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Technological Integration and Obstacles in China's Agricultural Extension Systems: A Study on Disembeddedness and Adaptation

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Abstract: In light of China's evolving agricultural technology extension system, this study investigates a critical issue known as "technological disembeddedness". This phenomenon, observed in the context of the country's push towards administrative and market-oriented extension, reflects a significant disconnect between the formalized methods of technology extension, such as classroom instruction, and the practical needs of farmers. As a consequence, the envisioned improvements in agricultural production efficiency have not materialized as expected. The analysis, based on fieldwork conducted in Shandong Province from 2019 to 2020, identifies that different stakeholder interests have further exacerbated the situation. Agricultural technology extension, driven by diverse agendas, has been utilized as a tool for profit, resulting in a stark disparity in farmers' access to technology and the emergence of multiple, formalized extension models. This marginalized small-scale farmers and undermined the initial objectives of the extension system. The study proposes a fundamental shift in approach. It advocates for a social-centric perspective on technology extension, suggesting that the solution lies in harnessing local community dynamics to gradually build a technology extension system that aligns with the practical realities of farmers' production and daily lives. In summary, the study identifies "technological disembeddedness" as a primary challenge within China's agricultural technology extension system. It underscores the need to reorient the approach towards a more socially connected model, with a focus on the local community's role in creating a technology extension system that genuinely serves the needs of farmers.

Keywords: agricultural technology extension; technological disentanglement; social relationships

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1. Research Background and Problem Statement

Agricultural technology plays a crucial role in improving agricultural production efficiency and driving the modernization of agriculture [1]. In 2023, China's central "Document No. 1" emphasized the need to strengthen support for agricultural science, technology, and equipment to accelerate the development of a strong agricultural sector (*source: "Opinions of the Central Committee of the Communist Party of China and the State Council on Key Tasks for Comprehensive Advancement of Rural Revitalization in 2023"*). Since the beginning of the reform and opening-up policy, China has undergone reforms in its grassroots agricultural technology extension system, adapting to the processes of marketization and the management of grassroots agricultural technology personnel. These reforms built upon the existing organizational structure for agricultural technology developed since the founding of the People's Republic. The reforms involved the transfer and delegation of certain powers (*referred to as "two releases" in 1989–1990 and 2001–2003, related to the delegation of management rights over personnel, finances, and resources of township-level agricultural technology*

stations from counties to townships) and the centralization of other powers (*referred to as "two receptions" in 1991–2000 and 2004–2008, related to the centralization of certain rights*) [2]. These changes have gradually shaped the agricultural technology extension system, which is primarily led by government administrations and market entities, with the involvement of research institutions. The aim has been to improve the efficiency of agricultural technology extension through diverse participation.

However, practical observations have shown that this system's effectiveness is not ideal in practice. It is characterized by a trend towards a singular mode of extension, where many training activities are conducted for the sake of completing tasks, and formalism in agricultural technology extension is prevalent. A significant challenge is the coexistence of low agricultural technology adoption rates and low acceptance levels of agricultural technology extension. The gap between the agricultural technology extension system and its intended goals remains a central issue in contemporary agricultural technology extension. Existing research has primarily focused on the following aspects:

First, examining the effectiveness of the agricultural technology extension system: Although researchers acknowledge that training-based agricultural technology extension effectively increases grain production [3,4], raises agricultural income [5,6], and reduces the use of agricultural chemicals [7,8], there is a widespread consensus that China's agricultural technology extension system still operates at a low level of performance [9,10]. This situation is attributed to insufficient government-led funding for agricultural technology extension [11], management problems at grassroots extension organizations [12], the scarcity of agricultural technology extension resources leading to only a small portion of farmers accessing public extension services [13,14], and the participation of diverse extension entities that has not completely resolved the issues [15]. The extension of agricultural technology based on kinship and consanguinity remains the primary channel for farmers to access new technologies [16].

Second, an attempt is made to explain the reasons behind the poor performance of the current agricultural technology extension system. The government, as a provider of public services, plays a primary role in the provision of public welfare-oriented extension services [17]. At the micro-level, the low educational levels and generally low income of agricultural technology extension personnel significantly affect the performance of technology extension [2,18]. From a meso-level perspective, a continuous process of interaction and bargaining between the state, grassroots agricultural technology extension agencies, and farmers has resulted in each forming its own logic of action and path dependency, leading to institutional dilemmas in the current agricultural technology extension system [19]. These contradictions have further exacerbated issues related to macro-level funding insufficiency and institutional mechanisms not functioning smoothly [20]. As administrative power is decentralized in rural society, it is continually eroded [21].

With China's market-oriented reforms, agricultural technology extension increasingly incorporates market-driven forces, including agribusiness, into the extension system [22,23]. While this diversifies the forms of technology extension, it also makes agricultural technology extension vulnerable to market dynamics, supply–demand relationships, and price fluctuations [24]. Additionally, market entities, in pursuit of maximizing organizational profits, are compelled to engage in technological innovation, promotion, and commercialized services [25], leading to the promotion of proprietary agricultural technologies. The agricultural technologies offered by these market entities are often highly profitable advanced technologies [26]. In this process, agricultural enterprises are burdened with dual goals, and as a secondary objective, agricultural technology extension can experience a certain degree of deviation due to coexistence with the primary goal of profit maximization. From the perspective of public economics, as agricultural technology is a quasi-public good, if government subsidies are insufficient to offset the income spillovers generated by the private sector supply of agricultural technology services, private sector entities are likely to withdraw from or reduce their supply [27]. Moreover, agricultural colleges and research institutions, as extension entities, continue to be centered around government-led

extension efforts. They face internal capacity constraints and a limited reserve workforce, making it challenging to take on a significant amount of agricultural technology extension work beyond their core responsibilities [28].

In summary, existing research generally acknowledges that the current effectiveness of agricultural technology extension is not promising. It recognizes that promoting entities, represented by the government and the market, are constrained by their own characteristics and cannot maximize the efficiency of technology extension. However, much of the existing research tends to view technology extension as a top-down process of knowledge transfer, often overlooking the fact that farmers, as recipients of technology, are also disseminators of technology. While existing research reveals the negative impact of government and market systems on technology extension, it often fails to connect the social context in which farmers are situated and the behaviors of farmers within their social context, thus not offering a comprehensive explanation for the suboptimal extension outcomes.

Agricultural technology is an integral part of farmers' production and daily lives, deeply embedded within local communities. It cannot exist independently of the local social and institutional environment. Some scholars have recognized that social networks influence technology adoption [29,30] and have attempted to explore their relationship through quantitative models. However, these attempts often lack corresponding theoretical analyses and fail to explain why the technology extension system constructed by the state is not the primary choice for technology adoption in rural communities.

This paper aims to introduce the concept of "technology disembeddedness", situating agricultural technology within the local social context. It dissects the underlying logic of technology extension in this domain and attempts to explain why the current agricultural technology extension system in China is suboptimal in practice within rural communities. Furthermore, it seeks to reveal the deep-seated logic of various stakeholders in technology extension and proposes potential pathways for escaping this predicament.

2. Theoretical Foundation and Analytical Framework

When examining the process of technology extension from an economic perspective, promoters tend to choose the most efficient pathways for extension, while recipients are inclined to accept agricultural technologies that maximize their individual benefits. However, rural life is deeply rooted in its local context [31], and agricultural technology is inseparable from this rural social fabric. It relies on the rural social environment for extension and is simultaneously "embedded" within the networks of village communities.

In fact, technology extension follows its own spontaneous order, and this order is built upon the foundation of rural communities. The existing literature has also discussed this viewpoint. Some scholars emphasize the embedded characteristics of social networks and their impact on technology extension [32], suggesting that the key to effectively connecting technology with smallholder farmers lies in the fact that technology is embedded within the social structure of rural communities. Additionally, individual farmers' interactive learning through social networks is a driving force for the extension of new technologies [33]. Farmers tend to rely on "acquaintance relationships" as their primary source of technology acquisition. It can be said that the process of technology extension is also a collective assimilation process [34].

Regarding technology adoption, traditional agricultural technology extension relies on social interactions among farmers, permeating rural communities and giving rise to farmers' spontaneous information exchange relationships [35]. However, to promote agricultural and rural modernization and enhance the rate of scientific and technological conversion, the government has established a system for technology extension. Nevertheless, some scholars have observed that this system's performance is suboptimal in practice, sometimes even conflicting with the needs of farmers [36]. They attribute this phenomenon to factors such as the lag in grassroots technology extension system development and the aging of knowledge among agricultural technicians [37]. However, they have not analyzed the relationship between rural communities and agricultural technology or technology extension.

As Granovetter elaborates in his work, "The economic actions of actors are not only individualistic but also embedded in social relationships. Apart from the influence of individual rationality and personal preferences, individuals are 'embedded' within social networks, constantly exchanging information with others in their social environment. They are influenced by these interactions, which may change their preferences and, ultimately, be reflected in their decision-making" [38]. When applied to the context of technology extension in agriculture, the pathways through which farmers transmit and receive agricultural technology information closely align with their social networks. Therefore, the technology extension methods that best suit farmers' preferences should be embedded within rural communities. However, with the reform of the technology extension system, the previously deep-reaching connections into rural communities have gradually disappeared. Simultaneously, the growing influence of market forces has caused the technology extension to be gradually disembedded from rural communities and farmers' lives.

While the term "technological disembeddedness" has not been introduced into research on technology extension, with the rise of new economic sociology, there is an increasing focus on the influence of social relationships on economic issues. "embeddedness" and "disembeddedness" have increasingly entered the field of rural development. In contrast to "embeddedness", the term "disembeddedness" refers to a state in which things detach from their original social structures, networks of relationships, cultural concepts, and other elements of social systems [39,40]. Polanyi's concept of "disembeddedness" pertains to the state in which an economic system detaches from the operation of a social system due to the development of self-regulating markets driven by the multiple commodifications of land, labor, and nature [41,42]. While Polanyi emphasized that self-regulating markets never fully emerged, this tendency has become increasingly pronounced, causing significant disruptions to the functioning of social systems [43]. Taking agricultural disembeddedness as an example, the influx of capital into rural areas and the market-oriented transformation have caused agricultural operations to disentangle from rural social networks, becoming disconnected from the production and daily lives of farmers. This has led to the separation of the multifunctionality of agriculture [44]. Some scholars also point out that the disembedded development of rural areas has resulted in contemporary environmental issues in rural regions [45].

Contemporary technology extension, to some extent, has been disembedded from social structures and relationship networks embedded in the daily production and lives of farmers, resulting in a series of adverse consequences. This paper introduces the concept of "technological disembeddedness", where "technology" specifically refers to agricultural technology, and defines "technological disembeddedness" as the promotion of technology detaching from the actual production and lives of farmers, as well as from their social relationship networks and village orders, operating outside the realms of village production and social life. Subsequently, the paper will elucidate the reasons behind the unsatisfactory outcomes of agricultural technology extension by focusing on technological disembeddedness through the analysis of social relationship networks from an embeddedness theory perspective. It will explore the specific manifestations of technological disembeddedness, investigate the negative consequences it leads to, and delve into the underlying reasons for technological disembeddedness and the suboptimal effects of technology extension. Based on these considerations, the paper constructs the following analytical framework (see Figure 1).

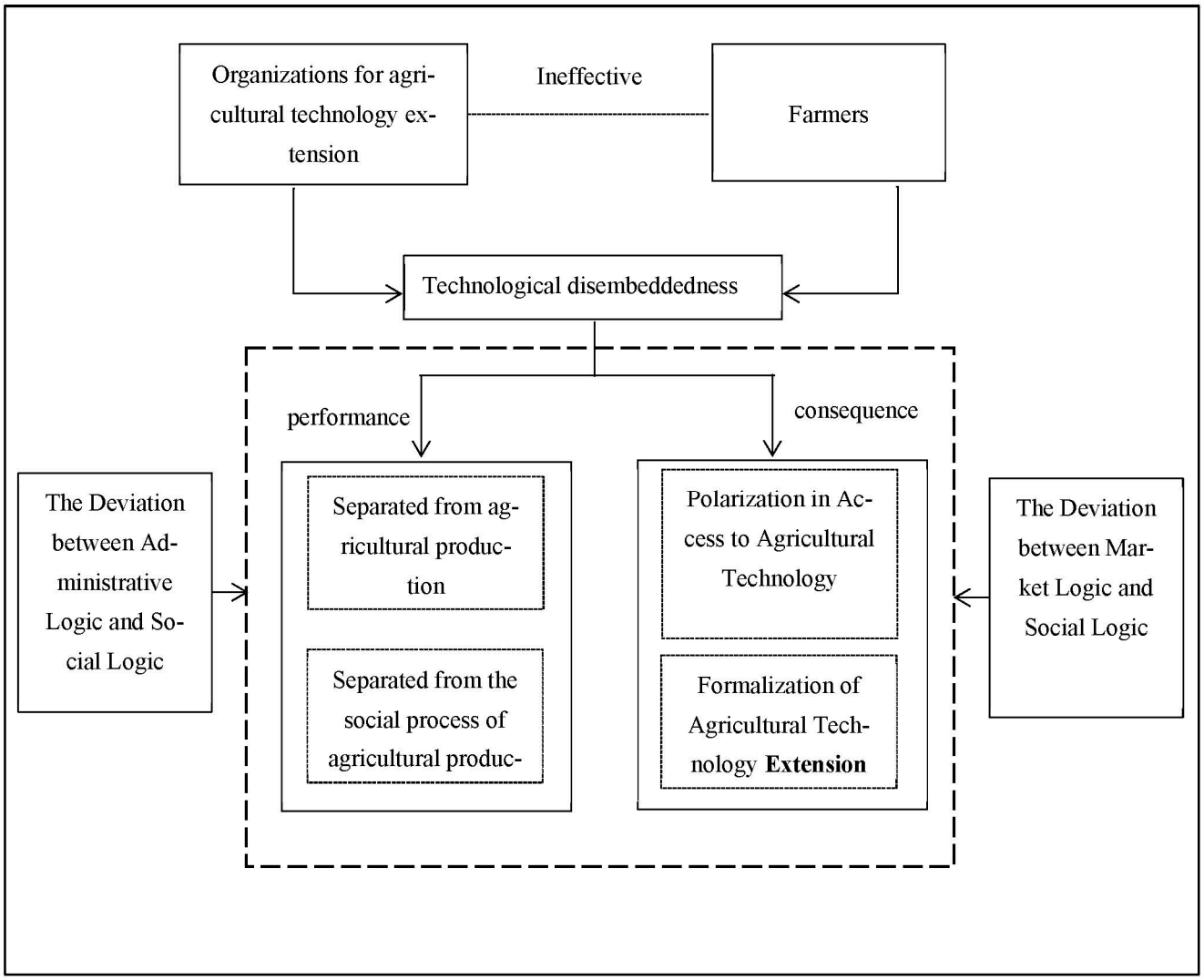

Figure 1. Analysis framework diagram.

3. Research Design

3.1. Method Selection

This study employs an exploratory, single-case research method. The reason for selecting this research method is because the core research question addressed in this paper is why China's current agricultural technology extension system is performing suboptimally in practice. Case study research is particularly well-suited for addressing questions that are rich in explanatory elements and seek to understand "how" and "why" [46]. Furthermore, by extracting key elements from a single case, refining, mining, and articulating them clearly, this method plays a crucial role in uncovering the inherent associations behind phenomena, formulating testable theoretical hypotheses, and advancing research [47]. The angle of inquiry in this study pertains to a portion that has not been deeply explored in the existing literature, making it appropriate for an exploratory single-case research approach.

Regarding data collection, the author's research team conducted four field surveys in Ma Lianzhuang Town, Laixi City, Shandong Province, from 2019 to 2020, accumulating nearly two months of research time. Substantial data were collected through the following means: First, the research team conducted in-depth interviews with a wide range of individuals, including government employees, village cadres, farmers, and various actors in the agricultural supply chain. The interviews primarily focused on topics such as agricultural industry development, agricultural technology extension, and the primary channels for accessing agricultural technology. Through this method, a total of 109 interview

materials were collected, covering all seven communities (new villages) in Ma Lianzhuang Town. (*Here, "communities (new villages)" refers to the new village units created after the amalgamation of villages. Ma Lianzhuang Town in Laixi City completed the amalgamation of the previous 77 administrative villages into 7 communities (new villages) by the end of 2019. The specific villages mentioned in the case below are all the administrative villages before the amalgamation.*) In total, 217 h of interview recordings were obtained, which were then transcribed and organized into approximately 870,000 words of interview data (as shown in Table 1).

Table 1. Interviewees and main interview topics.

Interviewee	Number of Interviewees	Interview Duration	Interview Topics
Director and Staff of Malianzhuang Town Agricultural Service Center	3	405 min	1. Agricultural industry development status 2. Agricultural technology extension work 3. Challenges in agricultural technology extension work
Farmers (various categories, including field crops, sweet melon, and grape growers)	45	5446 min	1. Personal history and current status of industry development 2. Use of technology in the cultivation process 3. Channels for accessing agricultural technology 4. Specific steps for cultivating crops and encountered issues 5. Purchase of agricultural production materials
Village Cadres from All 7 Communities (new villages) in the Town	52	6133 min	1. Village industry situation 2. Role of villages in the agricultural technology extension process 3. Farming activities of village cadres themselves
Agricultural Technicians	4	482 min	1. Personal experiences 2. How they conduct agricultural technology extension and where they acquire agricultural knowledge 3. Roles played in current agricultural technology extension
Owners of Agricultural Supply Chain (e.g., agricultural supply stores and upstream and downstream businesses)	5	558 min	1. Extension of agricultural technology information in the supply chain 2. Coverage of business operations 3. Personal experiences of the business owners

Secondly, the research team collected case data through a combination of direct observation and participant observation. Observational evidence often supplements research content [46]. During our research in Ma Lianzhuang Town, we established a favorable interactive relationship with the local government, which allowed us to attend certain meetings and gain access to government office premises. By observing the working style of the local government and interactions with village cadres who came for administrative matters, we obtained nearly 50,000 words of observational records, scene notes, and research reflections. These observational data, along with the information obtained from in-depth interviews, contributed to triangulation for validation [46].

Finally, the research team collected internal documents from the local government, including county annals, agricultural statistical data, and relevant policy documents.

3.2. Case Selection

The decision to focus on Malianzhuang Town in Laixi City as the subject for this case study is grounded in several key considerations, with the addition of a map providing visual context for a clearer understanding of the region:

Representativeness: Malianzhuang Town serves as a representative microcosm of China's agricultural technology extension system, showcasing the challenges faced in its practical implementation. The region's developmental logic shares commonalities with other areas, and its diverse cultivation structure enhances the general applicability of the study. (See Figure 2 for the geographical location of Malianzhuang Town within Shandong Province).

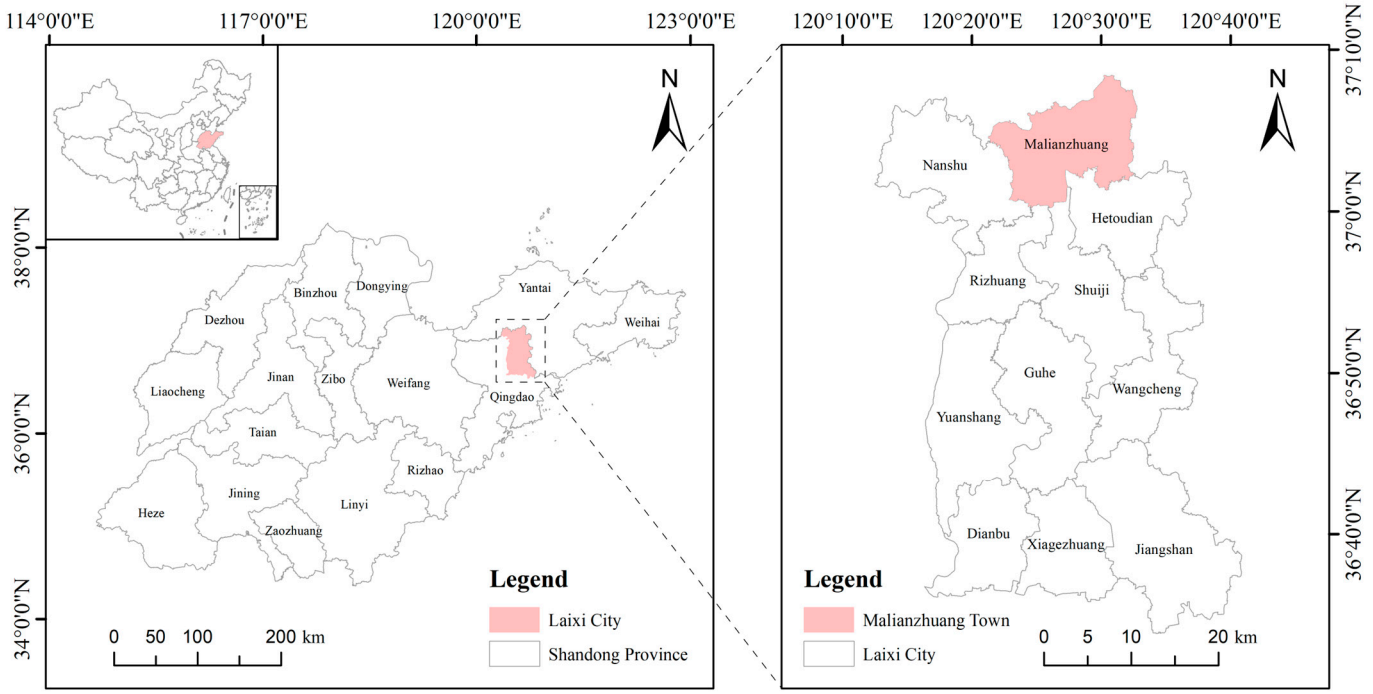

Figure 2. Geographical location map of Malianzhuang, Shandong Province, China.

Typicality: Positioned as a typical agricultural township, Malianzhuang experiences continuous evolution in agricultural technology parallel to its industrial development. Situated upstream of the Daguchuan River and adhering to environmental protection requirements, the absence of industrial activities has resulted in a unique cultivation structure dominated by field crops and high-yield crops, particularly fruits and melons. The role of agricultural technology in the growth of these crops is visually depicted in Figure 2, underscoring its significance as valuable research material for investigating the development and dissemination of agricultural technology.

Exploratory Value: Malianzhuang commenced agricultural industry transformation in the 1990s, marking a period of substantial changes in agricultural technology dissemination methods. These transformative shifts provide the basis for longitudinal comparative analysis, facilitating the exploration of deeper reasons behind the suboptimal performance of the current agricultural technology extension system. (Refer to Figure 2 for a visual representation of the spatial layout of Malianzhuang Town and its surrounding areas.)

3.3. Case Background Introduction

Malianzhuang Town is situated in the northernmost part of Qingdao City, bordered by Laiyang City to the east and adjacent to Zhaoyuan City to the north. It is located upstream of the Daguchuan River and is renowned for the abundant production of staple food crops such as peanuts, wheat, and maize. In recent years, Malianzhuang Town has vigorously

encouraged the local populace to engage in the cultivation of fruits and melons. Currently, it has established a year-round fruit cultivation pattern, encompassing sweet melons in spring, grapes in summer, apples (pears) in autumn, and strawberries in winter. According to statistical data from 2019, the town collectively cultivates approximately 10,071 hectares of sweet melons, 1386 hectares of strawberries, 2271 hectares of pear trees, 6704 hectares of apple trees, and 5114 hectares of grapevines. It has earned the reputation of being the "Land of Fruits" and the "Sweet Melon Town".

The cultivation of high-yield crops in the area can be traced back to the early 1990s, when local farmers spontaneously initiated the planting of watermelons, sweet melons, apples, and other fruits. In 1996, the Malianzhuang Town government commenced guiding farmers in sweet melon cultivation. In 2000, Laiyang City, considering the local topography and the spontaneously emerging cultivation pattern, introduced an agricultural industry development plan termed "Southern Vegetables and Northern Fruits". This plan elevated the status of fruit and melon cultivation to a pivotal component of the county-level overall layout. In 2005, Malianzhuang Town constructed a sweet melon market to facilitate sweet melon sales. Over the subsequent decade, through the establishment of brands and trademark registration, the local sweet melon cultivation area rapidly expanded to encompass approximately 1340 hectares. From 2014 to the present, with the diversification of planting varieties, the area has established a relatively stable development pattern.

The historical development of fruit and melon cultivation in Malianzhuang Town is illustrated in Figure 3.

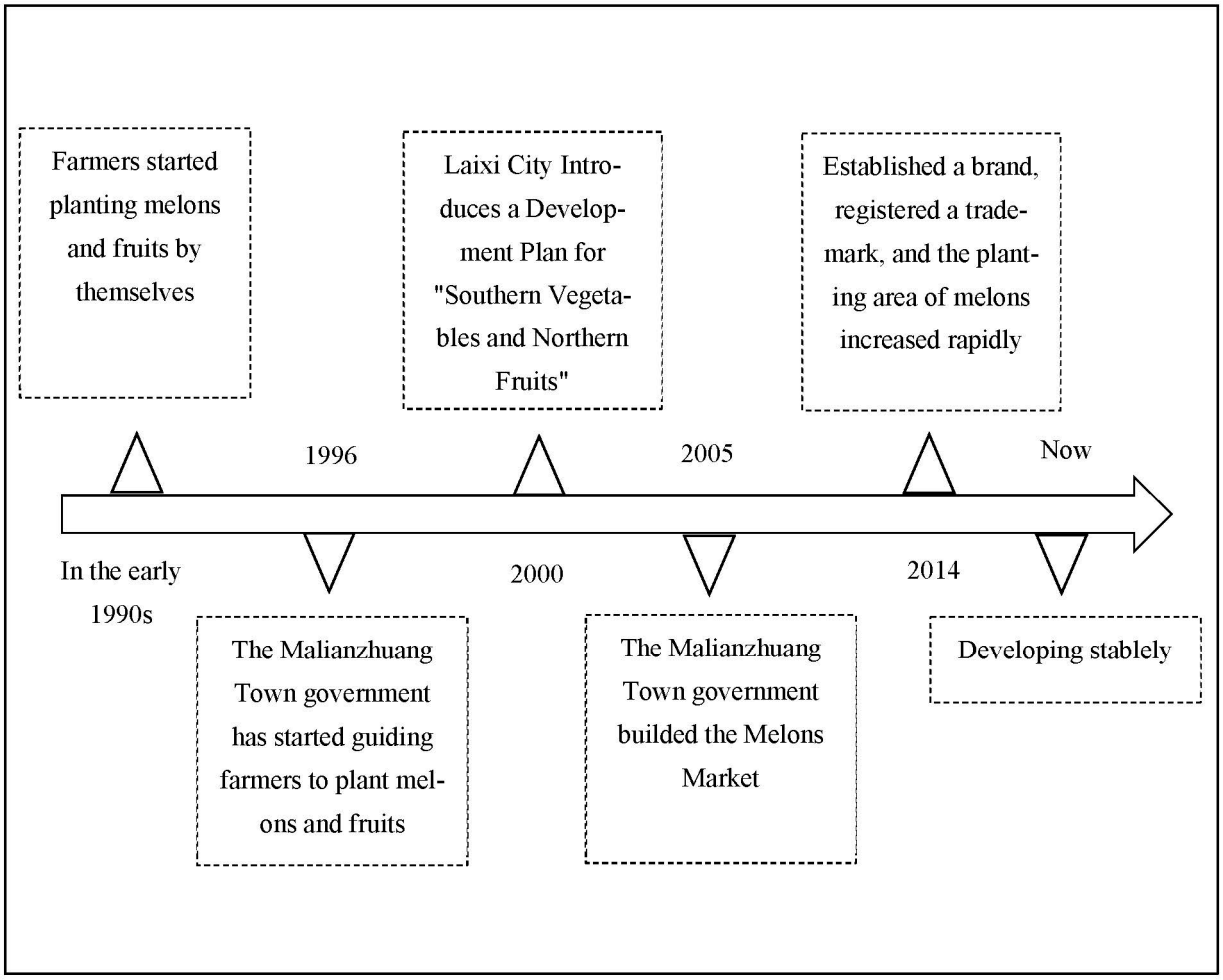

Figure 3. The development history of melon and fruit planting in Malianzhuang Town.

4. Case Analysis Results

In examining the case analysis, three key aspects have surfaced, each revealing profound insights into the repercussions of the evolving landscape of agricultural technology extension. Two primary research conclusions emerge prominently. Firstly, the detachment of agricultural technology extension from the actual processes of agricultural production is evident. Secondly, there is a discernible disconnection between agricultural technology extension and the broader social fabric of agriculture. Additionally, the examination exposes a consequential negative outcome stemming from this technological disembedding. The overarching pattern that emerges is one of technological disembeddedness, as illustrated in Figure 4.

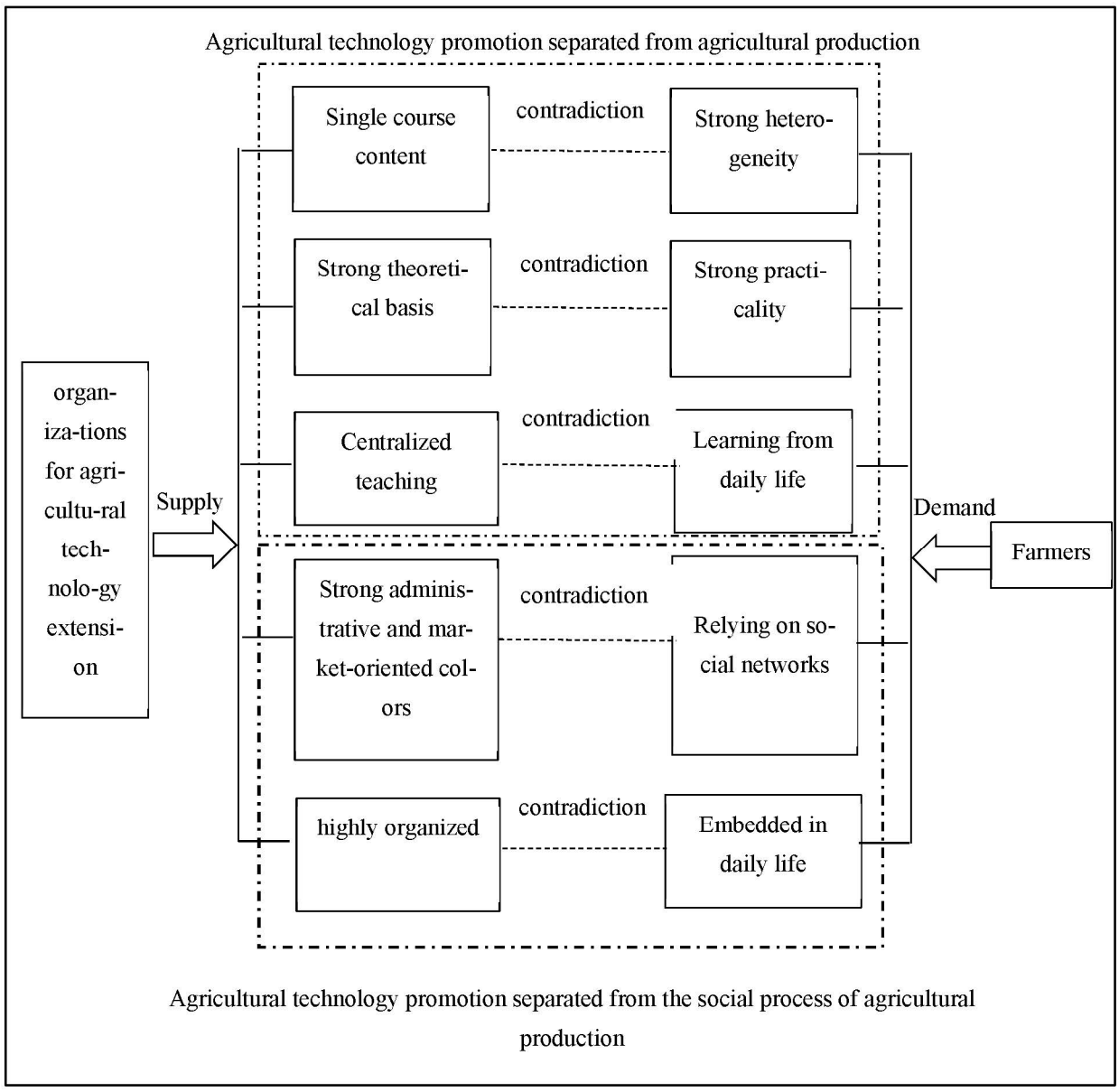

Figure 4. Performance of technical disembeddeddness.

4.1. Agricultural Technology Disembeddedness from Agricultural Production Practice

(1) Mismatch between Technology Supply and Farmer Production Demands

The misalignment between agricultural technology supply and farmer production demands is one of the manifestations of technological disembeddedness. In the current agricultural technology dissemination system in China, training is the primary form of

interaction between external entities and farmers [48]. Regardless of whether the disseminating entities are local agricultural extension agencies, market-based agricultural input suppliers like agribusinesses, or educational and research institutions such as universities, the attempt is made to disseminate technology through "centralized teaching" or "centralized teaching with field visits". However, this approach becomes disconnected from the actual practices of farmers.

Firstly, the singularity of training content conflicts with the complexity of agricultural production. Agricultural production varies depending on the specific geographic location, the methods of cultivation, and various other factors. Different soil conditions, planting methods, and other factors significantly impact crop growth. Moreover, even different fields within the same farm may face substantially different challenges. For local governments, although they understand the vital role of training in enhancing farmers' technical capabilities, they are often burdened by the heavy load of daily administrative work, coupled with the pressure of meeting superior-level assessment goals. This has led to a certain degree of formality in training, with the training's primary goal being the fulfillment of superiors' objectives. As a result, training sometimes takes on a superficial nature, wherein similar or identical course content is presented in many training sessions, even though the participating members exhibit high levels of heterogeneity. This has led to a situation where farmers across the entire county (or district) receive homogeneous technical content, which cannot cater to the diverse technological needs of individual farmers' production processes.

Secondly, the theoretical nature of the training content conflicts with the practical aspects of agricultural production. On one hand, agricultural production is highly practical, with farmers acquiring their production experience through day-to-day farming activities. The abstract nature of theoretical explanations makes it difficult for farmers to comprehend and, more importantly, fails to address their production issues. On the other hand, disseminating entities are constrained by factors such as time and space, making it challenging to effectively integrate theoretical training with specific practical farming contexts. This disconnect between training content and the actual demands of agricultural production contradicts the nature of agricultural production [24]. As a result, theoretical-oriented agricultural training has little impact on the farmers' actual production. Over time, agricultural training has become increasingly theoretical and formalized, becoming disengaged from practical production. Some of the farmers in Malianzhuang Town have participated in training organized by the township's agricultural technology department and higher-level departments. "The county offers technical training every year, and I attended it twice. *They are all oral lectures with no technical guidance, which did not have much impact*" ***(interview with ZJS, 6 August 2020)***. This illustrates the real situation of technology disembeddedness and reflects the dissatisfaction of farmers with the current formal agricultural technology dissemination content. This dissatisfaction is due to their inability to access agricultural knowledge that meets their specific needs.

In the long run, the misalignment between the supply of agricultural technology knowledge and the demands of agricultural production directly results in low receptiveness among farmers and relatively passive participation in agricultural technology training. Even when farmers participate in training sessions, due to factors like the authority of village cadres, social obligations, and social prestige, the effectiveness of agricultural technology extension is limited. In comparison to practical application, farmers have weaker comprehension and assimilation capabilities of theoretical knowledge, and homogenized training content cannot address the specific challenges that farmers face in their practical production processes. This has resulted in the disengagement of agricultural technology extension from actual agricultural production practices in China.

(2) Contradictions Between the Organization of Agricultural Technology Dissemination and Farmers' Production Habits

The disembeddedness of agricultural technology extension from agricultural production practice is further evident in the impact of its organizational methods on the behavioral

logic of farmers. For farmers, their knowledge systems and behavioral logic are developed through daily life practices and village social interactions. This determines the routine nature of their agricultural production knowledge acquisition, with their production skills gained through actual agricultural activities and interactions with other farmers. However, in the context of current agricultural technology training, local governments often tend to offer centralized training sessions, primarily due to considerations of time, organizational costs, and performance assessment metrics. These training sessions typically have fixed schedules, which do not align with the daily routines of farmers, especially during peak agricultural seasons when they have limited time for training.

For instance, in Malianzhuang Town, where farmers primarily cultivate sweet melons, one cycle of sweet melon production takes about six months, from planting in December to harvesting in May of the following year. Throughout this period, farmers are engaged in continuous, fragmented agricultural activities. They have to attend to their sweet melon fields nearly every other day. Some melon farmers even cultivate two cycles of sweet melons, leaving them with limited time and energy for formal training. **(*Data derived from interviews with several farmers in Malianzhuang Town*)**.

The process of agricultural technology extension carries multiple objectives as it attempts to penetrate villages from the outside, and it inherently involves a long and challenging journey. Throughout this process, farmers gradually realize the conflicts between the form and content of agricultural technology extension and their own agricultural production practices. This realization may lead them to reject or resist the new forms of agricultural technology extension. They avoid the possibility of "classroom-style" extension impacting the logical systems they have constructed in their own behavior. They continue to acquire new technology and implement technical improvements through their traditional technology extension channels.

It is observed that administrative-driven agricultural technology dissemination often results in deviations from policy goals, leading to poor or even counterproductive dissemination outcomes. This contributes to one of the manifestations of technological disembeddedness.

In conclusion, administrative-driven agricultural technology extension primarily relies on classroom-based training. However, this form and content of agricultural technology extension do not align well with the processes of agricultural production. For farmers, agricultural technology is acquired and disseminated through their actual agricultural practices. While government efforts, such as training, have produced some results, the fixed format and excessive theoretical content limit its effectiveness. Consequently, government-led dissemination diverges from the specific production practices of farmers and their habitual knowledge acquisition patterns, failing to meet the actual technological needs of farmers, thus resulting in lower farmer engagement. Moreover, combined with the presence of performance assessment metrics in different regions, local governments often view this as an administrative task, leading to a high degree of formalization in training. Consequently, it often falls short of policy goals, resulting in poor training outcomes and even alienation, ultimately leading to the disembeddedness of agricultural technology dissemination from agricultural production.

4.2. Disembeddedness of Agricultural Technology Extension from Agricultural Social Processes

(1) Disconnection from Farmers' Social Networks

For agricultural production, farmers' adoption of technology is influenced not only by economic incentives but also by their social relationships. Given that farmers within the same region often share planting experiences and encounter similar issues, technology and expertise are frequently passed on through informal channels. The degree of farmers' adoption of a particular technology also depends on the intimacy of their social relationships. Thus, social relationships play a significant role in the dissemination of agricultural technology, rendering it a social process [49]. Agricultural technology dissemination in-

volves not only the exchange of technical information but also social interactions among various stakeholders.

As GYL, a farmer from Lugezhuang Village, who was among the first to cultivate sweet melons locally, explained, "Back then, everyone in the village was growing watermelons using greenhouses to cultivate the seedlings. However, one year, a heavy rainfall destroyed all the watermelon seedling greenhouses. There wouldn't be enough time to rebuild the greenhouses and then grow watermelons. So, that's why we switched to growing sweet melons. When I first started growing them, there were no techniques for roasting melons. At that time, we were growing honeydew melons. In the first year, we had no fruit, and we didn't use seed grafting. Grafting cucumber seeds onto sweet melons just didn't work because the flowers didn't pollinate. None of it worked. It was only in the second year that we got some fruit. I went to the Xinhua bookstore to buy books to learn, but none of them were related to sweet melons. Later, I heard that there was someone in Zhuangtou who was growing melons on a small piece of land (the cultivation methods for small-scale melon and sweet melon are the same). So, I contacted a relative, and he introduced me to learn there, and that's how I started roasting melons. But even after roasting them, the market didn't recognize these melons, so we had to 'create a market' ourselves. It took us three years just to sell honeydew melons, three years at Lai Xi market, and another three years at Zhaoyuan market. Eventually, we gradually opened up the market, and traders started coming. It was only seven or eight years later that people in the village began growing sweet melons. They learned the techniques from me. Sometimes they would come to my (melon) greenhouse (to learn), and other times they would ask me to visit their greenhouses. The village never organized any training sessions" **(interview with GYL, 4 August 2020)**.

From the interview data, it becomes evident that in the early stages of the sweet melon industry in Lugezhuang Village, a lack of technical knowledge about growing sweet melons posed challenges in producing market-quality agricultural products. To overcome this predicament, GYL, as the recipient of agricultural technology, took the initiative to expand his social network beyond the village, engaging with agricultural technology providers from other areas. This expansion allowed him to access agricultural technology information. It demonstrates that in this initial phase, informal agricultural technology was transferred across regions, and over time, GYL transitioned from being a technology recipient to becoming a technology owner. Meanwhile, agricultural technology began to disseminate within the village. This transition marks the onset of the second phase. It was initiated by GYL's gradual success in entering the market and earning the first substantial profits. When the village had its "first mover", who achieved significant financial gains by cultivating sweet melons, other villagers started emulating and learning from him. During the process of mutual interactions, their behavior and decision-making patterns evolved. In this context, GYL, as the owner of agricultural technology, took on the role of a technology extension in this phase. He taught fellow villagers the techniques for growing sweet melons. Due to the frequency and complexity of interactions in rural communities, a multifaceted pattern of interaction emerged between the disseminators and recipients, enabling the smooth operation of agricultural technology dissemination and adding implicit credibility to the process.

In summary, farmers' technology needs are predominantly acquired through their social relationships, and social networks serve as important conduits for agricultural technology dissemination. With the commercialization reform of agricultural technology dissemination, the dissemination methods have become more diversified, with government and market-based training gradually becoming the primary means of dissemination. Paradoxically, these varied dissemination methods have adopted a standardized training approach, which has removed agricultural technology from its embeddedness within social networks. This detached mode of agricultural technology dissemination fails to cater to farmers' actual needs and is met with their resistance.

It is evident that under government and market-driven standardization of agricultural technology dissemination, the unique logic of agricultural technology dissemination is

gradually eroded. It not only results in a lack of trust in the disseminating bodies but also reduces farmers' acceptance of new agricultural technology. Furthermore, it fails to meet the practical needs of farmers for agricultural technology.

(2) Disconnection from Farmers' Daily Life

Agricultural production itself constitutes an integral part of farmers' daily lives, and it unfolds as a part of daily life, interwoven with social interactions resulting from production. In fact, the initial agricultural technology dissemination system was founded based on this characteristic. During the collectivization period, the government established "seven stations and eight institutions" in towns, with personnel from these subsidiary organizations providing guidance in the fields. This significantly enhanced the efficiency of agricultural technology dissemination, and it was in alignment with the practicality of agriculture, integrated into the daily production and lives of farmers. However, this segmented institutional arrangement placed a considerable burden on local township governments. With the market-driven reform of agricultural technology dissemination, the original agricultural technology dissemination system disintegrated, and the dissemination approach gradually shifted toward classroom-style training. While this approach became more organized, it gradually disconnected from the production and lives of farmers as it was primarily driven by administrative tasks and market efficiency.

Lugezhuang Village is one of the major apple-growing villages in Malianzhuang Town. The village party secretary, YYX, explained, *"Now, the government organizes technical training through the village and community about 2–3 times a year. The content covers daily orchard management and learning about production processes. During regular days, some experienced orchardists give lectures to everyone. If anyone has questions, they'll ask them"* ***(interview with YYX, 15 August 2020)***.

The primary characteristic of this grassroots agricultural technology dissemination, where farmer technicians serve as the main disseminators, is its flexibility. It is not constrained by geographic limitations embedded in daily life and interpersonal relationships. Simultaneously, the implicit reputation network constructed within village life also serves as a reciprocal incentive for farmer technicians to engage in agricultural technology dissemination.

However, the current training approach, characterized by classroom-style instruction, relocates farmers from the fields to the classroom, where agricultural technology knowledge is imparted. This removes them from the actual production and life settings. Farmers not only find it challenging to understand this way, but it also detaches them from practical production. Even if they comprehend the material during the training, implementing it upon return becomes problematic. Over time, farmers lose interest in attending these training sessions. As described by YYX, *"The agricultural technology department organizes training once or twice in the spring and autumn, and for the rest of the time, they mainly focus on administrative work. They don't have time to participate in farmers' daily lives"* ***(interview with YYX, 15 August 2020)***.

Although these training sessions provide farmers with new technology and knowledge, the results achieved by the nationally driven agricultural technology dissemination system, as well as market-driven agricultural technology dissemination, still fall short of expectations. On the other hand, market-driven agricultural technology dissemination also leads to the increasing detachment of technology from farmers' daily lives. Driven by the pursuit of profit and market share, it naturally assumes a state of technological disembeddedness.

4.3. Adverse Consequences of Agricultural Technology Disembeddedness

(1) Polarization in Access to Agricultural Technology

In practical agricultural technology dissemination, whether driven by the government or the market, new agricultural entities and large-scale growers are often prioritized as the primary training targets [50]. This is partly because organizing such training involves lower costs and is relatively straightforward in terms of coordinating participants. Additionally, larger-scale operators tend to exhibit better understanding and acceptance of

the technologies being disseminated. This dynamic results in new agricultural entities and large-scale growers having a higher likelihood of receiving agricultural technology services. A staff member from the Agricultural Service Center in Malianzhuang Town revealed the logic behind their training approach, stating, *"One is the overarching trend of national policy, which encourages the development of large-scale farming operations, and we are committed to complying with this policy. Furthermore, large-scale growers, after training, tend to yield better results compared to smallholders. We prefer engaging with large-scale growers; they are relatively more open-minded"* ***(interview with YZR, 12 August 2020)***.

From the perspective of agricultural technology promoters, regardless of the scale of cultivation or individual qualifications, new agricultural entities are considered superior to smallholders. Not only can they assist in achieving administrative objectives, but they also demonstrate better results in terms of demonstrating and disseminating technology. They are even expected to drive the development of smallholders. However, in practice, owing to the socio-economic status disparities among farmers, the demonstration effect of large-scale growers on smallholders is not particularly pronounced [13]. This situation results in the creation of "technological barriers" or even exacerbates the polarization in technology acquisition between large-scale growers and smallholders. It is noteworthy that the operational scale of large-scale farms in China varies based on the type of agricultural activity. For those engaged in the cultivation of grains such as rice, wheat, and corn, the land management scale should be at least 10 hectares. For those involved in the cultivation of vegetables, fruits, horticultural crops, or other crops, the land management scale should be at least 8 hectares. In the case of aquaculture, the land management scale should be at least 5 hectares.

WXS, the village secretary of Xiawazi Village in Malianzhuang Town, began cultivating pear trees in 2014, with an orchard area exceeding 600 mu (approximately 40 hectares). His operations span multiple villages, including Xiawazi Village, Sunjia Village, Jijia Village, and Beishankou Village. He is renowned as a large-scale pear grower, and the government supports his endeavors through multiple subsidies and development projects, including comprehensive land development, water, electricity, and road projects. He stated, *"My farm has benefited from national subsidies. The irrigation channels were dug by the water conservancy department, electricity was provided by the power company, and the roads were constructed by a construction company. We also receive training sessions organized by the government. They invite experts from Yantai and Laiyang to give lectures"*. However, when asked about how to develop and uplift the two-thirds of growers who are smallholders, he explained, *"There is some assistance, but at most, it means helping them get an extra one yuan when selling the produce. Managing together is not feasible, and each household does not have the necessary facilities. Some production materials, such as plant growth regulators, can be shared among the community, but for fertilizers and pesticides, we use high-quality ones which are more expensive, something the average folks cannot afford"* ***(interview with WXS, 3 June 2020)***.

Clearly, "supporting the strong and the large" has become the core logic of organizing agricultural technology training. Although it allows agricultural technology extension departments to fulfill their training tasks at the lowest organization and coordination cost, it results in polarization between large-scale growers and smallholders in terms of technology training and adoption. Large-scale growers receive various economic and technical subsidies, while smallholders are effectively excluded and may not be included in the scope of agricultural technology training. This logic considerably restricts the space for smallholders to access agricultural technology. In other words, approximately 90% of China's total agricultural operators have not received effective agricultural technology training, leading not to improvements in their production techniques but rather to the wastage of significant resources *(data from the Third National Agricultural Census in 2016 show that China had a total of 314.22 million agricultural operators. Large-scale agricultural operators accounted for only 4.1% of the overall agricultural operator population. This demonstrates that smallholder farmers remain a vast and important segment of the agricultural landscape, both currently and in the foreseeable future)*.

(2) Formalization of Agricultural Technology Extension

In addition to indirectly excluding smallholders from agricultural technology training, technology disembeddedness leads to the gradual formalization of agricultural technology extension. In practical agricultural technology extension, multiple promotional entities become ensnared in conflicting objectives and gradually shift towards standardizing and task-oriented agricultural technology extension, ultimately reducing it to mere formality in order to fulfill their mandates. Faced with formal and often less practical agricultural technology training, farmers frequently opt not to participate. Even when some farmers partake in these training programs due to various administrative pressures and profit incentives, it is often seen as a perfunctory obligation. Importantly, the formalization of agricultural technology extension not only fails to enhance farmers' technical proficiency but also engenders resentment among them, leading to explicit or implicit resistance in practice.

ZQS, a pear orchard owner in Zhanjia Village, is among the younger generation in the village. He commented, *"I attended the training sessions led by new agricultural entities, and basically, it was the people working in the village who participated. They have no land of their own and are not very receptive. The money spent on these sessions is wasted. The organizers are aware of this, but why do they still conduct the training? It's because they all have vested* interests; all that money needs to be spent" ***(interview with ZQS, 31 May 2020)***.

A local agricultural supply store owner in Malianzhuang Town expressed, *"To promote fertilizers and agricultural materials, we usually hire lecturers. However, regular folks are quite pragmatic. Without freebies, they won't attend, and they won't even come for food"* ***(interview with LRB, 5 August 2020).***

It is evident that both government-driven and market-led agricultural technology extensions have strayed from their original purpose of enhancing farmers' technical abilities, becoming tools to fulfill administrative tasks and gain economic profits instead. This has led farmers to resist these efforts. Agricultural technology extension, influenced by both governmental and market forces, has increasingly drifted away from what rural communities genuinely require in terms of agricultural technology dissemination.

5. The Logical Paradox in Agricultural Technology Extension System Construction

As analyzed in the preceding sections, the current agricultural technology extension methods have become detached from agricultural production and social processes. This detachment has resulted in the formalization of agricultural technology extension and the exclusion of smallholder farmers, among other issues. The fundamental reason for these challenges lies in the inherent conflict between the supply logic of agricultural technology and the actual logic of its dissemination. The conflict between these two types of logic has led to suboptimal outcomes in agricultural technology extension.

5.1. Discrepancy between Administrative Logic and Social Logic

Generally, the core department responsible for agricultural technology extension is the local agricultural technology extension department, a direct subsidiary of government functional departments with administrative characteristics. While it does consider practical work outcomes, it is primarily oriented towards achieving upper-level tasks due to factors such as organizational costs and superior assessments. In contrast, the actual extension of agricultural technology is aimed at increasing efficiency, considering the localized nature of agricultural production. Agricultural technology extension is embedded in farmers' daily production, life, and social interactions and operates according to social logic. These two types of logic, administrative logic and social logic, are inherently contradictory in practical agricultural technology extension.

In the early years of the People's Republic of China, the government established agricultural technology stations at the township level, and their staff provided field-based agricultural technology guidance, which was in line with the reality of agricultural production, as previously discussed. However, with the advent of market-oriented reforms and

concurrent adjustments to grassroots administrative structures, many townships abolished specialized technical extension stations and established new agricultural offices or comprehensive service stations, incorporating agricultural technology extension within them. As a result, agricultural technology extension took on a more administrative coloration and often organized training sessions. Although this practice facilitated effective management of agricultural technology extension and improved administrative efficiency, the results were not as effective compared to the previous method, where agricultural technicians directly promoted technologies. This is because including agricultural technology extensions in new departments resulted in standardized assessments from upper authorities. Once agricultural technology extension was integrated into new departments, agricultural technicians fell under the dual jurisdiction of both the higher-level agricultural technology extension institutions and local governments. They had to fulfill the task of agricultural technology extension while also facing administrative assessments. However, the effectiveness of agricultural technology extension was often difficult to measure in the short term, leading to course-based training becoming the primary mode of technology extension. The agricultural department could use quantifiable indicators such as the number of training participants and the frequency of classes to highlight its workload, while whether the training actually improved the technical abilities of farmers became less important. This gradual shift led agricultural technology extensions to detach from the needs of farmers' production and lives, resulting in formalization.

In summary, the standardized assessments and administrative operations of agricultural technology departments emphasize the formal extension of technology, such as classroom lectures, and neglect the practicality of technology extension for farmers. This detachment from the social logic of agricultural technology extension based on social relationships ultimately leads to a suboptimal outcome in technology extension.

5.2. Discrepancy between Market Logic and Social Logic

After the implementation of economic reforms and opening-up policies, agricultural production resources in China began to gradually transition from state control to private capital operation [51]. This shift was accompanied by the rise of a new wave of agricultural input production companies. Over the years, these companies formed a supply chain for agricultural inputs, and the extension of agricultural technology became an integral part of the current agricultural technology extension system. In practice, market-driven agricultural technology extension becomes a vital component of the agricultural technology extension system. Despite being embedded in local communities through rural agricultural input shops, the primary objective of market-driven agricultural technology extension remains the sale of agricultural inputs. Agricultural technology services are provided to farmers only when they purchase these inputs. Thus, agricultural technology services have become tools for promoting agricultural inputs and maximizing profits for the input providers. The core logic governing this approach is driven by profit maximization. Under this logic, market entities possess a strong incentive to provide agricultural technology services, yet they tend to promote only the information that benefits their own financial interests. This may even lead to the irregular practice mentioned earlier, where market entities financially incentivize farmers to attend training sessions to compete in the sales market. Over time, the various costs borne by market entities are subtly transferred to the farmers, further increasing their production costs. Furthermore, some market entities forcefully implement technology upgrades to improve product profitability, leading to an excessive emphasis on agricultural technology extension.

The market-driven extension of agricultural technology runs contrary to the logic of its promotion in local communities. In fact, the spillover and quasi-public nature of agricultural technology imply that its promotion within rural communities should have a "shared" attribute. As mentioned earlier, agricultural technology is integrated into the production and daily lives of farmers, disseminated through social relationship networks, and its acquisition and promotion take place within the farmers' daily interactions. It involves

frequent reciprocal acts of mutual benefit, guided by the principles of "receiving favors" and "returning favors" among farmers. When the market logic of agricultural technology extension enters villages, agricultural input sales personnel naturally promote technologies that yield higher profits while excluding cost-effective, practical technologies. This not only increases farmers' costs but also hinders the sustainable development of agriculture.

In summary, government-led and market-driven agricultural technology extensions each have their own inherent logic. Government-led extension is primarily focused on meeting upper-level assessment targets, while market-driven extension places profit maximization at its core. Both of these logics deviate from the reality of agricultural production and diverge from the social logic of agricultural technology extension, which relies on social relationships. This ultimately results in the formalization and instrumentalization of agricultural technology extension, detaching it from rural communities.

6. Conclusions and Policy Recommendations

Agricultural technology promotion has been a pivotal force in reshaping agricultural production methods and expediting rural modernization in China. Despite state-led efforts to promote market-oriented reforms in this domain, aiming for a multi-participant system involving the government, market entities, and other stakeholders, the practical outcomes have fallen short. This paper introduces the concept of "technological disembedding" to elucidate the root cause of underperformance, attributing it to the conflict between the government and market-driven logic in agricultural technology promotion and the actual logic of agricultural technology dissemination.

In China, traditional agricultural practices have been deeply embedded in farmers' daily lives, promoted through interpersonal networks and social logic. However, the current promotion system, guided by the government and market, diverges from this approach, adopting formal and profit-centric characteristics. This deviation results in a disconnect from practical agricultural needs, leading to poor outcomes and farmer opposition. To address this, the paper proposes a shift towards a multi-dimensional agricultural technology promotion system, considering farmers' characteristics, production realities, and social dynamics. This involves increased investment in training for farmer technicians and informal promoters, leveraging local influencers to disseminate advanced technology widely.

Comparison with the European Union: A Holistic Approach

In contrast, the European Union (EU) has embraced a more holistic approach to agricultural technology promotion, aligning policies with the socio-economic and environmental dimensions of farming. The EU emphasizes sustainability, agroecology, and farmer empowerment. While both regions grapple with the challenge of balancing administrative and market-driven logic, the EU has seen success in fostering collaboration between government, research institutions, and farmers through agri-environmental schemes. Unlike the formalized approach in China, the EU's promotion models encourage diversified channels and informal networks.

Lessons from the EU: A Nuanced Strategy

Drawing lessons from the EU, China should pivot towards a comprehensive strategy that harmonizes administrative, market-driven, and informal promotion methods. Strengthening the role of informal agricultural technology promoters as the "last mile" ensures effective technology dissemination. This comparative analysis underscores the need for a nuanced and context-specific approach, promoting a balance between formalized training and diverse channels of technology promotion to avoid the pitfalls of technological disembedding.

Comparison with the United States: Market Orientation and Farmer Engagement

Simultaneously, a comparison with the United States reveals two distinct models of agricultural technology promotion. In the U.S., technology dissemination places greater

emphasis on market orientation and farmer engagement, adopting more flexible and diversified approaches. Collaboration between government, universities, and agricultural enterprises fosters technological innovation, and farmers actively participate in training and adopt new technologies. This open and flexible model brings U.S. agricultural technology promotion closer to practical needs, enhancing the acceptance of technology.

Lessons from the U.S.: A Flexible, Market-oriented Strategy

Drawing lessons from the U.S., China can adopt a more flexible, market-oriented strategy, promoting collaboration among the government, universities, and enterprises to stimulate farmer engagement.

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