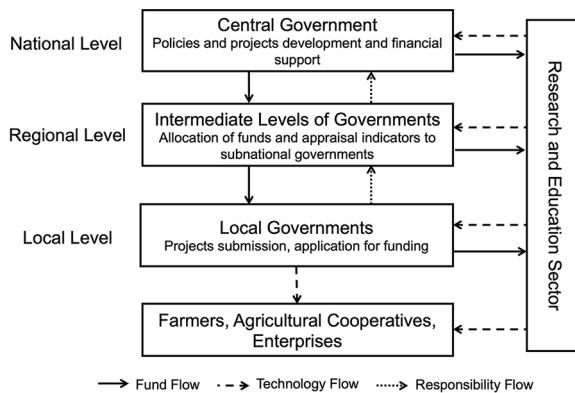

Figure 1.
LAT extension system in China

*2.2 Social capital links local governments with farmers and influences their behavioral
willingness*

Social capital sees the social networking links between people and the resulting social structures as a "capital" that can bring benefits to individuals or groups (Coleman, 1988; Putnam, 2000; Uphoff, 2000). Social capital at the micro-level is a resource that actors can access through their social networks which are similar to their private goods (Boix and Posner, 1998) while social capital at the macro-level emphasizes its groupness. Groups can improve their ability of action through their networks, trust and norms, which is similar to the group's public goods (Anderson *et al.*, 2004). Although the precise definition of social capital is debated (Siisiainen, 2000), it is generally accepted as an essential component of the foundation of sustainable livelihoods (Pretty and Ward, 2001).

This is because, first, social networks increase the potential cost of deception and foster reciprocal norms through the flow of information about individual behaviors within the community and the accumulation of previous cooperative experiences; second, social norms, which either extrinsically or intrinsically constrain behavior, can act as synergistic forces for cooperation; finally, social trust can effectively reduce transaction costs and increase the autonomy of individual voluntary cooperation (Nakagawa and Shaw, 2004; Petzold and Ratter, 2015; Spagnolo, 1999). Therefore, social capital is effective in reducing the cost of the consultation, encouraging cooperation, promoting productive activities and facilitating the supply of goods and services, etc.

The importance of social capital for the LAT extension has also been much discussed. For example, ATs are usually disseminated by farmers in the process of learning about their advantages through social networks (Magnan *et al.*, 2015). Social capital can enhance farmers' sense of self-efficacy and lead to their active participation in agricultural production and the use of new technologies (Wuepper and Sauer, 2016). Social capital can dispel farmers' doubts about the risks of new technologies (Bawakyillenuo *et al.*, 2016). Therefore, it is essential to promote the accumulation of rural social capital (Fox and Gershman, 2000). Possible initiatives include supporting farmers' production organizations and improving access to agricultural information and technology. In most cases, however, the LAT extension is a process of external input, which is then distributed among the farmers. Governments, NGOs or research and education sectors play the role of importers. However, how social capital connects the importers with farmers is not well understood. In particular, as follows:

- How efficiently connected these farmers are to the technical importers? and
- How efficiently the LATs are disseminated among farmers after the importation?

Regarding the first question, previous research has demonstrated that there can be higher bonding social capital between immediate family members, neighbors, friends and business partners (Woolcock, 2002). People of different backgrounds, but with similar socioeconomic status, can have more robust bridging social capital (Hoyman and Faricy, 2009). Moreover, a community or group is often less able to connect with formal organizations' influential people, such as the employees of banks, schools and police stations. This makes linking social capital less accessible, especially for the poor or rural residents (Compagnone and Hellec, 2015; Das, 2004).

The situations are different in rural China. As mentioned above, local governments (county or township level) primarily undertake the LAT extension in China. However, local governments at the county or township level are not directly involved in the managing of administrative or natural villages but instead take self-governance by villagers' committees. In other words, the local government's decrees at the township level, including, of course, the

LAT extension, are implemented by the villagers' committees. In China, villagers' committees are autonomous organizations directly elected by local villagers (Benewick *et al.*, 2004). The head of the villagers' committee and the secretary of the village party branch in rural China have often been the same person in recent years (O'Brien and Li, 2000; Liu *et al.*, 2019). The directly elected form of village committees dictates that, in most cases, village officials are local villagers and their families also regularly engage in agricultural production. As a result, village officials are not only part of the government's composition but also, they are immersed or embedded in the rural society that makes up the fabric of agricultural production and rural life. More importantly, many cooperatives and family farms are controlled by former government officials (Shen and Shen, 2018). Under this scenario, access to linking social capital is also possible. Thus, local government officials' dual role allows social capital to connect farmers with the local government (Figure 2).

As for the second question, rural Chinese society comprises blood ties and geographical links (Tang *et al.*, 2019). In this case, communication networks, trust and mutual norms and constraints between villagers are quickly established (Li and Li, 2007; Pretty and Ward, 2001). As a result, there is usually a more desirable bonding social capital among villagers. As villagers are embedded in the structure of social networks, their willingness to accept the LAT is also more influenced by social capital with interpersonal interaction properties. Subsequently, social capital, built by social networks, trust and norms, transforms the LAT extension into a collective behavioral willingness.

3. Study areas, data and methods

3.1 Study areas and data
Since the 1980s, the rapid development of Jiangsu's industrial economy has been accompanied by a long cycle of high growth in the agricultural economy. However, Jiangsu's agricultural economy's rapid development is typical of the "high-emissions, high-efficiency" model. Studies have shown that Jiangsu is at the forefront of the world regarding inputs of high-carbon production materials such as fertilizers, pesticides, agricultural films and herbicides (Xiong *et al.*, 2020). Since 2015, to achieve the Chinese Government's goal of energy saving and emission reduction, Jiangsu has started to promote LAT on a large scale in the agricultural sector while restraining GHG emissions in the industrial sector.

The questionnaire survey for farming households in Xuyi, Guanyun, Xinghua, Jingjiang, Lishui and Jiangning was conducted from July 2016 to April 2017. These areas are located in the northern, central and southern parts of Jiangsu, respectively (Figure 3). The number of questionnaires distributed was 714, of which 688 were valid. In general, the respondents have an average age of 53 and contracted an average of 5.33 acres of farmland. The

Figure 2.
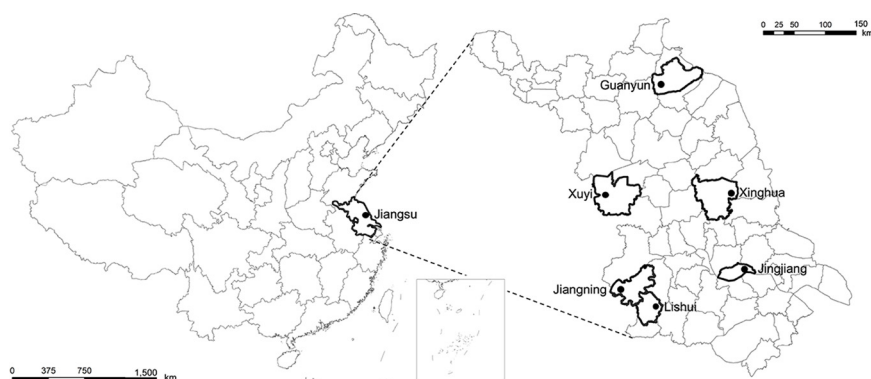Chinese rural social patterns in the context of social capital
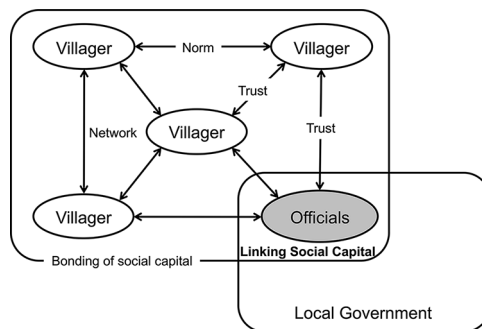
Figure 3.
Location of the
studied case

education attainments of the respondents were 45 illiterates, 101 primaries, 222 juniors high, 198 seniors high and 119 university and above. The average household size of respondents is 4.54 persons and the average household labor force is 3.25 persons. The minimum annual household income of respondents was 6,500 yuan and the maximum annual household income was 1,900,000 yuan; the average share of agricultural income was 22.38%.

Also, several farmers and government officials were interviewed (Table 1). This material will be applied in the discussion sector.

3.2 Methods

The core independent variable, social capital, is measured in three dimensions, namely, social networks, social norms and social trust. As shown in Table 2, the indicators of social trust selected were "level of trust in local government," "level of trust in village cadres," "level of trust in neighbors" and "level of trust in villagers of high moral standing." These three groups are the groups that farmers most often come into contact within their

No.	Venues	Date	Interviewees	Contents
1–6	Meeting room	July 2016	Local farmers	Mini-symposiums organized by local governments. The discussion focuses on the sources of LAT and the cooperation between farmers in the agricultural production process
7–12	Meeting room	October 2016	Non-local farmers	Mini-symposiums organized by local governments. Discussions focused on LAT's sources of technology, acceptance and communication and cooperation with local villagers
13–15	Office	January 2017	Village cadre	LAT's subsidy policy, local rural workforce structure and government performance appraisal indicators
16–21	Office	August 2016	Staff in the agricultural extension sector	AT extension process and key measures
22–27	Office	July 2016	Government officials	Participation of their family members in agricultural production

Table 1.
List of interviews
between 2016 and
2017

Social capital	No.	Evaluation indicators	Meaning and assignment	Mean	SD
Social trust	Q1	Level of trust in local government	1 (very distrust)	3.85	0.75
	Q2	Level of trust in village cadres	– 5 (very trust)	3.97	0.69
	Q3	Level of trust in neighbors		4.01	0.60
	Q4	Level of trust in villagers of high moral standing		4.06	0.62
Social norms	Q5	Whether you will be penalized or criticized for not participating in group activities	1 (surely not) – 5 (will certainly)	2.51	1.33
	Q6	How well can you help borrow money by establishing good interpersonal relations with villagers	1 (not helpful) – 5 (very helpful)	3.89	0.92
Social network	Q7	Frequency of contact with relatives	1 (none at all) – 5 (very frequent)	4.41	0.89
	Q8	Frequency of contact with acquaintances		4.45	0.88

Table 2.
Index indicators for the evaluation of farmers' social capital

agricultural production practices and the government is the source of LAT-related information. According to statistics, farmers have a relatively high level of trust in all of them. The following indicators were chosen as indicators of social norms: "whether you will be penalized or criticized for not participating in group activities" and "how well can you help borrow money by establishing good interpersonal relations with villagers." The mean value of the degree of whether non-participation in collective activities would be punished or criticized was 2.51, reflecting that the current traditional rural social norms are not very binding on farmers' behavior. However, farmers generally believe that establishing good interpersonal relationships with other people helps them borrow money (mean value of 3.89), indicating that farmers attach more importance to the social norms that can bring them direct benefits. Two indicators, "frequency of contact with relatives" and "frequency of contact with acquaintances," were chosen as indicators of social networks. The statistical results show that both indicators' mean values are high (4.41 and 4.45, respectively), which implies that farmers' social network in the study area is still a traditional acquaintance society.

Factor analysis is a multivariate statistical analysis method to explore how to extract a few factors from many original variables with a minimum of information loss and to make the factors have a certain naming explanation. Its main function is to use fewer independent factors to substantially reflect the information of the original variables and the internal relationships between the variables. The factor analysis method was used to measure social capital to gain the scores of indicators of social trust, social norms and social networks. The paper assigned values to the factor load matrix using principal component analysis, as follows:

$$F_j = \gamma_{j1}x_1 + \cdots + \gamma_{jp}x_p, j = 1, \ldots, m \tag{1}$$

In formula (1), γ_{jt} $(t = 1, \ldots, p)$ is the performance of the factor load after rotation. After this, formula (2) can compute a composite score F, where W_i is the contribution rate of the social capital level, W is the cumulative contribution rate and n is the number of selected public factors.

$$F = \sum_{j=1}^{n} \frac{w_j}{w} \cdot F_j \tag{2}$$

Beyond that, to make the model more reasonable, the paper selects control variables from both individual farmer characteristics and household characteristics. Among the individual characteristics of farming households, age, education level and whether they are village cadres were selected as control variables. On the other hand, the proportion of agricultural income, area of contracted farmland and annual income per capita were selected as control variables (Table 3).

The dependent variable is a binary variable comprising willingness and unwillingness to accept LAT. Thus, to analyze the degree to which it is influenced by social capital, a logistic regression analysis was performed.

$$\ln\left(\frac{p_i}{1-p_i}\right) = \alpha_0 + \sum \beta_i \chi_i + \varepsilon \tag{3}$$

In formula (3), $\frac{p_i}{1-p_i}$ represents the ratio of the probability of farmers' being willing to accept LAT to the probability of farmers being unwilling to accept LAT ($i = 1, 2, \ldots, n$). Additionally, p_i denotes the probability of the i-th farmer being willing to accept LAT, whereas $1-p_i$ denotes the probability of the i-th farmer being unwilling to accept LAT. α_0 represents a constant term while χ_i, β_i and ε represent the independent variable, the partial regression coefficient and the stochastic disturbance term, respectively.

4. Results
4.1 Factor analysis of farmers' social capital
Before measuring social capital, the quality of the scale is first analyzed. The analysis showed that the KMO value reached 0.725 and the test statistic of Bartlett's sphericity test reached 1,622.886, which passed the significance test at a level less than 0.01, reflecting that the data was suitable for factor analysis. Public factor extraction was then performed. Three public factors were obtained by analyzing the public factors according to the eigenvalues principal greater than 1. The total variance contribution of the public factor reached

Variable	Variable name	Meaning and assignment	Mean	SD
Dependent variable	*Acceptance*	Yes = 1, No = 0	0.69	0.46
Core variables	*Social trust*	Factor analysis value	2.54	0.94
	Social norm	Factor analysis value	2.49	0.77
	Social network	Factor analysis value	2.56	1.01
Control variables	*Age*	Continuous variable	52.98	13.55
	Educational attainment	Illiterate = 1, primary = 2, junior high = 3, senior high = 4, college (tertiary) and above = 5	3.36	1.13
	Village cadre	Yes = 1, No = 0	0.53	0.50
	Share of agricultural income	Continuous variable	22.38	29.22
	Area of contracted farmland	Continuous variable	5.33	3.29
	Annual income per capita	Continuous variable	21,996	32,978

Table 3.
Variable meanings
and assignments

67.658%, which shows that the public factor is a substitute for the overall information on farmers' social capital, indicating the validity of the factor analysis results. To better dissect the common factor, an orthogonal rotation of the factor analysis model is performed to bring the load factor of the common factor closer to 1 or 0 by rotation. The orthogonal rotation of the factor analysis converges after four iterations to generate a rotated factor load matrix (Table 4).

Based on the rotated factor load matrix, it can be observed that the first public factor has a higher load factor on Q1–Q4, reflecting social trust; the second public factor has a higher load factor on Q5 and Q6, reflecting social networks; and the third public factor has a higher load factor on Q7 and Q8, reflecting social norms. The load coefficients of the public factor on the original variables are above 0.5, all the original variables are not cross-loaded on the public factor, and the original variables exhibit proper differentiation and aggregation effects. According to the factor score factor matrix, three public factors were measured to the values of social trust, social norms and social networks.

4.2 Logistic regression analysis of farmers' willingness to accept low-carbon agricultural technology

The logistic model was used to analyze the impact of social capital on the farmers' willingness to adopt LAT. The first regression analysis introduced the control variables (individual characteristics of farmers and household characteristics) to obtain the benchmark model (Model 1). Based on the benchmark model, Model 2 introduced the core independent variable social capital (social trust, norms and networks). Overall, the cardinality test values of Model 1 and Model 2 both reach the 1% significance level, indicating that the models are valid (Table 5). It should be noted that Model 2 fits better when social capital is added (The Nagelkerke R^2 value of Model 2 is higher than Model 1). Therefore, the following analysis is based mainly on the estimates from Model 2.

Social trust positively influences farmers' willingness to adopt LAT at a significant level of 10%. All other things being equal, the probability of a farmer's willingness to adopt LAT increases by 19.12% for each level of social trust increment. The social network also has a positive effect on farmers' willingness to adopt LAT and is significant at the 1% level. All other things being equal, the probability of a farmer's willingness to adopt LAT increases by 52.50% for each level of social network increment. These results suggest that farmers with high social trust and network levels are more willing to adopt LAT than those with lower levels.

The effect norm on of the social the farmers' willingness to adopt LAT is positive. However, it did not pass the significance test and was not in line with theoretical expectations. The paper will explore the reasons in the discussion section. Beyond that, the educational attainment variable positively and significantly affects farmers' willingness to adopt LAT at the 1% level. Whether

Social capital	No.	Factor 1	Factor 2	Factor 3
Social trust	Q1	0.825	−0.006	0.096
	Q2	0.892	0.041	0.101
	Q3	0.791	0.099	0.016
	Q4	0.794	0.095	0.067
Social norms	Q5	−0.004	−0.037	0.876
	Q6	0.131	0.137	0.535
Social network	Q7	0.011	0.876	0.065
	Q8	0.128	0.866	0.073

Table 4.
Factor load matrix after rotation

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agricultural
technology

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Table 5.
Results of
regressions on
factors affecting
farmers' willingness
to accept LAT

Variable	Model 1	Model 2
Age	−0.001 (0.008)	0.000 (0.008)
Educational attainment	0.378 (0.099)***	0.340 (0.101)***
Village cadre	0.369 (0.179)**	0.319 (0.182)*
Share of agricultural income	0.003 (0.003)	0.003 (0.003)
Area of contracted farmland	0.052 (0.028)*	0.047 (0.028)*
Annual income per capita	0.000 (0.000)	0.000 (0.000)
Social trust		0.175 (0.095)*
Social norm		0.057 (0.088)
Social network		0.422 (0.110)***
Constant term	−0.837 (0.658)	−2.365 (0.815)***
Nagelkerke R^2	0.079	0.113
χ^2-test	0.000	0.000

Notes: *, ** and *** indicate the significance test at the 10%, 5% and 1% statistical levels, respectively; values in parentheses are standard errors

the farmers are village cadres positively and significantly influenced the willingness of farmers to adopt LAT at the 10% level. The area of contracted land has a positive and significant impact on farmers' willingness to adopt LAT at the 10% level.

5. Discussion: how did social capital intervene in the low-carbon agricultural technology extension and influence farmers' willingness to accept it

5.1 Linking social capital facilitates low-carbon agricultural technology integration and bonding social capital facilitates low-carbon agricultural technology expansion

Previous studies in LAT extension suggested that farmers are neither simple imitators nor unconditionally submissive in embracing new technologies (Compagnone and Hellec, 2015; Monge *et al.*, 2008). They do not imitate techniques from neighbors or friends easily, much less take advise from experts. Especially in the latter case, when experts show them the merits of new technology, farmers will practice their judgments and even question them. The problem of trust and communication between the two parties makes it challenging to promote LAT.

However, such barriers do not seem to be evident in our case areas. According to our survey, the LAT in the case areas comes mainly from various training organized by the government and demonstrations presented by agricultural cooperatives. However, farmers are not passive recipients in the process of adopting new technologies. On the contrary, there was a lot of communication and exchanges involved in the process and even mutual assistance in agricultural equipment, labor, etc. According to the interviewee as follows:

> [. . .] I always come to the training with my friends, and after the training, we discuss together whether we want to use these new techniques, or new seeds (interviewed by authors in July 2016, see *Table 1* No.1).

> [. . .] I would only consider using the new growing techniques if everyone else was adopting them (interviewed by authors in July 2016, see *Table 1* No. 3).

As the glue that holds the villagers together, social trust is essential in promoting cooperation. In turn, social networks as a vehicle for information transfer also help to facilitate the spillover and dissemination of LAT-related information and knowledge.

Besides, there are fewer barriers to communication with the government. On the supply side, the Executive Order's constraints require village officials to maintain frequent contact with farmers (usually once every two weeks). On the demand side, farmers are more likely to understand village officials' "language" than that of the experts. The use of dialects is one reason, but a more important reason is that government officials are less likely to use specialized vocabulary that farmers have difficulty understanding. According to the interviewee as follows:

> [. . .] Much of what the experts present we do not care about and do not understand. Other local agricultural extension workers are much better, and he will directly tell us how much the government subsidies, whether the yield is guaranteed, and whether it will increase the income. These are what we care about (interviewed by authors in July 2016, see *Table 1* No. 6).

As mentioned earlier, most village officials or their families are also engaged in local agricultural production. Hence, village officials can use their own or their family's practical experience to convince the farmers. As a result, farmers are more likely to network and build trust with government officials.

Farmers' acceptance of LAT is based solely on the trade-off between the benefits of local networks and trust in local villagers and village officials. Therefore, it can be established that the linking network structure between government and farmers facilitates the input of LAT in the regions that rely on external resources and information and the bonding network structure facilitates the development of LAT within the region.

5.2 Lack of social norms leads to low-carbon agricultural technology's practice failing to become a norm of behavior

Unfortunately, the social norms in this study failed to influence farmers' willingness to accept the LAT (not significant in the Logistic model). There are the following two main reasons for this: the inadequacy of LAT norms and institutions and the gradual disintegration of traditional rural social structures. Currently, Chinese agricultural production is in a transition period of large-scale LAT adoption and the formal system associated with LAT is not yet robust (Zhou, 2017). Nevertheless, the Chinese Government has amended several laws over the past decade to address agro-ecological environmental issues such as the *Basic Agricultural Land Protection Regulations* and the *Land Management Law*. Despite the strengthening of the regulation of the agro-ecological environment in these laws, the legal and technical norms directly applicable to low-carbon agriculture remain absent. Moreover, for local officials, guaranteeing food production and farmers' incomes remains of paramount importance. In recent years, comprehensive poverty eradication and the pursuit of small prosperity have been the focus of rural grassroots officials. Consequently, government officials have turned a blind eye to some farmers who violate the rules of low-carbon agricultural production to increase their income. According to the interviewee as follows:

> [. . .] Although the ratio used for LAT is also part of the [performance] appraisal, the [appraisal] weight of guaranteed production is a bit higher (interviewed by authors in Jan. 2016, see *Table 1*, No.13).

Beyond that, with the acceleration of urbanization and agro-industrialization, the traditional rural social structure has gradually disintegrated (Day and Schneider, 2018). As most of the young rural labor force chose to go to the cities for employment, the rural areas of our study area slowly began introducing new professional farmers (Wilson *et al.*, 2018; Zhang *et al.*, 2018). These outsiders lack the original geographic and blood ties with the local farmers.

Moreover, collective behavioral constraints are weaker for them. For the outsiders, the primary purpose of engaging in local agricultural production is to increase their income. They do not care if their productive behavior is consistent with the surrounding villagers. In our research, such samples were also relatively low in their willingness to adopt LAT. According to the interviewee as follows:

> [. . .] We just rent land here to plant, our hometown is out of town, there is no acquaintance here, we want to make more money and then go back home (interviewed by authors in Oct. 2016, see Table 1 No.7).

Therefore, it can be argued that both the government and the villagers lack mechanisms for rewards and punishments for LAT practice. The absence of LAT norms and reward and punishment measures, in turn, fails to strengthen the authority of LAT practice. Ultimately, the farmers' willingness to accept the LAT is a self-serving choice based on social trust and after adequate communication with the social network. In other words, farmers fail to internalize the practices of LAT into their norms of behavior.

Climate change has become an essential factor limiting society's sustainable development (Bai *et al.*, 2019; Zhen *et al.*, 2017). Agriculture, as the second-largest source of GHG emissions, has a profound impact on climate change. As a result, promoting and applying LAT is crucial for the agricultural sector to cope with climate change (Kogo *et al.*, 2020). There are already many successful LAT application cases, but the difficulty is extending it to a broader area or country (Norton and Alwang, 2020). The accumulation of social capital contributes to LAT extension and also can ensure the practice of it.

6. Conclusions and policy implication

This paper explores the factors that influence the acceptance of LAT by farmers from the perspective of social capital. This paper first constructs a theoretical analysis framework based on social capital. In this theoretical framework, the paper argues that village officials are what make up the local government and form part of the local villagers' collective. This linkage makes it easier for local villagers to access linking social capital, which was considered by previous studies as more difficult for rural residents. The local government's linking to the villagers (farmers) allows the LAT to be introduced from outside into the farmers' circle. Subsequently, based on the network of trust and communication among farmers and between farmers and local governments, farmers made choices that were in their interest.

Moreover, and more importantly, while social trust contributes to LAT's extension, this trust is still very much dependent on traditional geographical and blood ties in rural China. Therefore, the institutional safeguards required for the extension and practice of LAT are particularly essential. However, due to the absence of LAT-related laws, technical standards and the gradual disintegration of traditional rural societies, social norms among farmers and between farmers and local governments have not been significant factors that have affected the willingness to accept LAT. This has further led to the fact that farmers, although generally willing to accept LAT, did not adopt LAT-based agricultural production as their behavioral norm. Therefore, while it is essential to strengthening grassroots communication networks and government model demonstrations in LAT extension, it is even more important that China should improve the LAT-related laws and technical norms and strengthen LAT-based agricultural production's authority and compulsion. This will further enable adopting low-carbon agricultural production models as the norm for farmers' own and collective behavior.

This paper's findings also have implications for the LAT extension to control GHG emissions from the agricultural sector in other countries, especially in developing countries. An effective response for policymakers is establishing or strengthening local social networks, such as agricultural cooperatives or farmers' clubs. Then, through policy incentives or financial incentives, farmers are encouraged to frequent these organizations. When providing LAT-related services within these organizations, it is essential to avoid monolithic knowledge or technology input instead of promoting mutual assistance among organizational members to form self-help communities. Such communication and mutual assistance also facilitate the formation of social trust. Finally, and most importantly, the practice of LAT should be as a regional and collective behavior norm through specific laws, regulations and other mandatory measures.

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