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## Social Media, Knowledge Management, and Learning in Farmer Innovation

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### Abstract

This study aims to address the research gap by investigating how social media influences the innovation ability of new professional farmers, with a specific focus on technological perspectives. Grounded in embeddedness theory and taking into account the roles of knowledge management and learning orientation, the research aims to unveil the dynamics shaping farmer innovation within the context of social media engagement. Employing a structural equation model and utilizing survey data from 336 farmers, the empirical research concludes that social media embedding significantly and positively impacts the innovation ability of new professional farmers. Knowledge management acts as a partial intermediary between network media embedding and the innovation ability of new professional farmers, and a complete intermediary between network community embedding and their innovation ability. Learning orientation positively moderates the relationship between network media embedding, network community embedding, and knowledge management. The study seeks to contribute to the comprehension of how social media can foster innovation among farmers, thereby promoting high-quality and sustainable development in agriculture. In light of this, recommendations are suggested for the government to encourage social media usage, for farmers to enhance their media literacy, strengthen knowledge management, and cultivate a learning-oriented mindset.

**Keywords:** Social Media Embedding; Network Media Embedding; Network Community Embedding; Farmer Innovation Ability; Knowledge Management; Learning Orientation.

## 1. Introduction

The agricultural landscape has undergone a transformative evolution in recent years, marked by a discernible shift towards high-tech methodologies and innovative practices [1]. In this era of rapid technological advancement, the farming industry is increasingly embracing cutting-edge technologies to enhance productivity, efficiency, and sustainability. The integration of digital tools, precision agriculture, and data-driven decision-making has ushered in a new era of agricultural practices, redefining traditional approaches to farming [2]. As the farming sector continues to grapple with challenges posed by a growing global population, climate change, and resource constraints, the adoption of innovative solutions becomes imperative [3]. High-tech innovations not only promise increased yields and resource optimization but also open up new possibilities for aspiring and emerging professional farmers [4]. Understanding the role of social media in fostering innovation among new professional farmers becomes a crucial area of exploration, particularly considering the potential intermediaries such as knowledge management and the moderating influence of learning orientation [5]. The contribution of new professional farmers to the revitalization of rural industries, economic

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development, and social prosperity in China is undeniable [6]. At all levels of government in China, there is a strong emphasis on providing vocational training for new farmers to enhance their innovation and entrepreneurship capabilities [7]. Innovation has always been a vital component of agricultural development, and farmers' innovative ability is no exception. Globally, farmers' innovation, such as selecting new agricultural varieties, utilizing new machinery, and adopting novel business models, can amplify agricultural production scale, improve food quality, and help farmers reduce production costs by enhancing labor efficiency [8]. Farmers' innovation and rational use of resources such as water, land, and labor can sustain the rural environment and economic development, aligning with the United Nations Sustainable Development Goals to a greater extent [9].

Innovation ability is the embodiment of innovative behavior and comprehensive quality, and it is crucial for the development of innovative activities and performance [10]. Exploring the formation mechanism of farmers' innovation ability is helpful for cultivating their innovative skills [11]. Currently, scholars have primarily investigated the impact of government policies [12], non-cognitive skills [13], and peer effects [14] on farmers' innovation ability from institutional, individual traits, and network perspectives, respectively. Information technology is a significant force driving innovation, and its role is increasingly receiving attention from scholars in the agricultural field. A survey conducted among female small farmers in Kenyan agricultural communities found that farmers have a positive attitude toward information technology tools, which support their agricultural operations, improve agricultural productivity, and provide convenient and accessible markets for their products [15]. More research has also begun to analyze the relationship between information technology and agricultural innovation to further the development of emerging digital tools. However, through reading relevant literature, it can be found that current research mainly focuses on the role of traditional information technology tools such as television, the internet, and radio [16], and there is relatively little analysis of social media as the latest information tool, especially a lack of specific path research on the role of social media in farmers' innovation. In rural China, new professional farmers have used WeChat, TikTok, and other social media to carry out innovative agricultural management and have achieved remarkable results [17]. Therefore, exploring the relationship between the latest social media tools and farmers' innovation is particularly urgent.

In addition, network media embedding is described as the integration of social media platforms into farmers' communication networks, facilitating knowledge exchange and information sharing within agricultural communities [18]. This exchange of information fosters idea generation and problem-solving, thereby enhancing innovation abilities among farmers [19]. Similarly, network community embedding, characterized by farmers' involvement in online agricultural communities and forums, has been shown to positively impact innovation ability [20]. The role of online communities in providing a supportive environment for knowledge acquisition, collaboration, and collective learning is essential. Through active participation in these communities, farmers gain access to diverse expertise, resources, and innovative ideas, contributing to the development and implementation of novel farming practices and technologies [21]. Hence, this research aims to examine the relationships of network media embedding and network community embedding on farmers' ability to innovate.

The development of agricultural systems is based on various innovative processes, which are currently being challenged by sustainability issues. Especially today, various reports and scientific research emphasize the knowledge of farmers as a way to design more sustainable agricultural systems [22]. Knowledge and Innovation Management (KIM) can play a key role in cultivating and managing the creativity of integrated enterprises [23]. Information technology is widely used for knowledge management [24]. In many countries around the world, farm innovators regularly use WhatsApp on their phones. They use social media to learn and share personal agricultural management knowledge and experience, build knowledge through social networks, innovate farmer learning and exchange forums, and promote the creation of social wealth [25]. In Mexico, female farmers use digital tools such as mobile phones and the internet to manage the knowledge and technology contained in the traditional Tequila Mescal process, reflecting the significance of knowledge management for sustainable agricultural development [26]. In China's rural areas, new professional farmers extensively employ social media platforms like WeChat and TikTok to sell agricultural products and carry out agricultural operations, resulting in a continuous stream of innovation activities [27]. Farmers have also made significant improvements in their knowledge of markets, products, and marketing, but there is relatively little research on social media, knowledge management, and the relationship between their outcomes. The practicality of farmers' knowledge management is far ahead of theoretical research.

Research has elucidated that network media embedding, involving the integration of social media platforms into farmers' communication networks, facilitates the dissemination and sharing of agricultural knowledge and information [18]. Utilizing online platforms, farmers gain access to a diverse range of agricultural resources, expert insights, and best practices, thereby enriching their knowledge base and improving knowledge acquisition processes [28]. Similarly, network community embedding, characterized by farmers' participation in online agricultural communities and forums, contributes to effective knowledge management [20]. Research has emphasized the role of online communities in fostering collaborative knowledge creation, exchange, and retention among farmers. Through active participation in discussions, sharing experiences, and seeking advice within these communities, farmers can tap into collective intelligence, leveraging diverse perspectives and expertise to address agricultural challenges and enhance farming practices [29]. Hence, this research aims to explore the relationships of network media embedding and network community embedding in knowledge management.

Knowledge management plays a critical role in fostering innovation ability among farmers. By systematically organizing and leveraging existing knowledge resources, farmers can enhance their problem-solving abilities and generate novel ideas to improve agricultural practices [30]. Furthermore, knowledge management facilitates the creation of conducive environments for innovation. The importance of knowledge sharing and collaboration in stimulating innovation among agricultural communities is essential. Through knowledge management initiatives, such as training programs, workshops, and knowledge exchange platforms, farmers can exchange ideas, experiences, and insights, fostering a culture of innovation and experimentation [31]. Moreover, knowledge management enables the effective utilization of external knowledge and expertise, which is essential for innovation. The role of knowledge sourcing from external networks, including research institutions, universities, and industry experts, in driving innovation in agriculture [29]. By accessing external knowledge networks and leveraging external resources, farmers can access cutting-edge technologies, innovative practices, and market insights, thereby enhancing their innovation ability [28]. As a result, this research explores knowledge management as a mediating variable for the relationships of network media embedding and network community embedding on the farmer's ability to innovate.

In a dynamic environment, achieving sustainable agricultural development demands that farmers possess strong adaptability [32], making it necessary for farmers to establish a strategic concept of learning orientation and develop a habit of lifelong learning. Studies have long proven that learning orientation has a significant impact on employees' knowledge management [33]. Currently, while many farmers use social media, variations exist in the management effects and innovation abilities concerning social media information and knowledge among individual farmers [34]. Does this difference result from differences in new professional farmers' learning orientation? Can learning orientation regulate the relationship between new professional farmers and social media? Can it encourage new professional farmers to better use social media tools to obtain better knowledge management results? Currently, there is no relevant research analyzing these issues. Hence, this research employs learning orientation as a moderating variable.

This study addresses several critical research gaps by employing the embeddedness theory. Firstly, it contributes to the understanding of social media's role in enhancing innovation ability among new professional farmers, an area where empirical research is scarce. Second, by adopting embeddedness theory and considering structures within a particular context, this study sheds light on how social media embedding influences innovation dynamics within agricultural communities. Additionally, by integrating the perspectives of knowledge management and learning orientation, embeddedness theory provides a holistic framework for analyzing the complex interactions between social media use, knowledge sharing, learning processes, and innovation outcomes among farmers. Therefore, this study not only advances our understanding of social media's impact on farmer innovation but also demonstrates the utility of embeddedness theory in addressing multifaceted research inquiries in agricultural contexts.

This study utilizes embeddedness theory to analyze the impact of various social media embedding methods on the innovative ability of new professional farmers from the perspective of knowledge management. It aims to reveal the specific path of network embedding and media embedding's influence on innovative ability, explore the mediating effect of knowledge management, and investigate the moderating effect of learning orientation. The goal is to provide reference and inspiration for cultivating the innovative ability of new professional farmers under information technology scenarios and to offer better human resource reserves for agricultural sustainable development.

## 2. Theoretical Foundation and Research Hypothesis

### 2.1. Social Media Embedding

Embeddedness theory suggests that organizational economic behavior is closely related to social systems [35]. In the era of the internet, internet embedding is used to measure the relationship between human behavior and the internet. According to Yongyun et al. [36], the internet serves as both a content platform and a network platform. Therefore, internet embedding is represented by two dimensions: network community embedding and media embedding. Social media, as a content production and communication platform based on internet-user relationships [37], has become a typical manifestation of internet embedding. Social media embedding reflects the extent to which people use social media for work and daily life, showcasing the interdependent relationship between people and social media. Similarly, social media embedding can be divided into two dimensions: network community embedding and network media embedding [36]. Network community embedding pertains to the breadth and closeness of various social relationship networks formed by entrepreneurs through the use of social media tools such as instant messaging and short videos on the internet. For instance, some African women have expanded their social circles through social media, developed personal care and beauty products at home, and grown into female entrepreneurs [38]. Network media embedding refers to the frequency and extent of entrepreneurs' use of social media network media functions. This includes obtaining information through search and browsing on social media, publishing information through content creation, forwarding, and commenting, and conducting social activities through voice and video functions [18]. From the perspective of embeddedness, analyzing the impact of different embedding methods of social media on farmers' innovative ability contributes to a deeper understanding of the ways in which social media affects farmers' innovative behavior.

## 2.2. Knowledge Management Theory

According to knowledge management theory, acquiring, integrating, and creating new and valuable knowledge are key to maintaining a competitive advantage for enterprises and significantly influence the enterprise's performance and sustainable development [39]. In the field of agriculture, farmers' knowledge management has long been considered an important factor in determining the quality of agricultural operations [40]. Agricultural entrepreneurship mostly involves small and micro-scale operations, and the comprehensive quality and ability of farmers often determine the success or failure of agricultural entrepreneurship. During facing natural disasters, the fragility of agricultural operations becomes evident, and farmers' knowledge, values, and other factors influence their adaptive decision-making and behavior, resulting in different agricultural operation results [41]. Therefore, strengthening knowledge management for farmers is an important way to deal with risks and improve business performance [42]. Knowledge is the main driving force for innovation, and the development of sustainable agricultural innovation requires farmers to have various knowledge reserves, including adaptive crops, the local environment, and farming systems [43]. Therefore, farmers should not only use existing knowledge but also invest in external knowledge acquisition. In France, farmers draw on a variety of knowledge sources, exhibiting individual differences in the intensity of knowledge use and determining their differences in sustainable agricultural innovation [44]. Strengthening research on the relationship between social media and farmers' knowledge management is an effective exploration of information technology methods to improve farmers' knowledge management levels.

## 2.3. Learning Orientation

According to Calantone et al. [45], learning orientation is the foundation of learning, with the aim of generating a learning process. Learning orientation is often used to develop new insights [46] and create and manage knowledge [47]. In practice, learning orientation continuously stimulates organizational learning through openness of thinking and commitment to learning. According to Liao et al. [48], organizational learning ability is the source of sustainable competitive advantage, significantly affecting organizational knowledgeability and innovation [49].

## 2.4. Social Media Embedding and Innovation Ability

Organizations' information technology resources can enhance their performance [50]. Social media serves not only as a medium for entrepreneurial learning and self-employment but also as a tool for entrepreneurial marketing and a source of entrepreneurial opportunities. It also acts as a facilitator of entrepreneurial networks and ecosystems [51], playing a crucial role in integrating internal and external resources and developing new products and services [52]. Social media allows the publication of videos, and learning courses through video intermediaries are more effective than traditional seminars and training. This can improve farmers' understanding of plant pesticides, alter their attitudes, and ultimately lead them to adopt these methods. Videos can convey complex issues and explain the biological and physical processes underlying agricultural innovation, making it easier for farmers to accept innovation and thereby enhancing their innovation ability [53]. Social media also promotes innovative interaction. Scholars widely recognize the use of social media to leverage the wisdom of the masses in shaping significant commercial decisions and societal lifestyles [54]. Numerous studies have demonstrated that social media can drive innovation in the retail business [55]. In the agricultural products retail industry, both radical and incremental innovations have significantly increased with the use of social media. A study on Spanish family businesses found that social media has completely transformed the relationship between the enterprise and the market. Family businesses can use social media to connect and collaborate with different stakeholders, strengthening open innovation activities [56]. In Indonesia, farmers traditionally obtain information on agriculture, forestry, and their innovations through interpersonal communication. Social media has built a rich social network that facilitates interpersonal communication on the network at a lower cost, faster speed, and in a more convenient manner. This is more conducive to the role of farmer experts and opinion leaders in promoting innovation dissemination [57]. Based on the above research, the following hypotheses are drawn:

**H1:** *Network media embedding has a significant positive impact on the innovation ability of new professional farmers.*

**H2:** *Network community embedding has a significant positive impact on the innovation ability of new professional farmers.*

## 2.5. Social Media Embedding and Farmer Knowledge Management

IT technology is one of the key factors affecting knowledge management, helping enterprises improve the efficiency of knowledge storage, sharing, and acquisition [58]. Academic research has found that social media is increasingly used as a tool to manage the flow of knowledge within and across organizational boundaries in the innovation process [54]. As a popular medium, social media also has a significant impact on farmers' agricultural technology and related knowledge. Social media serves as a potential communication channel for farmer interaction and knowledge sharing. Foreign research scholars have found that Twitter, as an example, can capture the immediacy and visual impact of real-

time operations. The brief messages shared through Twitter attract time-limited farmers to learn and share agricultural innovation practices on social media. Farmers also form virtual networks around specific topics. Within these networks, farmer entrepreneurship models emerge and are respected by other farmers. Proactive farmer innovators can learn more about agricultural technology and management knowledge from entrepreneurship models and experts in virtual networks [59]. A survey of Rwanda and Uganda found that mass media promotional activities such as mobile text messages and video screenings are significantly associated with increasing farmers' awareness of pesticide risks and safety prevention measures. This can encourage farmers to adopt safer pest management strategies [60]. In foreign countries, online social networking technology is also used by agriculturally integrated enterprises to access information and generate knowledge. This provides supplementary information for management and decision-making in the agricultural system, allowing companies to respond more quickly to market changes [61]. Scholarly research also confirms that farmers using smartphones with appropriate applications have a higher adoption rate of innovative fertilization practices than those listening to radio broadcasts. They perform better in agronomic knowledge and are more cost-effective. Therefore, promoting the use of smartphones among farmers has an important positive effect on the dissemination of agricultural information technology [62]. Based on the above research, the following hypotheses are drawn:

**H3:** *Network media embedding has a significant positive impact on the knowledge management of new professional farmers.*

**H4:** *Network community embedding has a significant positive impact on the knowledge management of new professional farmers.*

## 2.6. Knowledge Management and Innovation Ability

Knowledge management is a decisive factor for enterprise innovation, and through knowledge management, the decision-making environment gains the ability to effectively manage stakeholder satisfaction processes [63]. Both knowledge acquisition and integration, as well as creation, are positively correlated with dual innovation [64]. Scholarly research has found that companies embedded in automotive industrial clusters can enhance their innovation ability by strengthening knowledge management, influencing innovation performance [65]. Executives of companies can catalyze innovation through knowledge management, positively promoting enterprise innovation [66].

Virtual and real practice communities built based on social media also play a crucial role in promoting farmers' innovative behavior. Farmers who collectively construct knowledge in practice communities are better equipped to innovate than those who work alone with expert support [67]. According to Rosário et al. [68], the ability and behavior of farmers' sustainable agricultural innovation are influenced by the relevant knowledge, attitudes, and subjective norms of sustainable innovation. By enhancing the management of relevant knowledge, the probability of farmers' sustainable agricultural innovation will increase. It is evident that knowledge is a necessary element for the growth of agricultural enterprises, and the management ability of farmer knowledge significantly influences the promotion of the innovation ability of agricultural enterprises [23]. Based on the above research, the following hypothesis is drawn:

**H5:** *The knowledge management of new professional farmers has a significant positive impact on innovation ability.*

## 2.7. Knowledge Management as a Mediating Factor

Scholars have found in their study of the development of small and medium-sized enterprises in South Asia that social media has led to the joint creation of knowledge in developing societies and has thereby promoted innovation, accelerating the growth of the creative economy [69]. Chilean fruit farmers use integrated and bridging social capital to explore and acquire new knowledge and resources, ultimately promoting the implementation of new agricultural technologies and practices. Different participants in farmers' social networks, such as peers, advisors, and researchers, provide support for the knowledge needed for agricultural innovation on farms [70]. According to Cepeda-Carrion et al. [56], in Spain, social media usage helps family businesses identify and obtain more innovation opportunities by accessing external information and knowledge. For new professional farmers, the influence of social media embedding on innovation ability must undergo an intricate process, specifically involving the management of farmer knowledge. It is only through acquiring sufficient knowledge, learning to share, integrate, and apply that knowledge, that the innovation ability of farmers can genuinely improve. Based on the above research, the following hypothesis is drawn:

**H6:** *Knowledge management plays a significant mediating role between social media embedding and the innovation ability of new professional farmers.*

**H6a:** *Knowledge management plays a significant mediating role between network media embedding and the innovation ability of new professional farmers.*

**H6b:** *Knowledge management plays a significant mediating role between network community embedding and the innovation ability of new professional farmers.*

### 2.8. The Regulatory Effect of Learning Orientation

Learning orientation (LO) is a crucial strategic orientation that empowers companies to better acquire external knowledge, transform and utilize it, induce changes in their thinking patterns and behavior, and enhance the likelihood of engaging in innovative and proactive activities [39]. The significant impact of learning orientation on knowledge management has been generally verified. According to Alerasoul et al. [71], in specific social network relationships, companies with a strong learning orientation have a clearer purpose in knowledge searches. They are more proactive in obtaining information and are more likely to discover valuable knowledge. They also use their subjective initiative to seize opportunities, match, integrate, and utilize knowledge, and even create knowledge again. Research on small and medium-sized enterprises (SMEs) found that learning orientation affects the acquisition and utilization of operational information and knowledge, thereby influencing the performance of SMEs [72]. Cross-border search is employed to gather various resources, including knowledge, related to the study of innovative behavior in new ventures. Learning orientation plays a moderating role, and the more LO-oriented enterprises are, the stronger their cross-border integration ability is, ultimately leading to better innovation performance [73]. Alnuaimi et al. [74] proposed that in the IT environment, companies with a stronger LO are more willing for employees to communicate, share knowledge, and integrate knowledge, which is beneficial for promoting enterprise performance. For new professional farmers, if their LO is stronger, they are more likely to use social media as a means to learn and carry out knowledge management. Ultimately, whether it is from online media or online communities, they can better acquire, integrate, and utilize relevant knowledge to serve agricultural entrepreneurship. Based on the above research and analysis, the following hypotheses are proposed:

**H7:** LO plays a positive regulatory role between online media embedding and new professional farmer knowledge management.

**H8:** LO plays a positive regulatory role between online community embedding and new professional farmer knowledge management.

Based on the above, this study has developed the following conceptual model diagram (Figure 1).

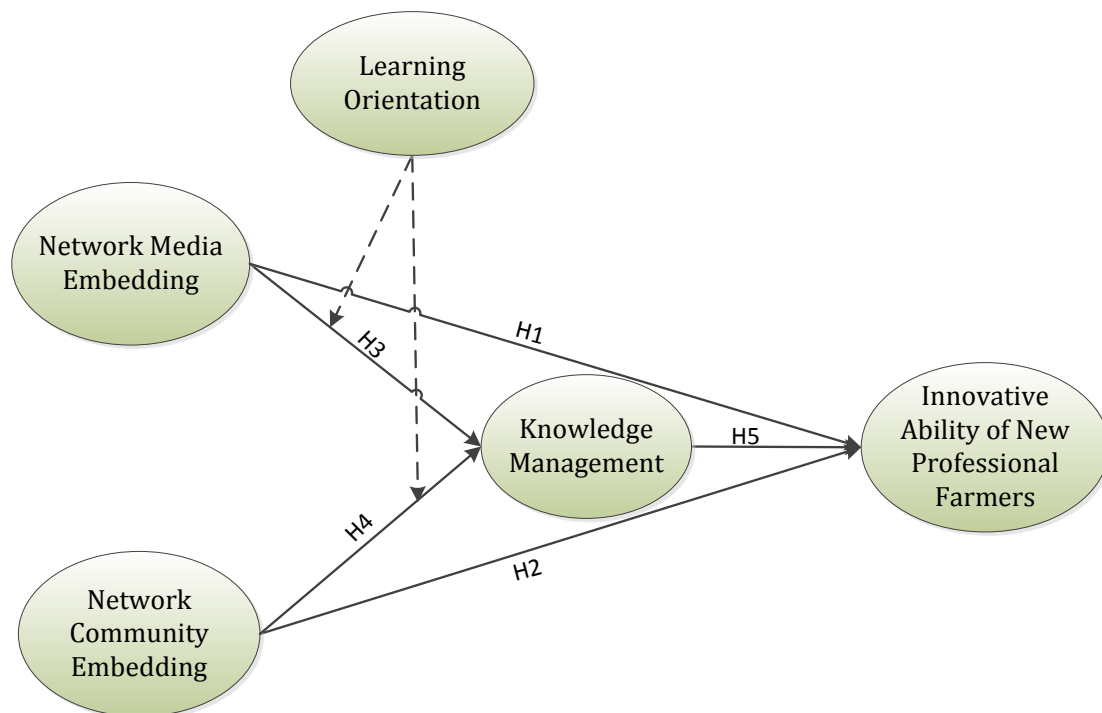


Figure 1. Conceptual model diagram of this study (Note: The dotted lines represent the moderating effects)

## 3. Research Design and Data Collection

### 3.1. Variable Measurement and Questionnaire Design

This study includes five variables: online media embedding, online community embedding, knowledge management, innovation ability, and learning orientation. The scales for online media embedding and online community embedding are adapted from Xie et al. [27], the scale for knowledge management is adapted from Mardani et al. [30], the scale for innovation ability is adapted from Borah et al. [75], and the scale for learning orientation is adapted from Wahyono & Hutahayan [49].

All measurement items are devised using a 7-point Likert scale, encompassing fully consistent, consistent, relatively consistent, general, relatively inconsistent, inconsistent, and fully inconsistent. The research team conducted interviews in the early stage to comprehend the relevant situations of the research variables. The questionnaire was crafted in conjunction with the specific rural context to refine the expression of the items and consulted experts in agricultural business operations. This detailed information bolsters the transparency and credibility of the research methodology, providing a clear rationale for the selection of parameters and the design of the measurement instruments. Moreover, it underscores the researchers' efforts to ensure the validity and reliability of the study findings within the agricultural context. The manuscript employed Harman's single-factor test to evaluate convergent bias. Prior to this analysis, reliability and validity tests were executed on the scales included in the survey questionnaire. Using SPSS 24.0, reliability analysis was carried out, revealing Cronbach's  $\alpha$  values for the five variables were higher than the others. These findings further fortify the methodological rigor of the study by demonstrating the reliability of the measurement instruments used to assess the variables of interest. Moreover, they provide assurance regarding the internal consistency of the questionnaire items, enhancing confidence in the validity of the research findings. The specific research variables and their measurement items in the questionnaire are presented in Appendix I.

### 3.2. Data Collection

The research team collected data through both offline and online questionnaires. The offline questionnaire was mainly distributed to fruit, animal husbandry, and vegetable classes of the new professional farmer training program in Fujian Province. These students are typical representatives of new professional farmers in various regions of Fujian Province and have received training in social media operations. Selecting them as research subjects enables a reflection of the current situation of social media use and innovative management among new professional farmers in China. The online questionnaire, on the other hand, was disseminated to teachers knowledgeable about individuals conducting rural e-commerce training throughout the province, aiming to collect information on the responses of local training class students to the questionnaire.

The research team distributed a total of 417 questionnaires, and 336 valid questionnaires were collected after excluding invalid responses, resulting in an effective questionnaire recovery rate of 80.58%. Among the respondents, 177 were male, constituting 52.68%, and 159 were female, accounting for 47.32%. In terms of age, 191 people were aged 31 to 40, accounting for the highest proportion, reaching 56.85%. In terms of education, agricultural entrepreneurs with a high school (or technical secondary school) education had the highest proportion, with 187 people, accounting for 55.65%. Farmers with a junior high school education ranked second with 93 people, accounting for 27.68%, and those with a college education or above had 56 people, accounting for 16.67%. In terms of entrepreneurial activities, 238 individuals engaged in large-scale planting and breeding, agricultural product processing, agricultural product sales, and agricultural tourism services were 238, 19, 56, and 23 people respectively.

## 4. Data Analysis and Results

### 4.1. Analysis of Convergent Bias

In order to evaluate the potential impact of convergent bias, this study utilized Harman's single-factor test, a widely recognized method for detecting common method bias in survey research. Exploratory factor analysis was conducted on a dataset comprising 336 questionnaires, aiming to assess the extent to which variance in responses could be attributed to a single underlying factor. The analysis revealed that, in the absence of rotation, the first factor accounted for 46.731% of the total variance. Typically, if a single dominant factor explains more than 50% of the variance, it suggests the potential presence of common method bias. However, in this instance, the first factor explained less than 50% of the variance, indicating that common method bias was not a significant concern in this study. This finding enhances the credibility and validity of the research results, suggesting that the observed relationships among variables are unlikely to be distorted by methodological biases.

### 4.2. Reliability and Validity Test

The initial phase of this study entailed conducting thorough assessments of reliability and validity on the scales employed within the survey questionnaire. Utilizing SPSS 24.0, reliability analysis was performed to compute Cronbach's  $\alpha$  values for each of the five variables: network media embedding, network community embedding, knowledge management, innovation ability, and learning orientation. The resulting Cronbach's  $\alpha$  values were 0.878, 0.772, 0.905, 0.890, and 0.879, respectively. These values surpassed the conventional threshold of 0.7, indicating strong internal consistency and reliability of the questionnaire scales. A Cronbach's  $\alpha$  value exceeding 0.7 signifies that the items within each variable consistently measure the same underlying construct. Hence, the questionnaire demonstrates reliability in assessing the targeted constructs. A detailed summary of these reliability analysis outcomes is provided in Table 1, supporting the credibility of the measurement instrument employed in the study.

**Table 1. Reliability and validity test results of each variable**

Variables	Indicators	Measurement items	Factor loading coefficient	CR	AVE	Cronbach's $\alpha$
Network media embedding	ME1	I use social media to disseminate information.	0.923	0.894	0.739	0.878
	ME2	I utilize social media to acquire information.	0.850			
	ME3	My entrepreneurial activities are dependent on the media functionality of social media.	0.802			
Network community embedding	CE1	I maintain close contact with friends on social media networks.	0.739	0.776	0.537	0.772
	CE2	I have many friends I can interact with on social media.	0.704			
	CE3	I can obtain a large amount of heterogeneous information from social media friends.	0.754			
Knowledge management	KM1	I can acquire information on agricultural innovation and management.	0.839	0.907	0.661	0.905
	KM2	I possess information required for agricultural innovation and management.	0.871			
	KM3	I share information on agricultural innovation and management.	0.788			
	KM4	I integrate various types of agricultural innovation information.	0.816			
	KM5	I utilize agricultural innovation information based on my needs.	0.744			
Innovative ability	AI1	I can flexibly respond to and solve agricultural management issues.	0.871	0.890	0.730	0.890
	AI2	I can propose innovative agricultural management strategies.	0.863			
	AI3	My agricultural innovation and management have achieved relatively good results.	0.829			
Learning orientation	LO1	I believe learning is important in agricultural innovation and management.	0.810	0.879	0.645	0.879
	LO2	I regularly spend time learning how to improve agricultural innovation and management.	0.755			
	LO3	I am willing to spend money to learn agricultural innovation and management.	0.835			
	LO4	Learning is an essential component of my agricultural entrepreneurship.	0.811			

After the examination of reliability and validity, this study employed AMOS 24.0 to execute confirmatory factor analysis on the examined variables. The outcomes, detailed in Table 2, unveiled average variance extracted (AVE) values for each variable: network media embedding, network community embedding, knowledge management, innovation ability, and learning orientation. These AVE values were determined to be 0.739, 0.537, 0.661, 0.730, and 0.645, correspondingly. It is noteworthy that all AVE values exceeded the prescribed threshold of 0.5 as advocated by scholars, indicative of satisfactory convergence validity for every variable. Subsequently, adopting the AVE method, the square root values of the AVE for each variable were juxtaposed with the Pearson correlation coefficients between variables to evaluate discriminant validity. The square root values of the AVE for each variable were 0.860, 0.733, 0.813, 0.854, and 0.803, respectively, with correlation coefficients ranging from 0.217 to 0.686. Importantly, all correlation coefficients were found to be lesser than the square root values of the diagonal AVE, a finding that aligns with recommendations from scholars. This observation underscores the favorable discriminant validity of the study variables. Hence, the results of the confirmatory factor analysis validate the reliability and validity of the measurement model, showcasing satisfactory convergence and discriminant validity for all variables examined. Consequently, the dataset is deemed apt for further analysis, poised to provide robust insights into the relationships among the variables under scrutiny.

**Table 2. Variable correlation coefficients and discriminant validity**

	AVE	Network Media Embedding	Network Community Embedding	Knowledge Management	Innovative Ability	Learning Orientation
Network Media Embedding	0.739	<b>0.860</b>				
Network Community Embedding	0.537	0.677**	<b>0.733</b>			
Knowledge Management	0.661	0.663**	0.633**	<b>0.813</b>		
Innovative Ability	0.730	0.619**	0.553**	0.686**	<b>0.854</b>	
Learning Orientation	0.645	0.326**	0.395**	0.303**	0.217**	<b>0.803</b>

Note: \*  $p < 0.05$ , \*\*  $p < 0.01$ . The items on the boldface diagonal represent the square roots of the AVE; off-diagonal elements are the correlation estimates. AVE refers to the average variance extracted.



### 4.3. Structural Model Testing

This study continued to use AMOS24.0 to test the fitness of the model, and the results are shown in Table 3. The chi-square/degree of freedom ( $\chi^2/DF$ ) value is 1.663, which is within the acceptable range of less than 3. The values of TLI, CFI, GFI, RFI, NFI, and IFI are 0.981, 0.985, 0.953, 0.954, 0.964, and 0.985, all greater than 0.9. The RMSEA value is 0.044, which is less than 0.08. All fitness index values are within the acceptable range and meet the suggestions of scholars, indicating that the fitness of the model in this study is good and can proceed to the next step of testing.

**Table 3. Model fit**

Fitting index	$\chi^2/DF$	TLI	CFI	GFI	RFI	NFI	IFI	RMSEA
Allowable range	$1 < \chi^2/DF < 3$	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	<0.08
Study model fit	1.663	0.981	0.985	0.953	0.954	0.964	0.985	0.044

### 4.4. Path Analysis Test

The path relationships between variables in the research model were tested using AMOS24.0, and the results are detailed in Table 4. Firstly, social media embedding significantly and positively affects innovation ability ( $\beta=0.277$ ,  $p=0.029$ ), supporting H1. This implies that the network media function of social media directly and positively impacts the innovation ability of new professional farmers. However, the path of network community embedding on the innovation ability of new professional farmers is not significant ( $\beta=0.113$ ,  $p=0.376$ ), contradicting H2. This suggests that the network community function of social media does not directly and positively impact the innovation ability of new professional farmers. This may be because the farmers' abilities are relatively weak, and although they have formed communities, they have not fully utilized the communities, so the impact of communities on innovation cannot be realized. Secondly, in the path from social media embedding to knowledge management, network media embedding significantly positively affects knowledge management ( $\beta=0.435$ ,  $p=0.002$ ), supporting H3, indicating that the network media function of social media can promote knowledge management. Network community embedding also significantly positively affects knowledge management ( $\beta=0.563$ ,  $p < 0.000$ ), supporting H4. This indicates that the network community function of social media can also promote knowledge management. Finally, knowledge management significantly positively affects innovation ability ( $\beta=0.511$ ,  $p < 0.000$ ), supporting H5. This suggests that enhancing knowledge management in the context of social media is beneficial for improving the innovation ability of new professional farmers.

**Table 4. Path analysis results**

Action path	Unstandardized path coefficient	SE	z (CR)	p	Standardized path coefficient	Hypothesis	Result
Network media embedding $\Rightarrow$ Innovative ability	0.277	0.127	2.181	0.029	0.213	H1	Support
Network community embedding $\Rightarrow$ Innovative ability	0.113	0.127	0.886	0.376	0.102	H2	Not support
Network media embedding $\Rightarrow$ Knowledge management	0.435	0.140	3.099	0.002	0.322	H3	Support
Network community embedding $\Rightarrow$ Knowledge management	0.563	0.130	4.330	***	0.490	H4	Support
Knowledge management $\Rightarrow$ Innovative ability	0.511	0.078	6.566	***	0.529	H5	Support

Note: \*\*\*  $p < 0.001$ .

### 4.5. Mediating Effect Test

This study continued to utilize the bootstrap method (Bootstrapping) to analyze the mediating effect mechanism of social media embedding on the innovation ability of new professional farmers in AMOS 24.0 software. A 95% confidence level was chosen, and 5000 repeated samplings were set to obtain the results shown in Table 5. In the "network media embedding $\Rightarrow$ knowledge management $\Rightarrow$ innovation ability" path, the point estimate of the mediating effect of knowledge management was 0.223, and the Z value was 2.398. The 95% Bootstrap interval was [0.066, 0.434], indicating that the mediating effect of knowledge management reached a significant level, supporting H6a. In the "network community embedding $\Rightarrow$ knowledge management $\Rightarrow$ innovation ability" path, the mediating effect of knowledge management was 0.289, and the Z value was 2.558. The 95% Bootstrap interval was [0.124, 0.573], indicating that the mediating effect of knowledge management also reached a significant level, supporting H6b. The total mediating effect of the two paths was 0.512, and the Z value was 4.833. The 95% Bootstrap interval was [0.300, 0.722], indicating that the total mediating effect of knowledge management reached a significant level, supporting H6. Therefore, knowledge management played a significant mediating role between social media embedding and the innovation ability of new professional farmers. Based on Table 4 and Table 5, in the "network media embedding $\Rightarrow$ innovation ability" path, there were both direct and mediating paths, so knowledge management played a partial mediating role. In the "network

community embedding⇒innovation ability" path, the direct path effect was not significant, but the mediating effect was significant, indicating that network community embedding completely influenced innovation ability through the mediating effect of knowledge management. In Table 5, the total effect of social media embedding on innovation ability was 0.904, and the Z value was 12.556. The 95% Bootstrap interval was [0.762, 1.046], indicating that the total effect of social media embedding on innovation ability reached a significant level.

**Table 5. Analysis of Direct Effects, Mediated Effects, and Total Effects**

	Effects Item	Effect Coefficient	SE	z	p	LLCI	ULCI
Mediated Effects	Network media embedding⇒Knowledge management⇒Innovative ability	0.223	0.093	2.398	0.013	0.066	0.434
	Network community embedding⇒Knowledge management⇒Innovative ability	0.289	0.113	2.558	0.000	0.124	0.573
	Total Mediated Effects	0.512	0.106	4.830	0.000	0.300	0.722
	Direct Effects	0.392	0.120	3.267	0.001	0.167	0.647
	Total Effects	0.904	0.072	12.556	0.000	0.762	1.046

Note: Boot LLCI refers to the lower limit of the 95% confidence interval obtained by Bootstrap sampling, and Boot ULCI refers to the upper limit of the 95% confidence interval obtained by Bootstrap sampling.

#### 4.6. Moderating Effect Test

This study incorporated learning orientation as a moderating variable to analyze its impact on the relationship between network media embedding and knowledge management, as well as the relationship between network community embedding and knowledge management. The results presented in Table 6 reveal that when the dependent variable is knowledge management, the moderating effect of "network media embedding \* learning orientation" is 0.223 (t = 6.782, p < 0.000), indicating the presence of a moderating effect. For every increase of 1 unit in the moderator variable learning orientation, the influence of network media embedding on knowledge management will increase by 0.223 units, supporting research hypothesis H7. Additionally, the moderating effect of "network community embedding \* learning orientation" is 0.075 (t = 0.035, p = 0.034), indicating the existence of a moderating effect. For every increase of 1 unit in the moderator variable learning orientation, the influence of network community embedding on knowledge management will increase by 0.075 units, supporting research hypothesis H8. In summary, both network media embedding and network community embedding are affected by learning orientation in their impacts on knowledge management. According to the data analysis results, learning orientation has a more pronounced moderating effect on the relationship between media embedding and knowledge management. The more farmers adopt a learning attitude toward social media, the better they can engage in knowledge management in both media and communities.

**Table 6. Analysis of Moderating Effects**

Dependent variable	Independent variable	β	Standard error	t	p
knowledge management	Network media embedding	0.826	0.049	16.989	***
	Learning orientation	0.174	0.040	4.353	***
	Network media embedding*Learning orientation	0.223	0.033	6.782	***
	network community embedding	0.683	0.052	13.180	***
	Learning orientation	0.076	0.044	1.728	0.085
	Network community embedding*Learning orientation	0.075	0.035	2.133	0.034

Note: \*\*\* p<0.001.

### 5. Conclusions

Based on embedding theory and knowledge management theory, this study empirically examined the relationship between social media embedding, knowledge management, learning orientation, and the innovative ability of new professional farmers.

The following conclusions were drawn: Firstly, social media embedding significantly positively influences the innovative ability of new professional farmers. This finding aligns with a similar study conducted by Muninger et al. [76]. According to Muninger et al. [76], businesses increasingly employ social media for innovation, yet existing literature lacks comprehensive guidance for devising strategic approaches. Muninger et al. [76] adopted a qualitative, theory-building methodology to develop a conceptual framework of capabilities conducive to leveraging social media throughout the innovation lifecycle. The framework identified three critical capabilities and associated resources,

including social media management for coordinating activities across innovation stages, executive leadership for fostering support and enabling agile decision-making, and flexible processes facilitating rapid knowledge dissemination and experimentation. Muninger et al.'s [76] contribution enhanced organizational capability theory in the innovation context by offering practical insights for managerial implementation of social media strategies.

New professional farmers can directly enhance their innovative ability through the media function of social media. However, the tangible impact of network community embedding on their innovative ability is less apparent. This outcome aligns with a study conducted by Hafkesbrink & Schroll [21]. Hafkesbrink & Schroll [21] outlined a novel approach to innovation in the Digital Economy, termed "Embedded Innovation" or Innovation 3.0. It introduced the concept of "embeddedness" to highlight the growing importance of integrating firms into their surrounding communities to effectively absorb valuable knowledge. Hafkesbrink & Schroll [21] discussed the evolutionary transition from Closed to Open to Embedded Innovation in small and medium-sized enterprises (SMEs), shedding light on the varying modes of learning from communities based on firm relationships and knowledge flows.

Third, knowledge management plays a significant mediating role between social media embedding and the innovative ability of new professional farmers. This outcome resonates with a previous study conducted by Sapta et al. [77], where knowledge management also served as a mediating variable. Sapta et al. [77] investigated how organizational culture and leadership styles influenced knowledge management and sustainable performance. Additionally, Sapta et al.'s [77] study examined knowledge management's role as a mediator between organizational culture, leadership style, and sustainable performance, revealing the significant effects of organizational culture and transformational leadership on knowledge management. Furthermore, knowledge management was found to mediate the relationships between organizational culture, leadership style, and sustainable performance. These findings supported knowledge-based theory regarding knowledge management practices and sustainable performance, emphasizing the importance of organizational culture and transformational leadership in traditional organizations. Based on the above discussion and prior research comparison regarding knowledge management, it can be inferred that after using social media, new professional farmers can better manage knowledge through both network media embedding and network community embedding and thereby improve their innovative ability. Notably, in the network community embedding mode, the mere existence of the community does not inherently foster innovative development for farmers. It is through active participation, involving obtaining, sharing, integrating, and utilizing knowledge within the community, that they can effectively enhance their innovative ability.

Fourth, learning orientation positively moderates the relationship between network media embedding, network community embedding, and knowledge management. The results can be compared to prior research by Türk et al. [78] that similarly employed learning orientation in a moderating role. Türk et al. [78], drawing on social learning theory, explored the impact of prior entrepreneurial exposure on entrepreneurial passion and examined how an individual's learning orientation moderated this relationship. The study collected data from students across various disciplines to empirically validate the research model. Türk et al.'s [78] findings indicated that both types of prior entrepreneurial exposure positively influence entrepreneurial passion, with medium to high levels of learning orientation reinforcing these relationships. Building on this discussion, it can be posited that farmers with a stronger learning orientation are better equipped to actively leverage the media function of social media, influencing knowledge management, and effectively obtaining and utilizing knowledge through community relationships. This, in turn, leads to an enhancement of their innovation ability.

### 5.1. Managerial Implications

Agricultural sustainable development relies on high-quality farmers and continuous improvement of their innovative ability. The relevant conclusions of this study can provide important insights for relevant governments and the cultivation of innovative ability of new professional farmers. Firstly, the government can create better conditions for the promotion of information technology in rural areas. To fully realize the role of social media tools in enhancing the innovative ability of farmers, it is necessary for governments at all levels to further improve the construction of rural grassroots network facilities, increase the promotion of smartphones, strengthen training for farmers, and guide more new professional farmers to use social media tools effectively. Secondly, new professional farmers should enhance their media literacy, recognizing the influence of social media through network media embedding and network community embedding. Entrepreneurial farmers ought to strengthen their understanding of social media tools, continually refine their learning of social media tools, continuously improve their media operation skills, and be able to flexibly use the different functions of social media according to the needs of agricultural innovation. Thirdly, new professional farmers should cultivate awareness of using social media to carry out knowledge management. Knowledge management is a prerequisite for innovation. Given the positive role of social media in knowledge management, new professional farmers can learn to use social media tools to strengthen the acquisition, integration, and utilization of agricultural innovation knowledge through self-study, attending training classes, or learning from peers, and improving their agricultural innovation knowledge reserves. Finally, new professional farmers should adopt a learning-oriented management philosophy when

using social media. Recognizing the dual nature of social media, farmers need to avoid ineffective embedding that may lead to wasted time and energy. Instead, they should use social media as an entrepreneurial tool, consistently engage in lifelong learning, adapt to environmental changes, enhance their abilities, and fully leverage the positive functions of social media for promoting agricultural knowledge management and innovation. This approach will contribute to the sustainable development of agricultural entrepreneurship.

## 5.2. Limitations and Future Research

This study offers both theoretical and empirical evidence for new professional farmers to enhance their innovative abilities through social media tools, providing significant implications for fostering rural innovation and entrepreneurship activities. However, several aspects of the impact of information technology on the innovative behavior of new professional farmers warrant further analysis. This includes exploring the potential existence of other mediating variables between social media embedding and farmers' innovative abilities, examining how factors related to information technology tools may influence the effectiveness of farmers' social media usage, and conducting more in-depth research on the role of different modes of social media embedding in specific agricultural innovation behaviors (technical innovation, management innovation, etc.). Information technology represented by social media will profoundly affect the innovative development of agriculture and rural areas. In the future, academia can further explore more issues in related fields.

## 6. Declarations

### 6.1. Author Contributions

Conceptualization, G.X. and X.S.; methodology, G.X. and X.S.; software, G.X.; validation, X.S. and M.H.; formal analysis, G.X. and X.S.; investigation, G.X.; writing—original draft preparation, G.X., X.S., and M.H.; writing—review and editing, G.X., X.S., and M.H.; visualization, X.S. and M.H.; supervision, M.H. All authors have read and agreed to the published version of the manuscript.

### 6.2. Data Availability Statement

The data presented in this study are available in the article.

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### 6.4. Institutional Review Board Statement

Not applicable.

### 6.5. Informed Consent Statement

Not applicable.

### 6.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix I

### Questionnaire Items

Variables	Indicators	Measurement items	References
Network media embedding	ME1	I use social media to disseminate information.	Xie et al. [27]
	ME2	I use social media to acquire information.	
	ME3	My entrepreneurial activities are dependent on the media functionality of social media.	
Network community embedding	CE1	I maintain close contact with friends on social media networks.	Xie et al. [27]
	CE2	I have many friends I can interact with on social media.	
	CE3	I can obtain a large amount of heterogeneous information from social media friends.	
Knowledge management	KM1	I can acquire information on agricultural innovation and management.	Mardani et al. [30]
	KM2	I possess information required for agricultural innovation and management.	
	KM3	I share information on agricultural innovation and management.	
	KM4	I integrate various types of agricultural innovation information.	
	KM5	I utilize agricultural innovation information based on my needs.	
Innovative ability	AI1	I am able to flexibly respond to and solve agricultural management issues.	Borah et al. [75]
	AI2	I am able to propose innovative agricultural management strategies.	
	AI3	My agricultural innovation and management have achieved relatively good results.	
Learning orientation	ES1	I believe learning is important in agricultural innovation and management.	Hutahayan [49]
	ES2	I regularly spend time learning how to improve agricultural innovation and management.	
	ES3	I am willing to spend money to learn agricultural innovation and management.	
	ES4	Learning is an essential component of my agricultural entrepreneurship.	