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Research on Government Regulation, Agricultural Socialization Service and Green Treatment Behavior of Mushroom Residue by Mushroom Farmers—Based on Research Data from Gutian County, Fujian Province, China

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Abstract: Agricultural waste treatment in the post-production stage is a crucial component of agricultural green development. To achieve ecological revitalization, it is essential to address the pollution constraints posed by agricultural waste. This study is grounded in the survey data collected from 284 mushroom farmers in Gutian County, Fujian Province. Given that the explanatory variable pertains to the number of green treatment behavior adoptions by mushroom farmers regarding mushroom residue, which falls under the category of ordered discrete variables and exhibits an evident recurrence relationship, we opted to analyze the impacts of government regulation, agricultural socialized services, and their interaction terms on the green treatment behavior of mushroom farmers' mushroom residue through the Ordered Probit model. This approach enabled us to uncover how the differentiation among mushroom farmers influences their green treatment behavior. The study yielded several significant findings. Firstly, both government regulation and agricultural socialized services can effectively drive mushroom farmers to adopt green treatment behaviors for mushroom residue. Secondly, there is an interactive effect between government regulation and agricultural socialized services in relation to the green treatment behavior of mushroom farmers' residue, indicating a certain degree of complementarity between the two. Thirdly, the differentiation among mushroom farmers has a pronounced impact on the green treatment behavior of mushroom residue. Notably, there are distinct differences in the green treatment behavior of mushroom farmers with varying education levels and planting scales. Moreover, as the education level and planting scale increase, the influence of government regulation and agricultural socialized services on the behavior of mushroom farmers tends to strengthen. Consequently, in the process of promoting the green treatment behavior of mushroom farmers' mushroom residue, we should maximize the utilization of the policy constraints and guiding measures of government regulation to enhance the normative role of mushroom farmers' behavior. Simultaneously, we need to fully exploit the recycling and transportation support functions of agricultural socialized services. By grasping the complementarity between government regulation and agricultural socialized services in terms of both normative behavior and solution measures, we can effectively ensure the practical feasibility of the green treatment behavior of mushroom residue.

Keywords: agricultural socialized services; government regulation; green treatment behavior; mushroom farmers; mushroom residue

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1. Introduction

Sustainable development represents a long-term global pursuit. The green transformation of production activities within the agricultural sector, which is crucial for global food security and rural economic development, plays a significant role in driving sustainable progress. The greening of agriculture constitutes a key aspect of attaining sustainable agricultural development. It involves the adoption of environmentally friendly, efficient, and recyclable production methods throughout the agricultural process, thereby minimizing negative impacts on the environment and enhancing resource utilization efficiency. However, compared with the rapid advancement of agricultural modernization, the pollution prevention and control of agricultural production waste still reveals certain deficiencies. In recent years, the edible mushroom industry has been experiencing rapid growth, and currently, global production is witnessing remarkable expansion. There is a positive correlation between the production of edible fungi and that of waste mushroom residue, with the stockpile of mushroom residue increasing year by year. The volume is staggering, and given the high production of mushroom residue coupled with its low utilization rate, environmental pollution and resource waste have become increasingly prominent issues. On the one hand, the untreated random burning and accumulation of such a vast quantity of mushroom residue readily lead to atmospheric pollution, water pollution, and other forms of multi-dimensional pollution, impeding the sustainable development of the agricultural economy [1]; on the other hand, waste mushroom residues, as an underutilized agricultural by-product, possess considerable potential value. Their scope for resource utilization is extensive, and they can be converted into a support for the sustainable development of agricultural resources through innovative technologies and management strategies [2,3]. China has explicitly declared that it will "promote the prevention and control of environmental pollution", and has established specific regulations concerning solid waste prevention and control. Article 65 of the Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes stipulates that units, as well as other producers and operators of agricultural solid wastes, are obliged to take measures to recycle and prevent environmental pollution. It also clearly lays down the legal responsibilities for violations in terms of penalties. These encompass penalties for the illegal discharge, dumping, and disposal of solid waste, and fines for individuals or units that fail to dispose of agricultural waste in accordance with the regulations, thereby causing environmental pollution. In addition, such individuals or units will be subject to measures such as being fined, ordered to rectify, and other corrective actions. The green treatment and utilization of edible mushroom residue waste, as an embodiment of the national sustainable development strategy, can alleviate the contradiction between agricultural development and ecological environmental protection and promote agricultural transformation. As producers of edible mushrooms and direct participants in mushroom residue treatment, mushroom farmers' effective participation is of utmost importance in realizing the green treatment of mushroom residue. Therefore, by conducting an in-depth analysis of mushroom farmers' mushroom residue treatment behavior, we can uncover the problems and challenges in agricultural waste management, explore effective interventions, effectively stimulate and enhance the motivation of mushroom farmers to participate in mushroom residue waste treatment, and promote the reduction, harmless treatment, and resource utilization of agricultural waste. In this way, the waste can contribute to the achievement of sustainable agricultural development and the construction of ecological civilization.

Government regulation, also referred to as government control, represents one of the principal means of restraining or guiding the behavior of production entities [4,5]. From the perspective of agricultural waste treatment, government regulation plays an essential role. Mushroom farmers are not only the targets of government regulation, but also the

implementers of the green treatment of mushroom residue. Their behavioral choices are of great significance in promoting the green treatment of mushroom residue. Existing research indicates that government regulation can effectively prompt farmers' green treatment behavior regarding agricultural waste [6,7]. Institutional supply plays a decisive role in guiding farmers' behavioral decisions by offering a clear policy framework and mechanism. It prompts farmers to adopt economic behaviors with positive externalities. Government regulation creates an external environment for farmers to engage in the green treatment of agricultural waste, and farmers' behavior of green waste treatment has obvious positive externality effects [8,9]. However, the welfare effect generated by the green treatment of agricultural waste is shared by all farmers in a certain area, while the degree of individual contribution often goes unnoticed. As rational economic agents, other farmers may tend to enjoy the "welfare" and refrain from adopting green waste treatment measures. The government can play a role in discouraging or alerting farmers with respect to their behavior, which in turn can influence their decision-making and prompt them to reduce the amount of waste from agricultural production materials and other polluting behaviors [10]. Government intervention can effectively curtail the opportunistic behavior of farmers. The government can adopt measures such as patrol supervision and administrative penalties to restrain farmers' behavior, minimizing the likelihood of a divergence between farmers' willingness to conduct green treatment and their actual actions, and prompting them to make rational behavioral decisions [11,12], or through technical training, publicity and other means to strengthen farmers' awareness, and then stimulate their initiative and enthusiasm for green treatment during the agricultural production process [13,14]. Government regulation can be categorized into restrictive regulation and guided regulation. Different types of government regulations exert varying impacts on mushroom farmers' green treatment behavior regarding mushroom residue. Therefore, it is necessary to make selections based on the specific circumstances of mushroom farmers and the actual regional development situation of the edible fungus industry, to adopt appropriate policy measures.

According to the theory of farmers' behavior, farmers' behavioral decisions hinge on the consideration of expected costs and benefits. Put simply, if the expected benefits increase after adoption, farmers will tend to adopt the behavior; otherwise, they will refrain from doing so [15]. Small farmers are the most common agricultural production and management entities. However, due to the long-term constraints of resource endowment and other factors, small farmers, when faced with the application of green technology, often lack sufficient motivation and learning ability. In most cases, they tend to adopt unreasonable methods and means. Coupled with the aging of the remaining rural labor force, the constraints on green production in agriculture are further exacerbated [16]. Agricultural socialized services represent an effective solution for small farmers who face shortages in agricultural facilities and labor, among other challenges, enabling them to carry out production and operations. Moreover, it is an important organizational form for achieving the transformation of agricultural production methods and promoting the green development of agriculture. Agricultural socialized service organizations possess advantages such as professional agricultural and technical personnel, green production materials, and green treatment technologies. These can offer achievable pathways for mushroom farmers to internalize the positive externalities of the green treatment behavior of mushroom residue. Studies by some scholars have also demonstrated that agricultural socialized services play a crucial role in farmers' green treatment of agricultural waste. Specifically, agricultural socialized services can increase the likelihood of farmers adopting green treatment methods for agricultural waste, and farmers' adoption behaviors vary, depending on different aspects of these services [17].

The literature-review research method can systematically sort out and integrate existing research findings, constructing the knowledge system of a specific research field. In this way, it provides a solid theoretical foundation for subsequent research. Meanwhile, by analyzing a large amount of literature, it can also disclose the current development status and new directions of the ongoing research. The above method has respectively reviewed the domestic and international literature concerning the impact of government regulation and agricultural socialized services on farmers' behavior. Through an exploration of existing research, it is found that farmers' behavior is the outcome of being driven by both normative and incentive factors within a specific context [18]. On the one hand, farmers' behavioral decisions are regulated by the institutional system. Any organization or individual exists within a certain institutional framework, and government regulation shapes farmers' choices of profit-making avenues and enhances the efficiency of profit generation, ultimately influencing the occurrence of farmers' behaviors. On the other hand, alterations in farmers' behaviors are driven by market-based incentives. However, there has been no research that integrates government regulation, agricultural socialized services, and mushroom farmers' green treatment behaviors regarding mushroom residue into a unified analytical framework to explore the dynamic interplay among them and their impacts on mushroom farmers' behaviors. Consequently, this study endeavors to address the following questions: the significance of government regulation in the realm of agricultural production is widely acknowledged. However, whether it can precisely and effectively address the negative externalities stemming from mushroom farmers' adoption of non-green mushroom residue treatment methods, thereby playing a substantial role in enhancing the prevalence and sustainability of green residue treatment, remains a topic that has been scarcely explored in the existing literature. In the context of agricultural social services, whether it can reduce the economic cost, time cost, and technical barriers associated with mushroom farmers' green residue treatment through optimal resource allocation, facilitate the internalization of the positive externalities of such behavior, and ultimately effectively incentivize mushroom farmers' green residue treatment behavior, has also been under-explored in previous research. Moreover, as the two key external factors influencing mushroom farmers' green residue treatment behavior, the academic community has yet to conduct a systematic and in-depth analysis of whether there are complementary, synergistic, or substitutive relationships between government regulation and agricultural socialization services. Additionally, the specific patterns and characteristics of these relationships in the dynamic process of mushroom farmers' behavior changes remain unexamined. Furthermore, at the micro-level, the current academic research has not fully explored and elaborated on the heterogeneous effects that differences in individual characteristics and family production conditions within the mushroom-farmer group may have on their green residue treatment behaviors. This study focuses on the above-mentioned research questions. Through empirical analysis and theoretical deduction, it clarifies the mechanism underlying mushroom farmers' green treatment behavior of mushroom residue and promotes the green transformation of agriculture.

Drawing on existing research, the marginal contributions of this study are as follows: firstly, from the perspective of the research object, most of the existing research has mainly focused on fields such as livestock and poultry farmers and rice farmers, while relatively little attention has been paid to the treatment behavior of edible-mushroom farmers regarding mushroom residue waste. With the development of the edible-fungus industry, the increasing production of discarded mushroom residue has exerted tremendous ecological pressure on the agricultural production environment. Therefore, this study analyzes the green treatment behavior of mushroom farmers towards edible-mushroom residue, which can make a certain contribution to the research field of green treatment of reusable agricultural waste

and offer some reference significance for promoting sustainable agricultural development. Secondly, in terms of research content, most of the existing literature separately explores the impact of a single aspect, either government regulation or agricultural socialized services, on farmers' behavior, overlooking the possible synergies and complementarities between them. The unique contribution of this study within the academic realm lies in its innovative establishment of a comprehensive analytical framework. This framework integrates government regulation, agricultural socialized services, and mushroom farmers' green treatment behavior of mushroom residue into a unified research domain. It probes into the comprehensive influence mechanism of government regulation and agricultural socialized services, as well as their dynamic interaction, on mushroom farmers' behavior, thereby offering a more holistic perspective for comprehending the behavior of mushroom farmers within a complex agricultural system. With the aim of understanding farmers' behavior in such complex agricultural systems, this study devises an analytical framework for mushroom farmers' green treatment behavior of mushroom residue from the vantage points of government regulation and agricultural socialized services. By leveraging 284 sets of research data collected from farmers in Gutian County, Ningde City, Fujian Province, it analyzes the impacts of government regulation and agricultural socialized services on mushroom farmers' green treatment behavior of mushroom residue. On this foundation, it further dissects the influence of the interaction between government regulation and agricultural socialized services on mushroom farmers' green treatment behavior, aspiring to furnish more comprehensive insights for regulating the behavior of mushroom farmers in a complex agricultural system. Moreover, it endeavors to provide certain empirical evidence and a valuable reference for standardizing mushroom farmers' green treatment behavior of mushroom residue, refining relevant policies, and optimizing agricultural socialized service systems.

2. Theoretical Analysis and Research Hypotheses

2.1. Mechanism of the Impact of Government Regulation on Mushroom Farmers' Green Treatment Behavior of Mushroom Residue

The theory of farm household behavior regards the farm household as the fundamental unit of agricultural production. Its behavioral decision-making adheres to the rational man assumption in economics. This assumption posits that, within the context of resource scarcity and market uncertainty, the farm household, by comprehensively taking into account costs and benefits, risks and returns, and incorporating the influence of socio-cultural factors and policy environments, employs strategies of information processing, decision analysis, and risk management. The ultimate aim is to maximize household utility and attain long-term sustainable development. Mushroom farmers, as the micro entities of agricultural production and operation, embody the attribute of the "rational economic man". In the course of production, they determine whether to carry out the green treatment of mushroom residue after production, with the aim of maximizing profits. Since the ecological environment bears the characteristics of public goods, the behavior of mushroom farmers in applying green treatment to mushroom residue for environmental protection is non-competitive and non-exclusive. This tends to give rise to the random disposal behavior of mushroom farmers towards mushroom residue, which generates negative externalities and subsequently leads to market failure. In the absence of external interventions, the green treatment of mushroom residue behavior engenders a positive externality effect and can effectively safeguard the ecological environment. However, this process demands that mushroom farmers shoulder the relevant treatment costs. In the short term, it is infeasible to strike a balance between costs and benefits, thereby inducing a resistant mentality among mushroom farmers towards the green treatment of mushroom residue behavior.

As the pollution caused by mushroom residue waste and the green treatment behavior are typical externality problems, the internalization of externalities can be achieved through the direct regulation of the government, as advocated by Pigou. Therefore, based on the theory of externality, the government, as a representative of the public interest, on the one hand, can implement restrictive government regulation through economic penalties or legal sanctions. This can fundamentally reduce the unreasonable behaviors of agricultural entities, and plays a warning and regulatory role in facilitating the realization of green production behaviors [19]. Through patrol supervision, punishment and other forms of regulatory government measures, the behavior of mushroom farmers in disposing of mushroom residue that may cause environmental pollution can be regulated, achieving the internalization of the negative externality effect caused by their arbitrary treatment of mushroom residue. On the other hand, guided government regulation improves the cognitive level and behavioral control of agricultural entities through the approach of "flexible law enforcement" [20,21]. Through guided government regulation measures such as relevant education and publicity, and technical training, the knowledge of mushroom farmers regarding the green treatment of mushroom residue can be enhanced. This helps to reduce the negative externality caused by the irrational treatment of mushroom residue and promotes mushroom farmers to engage in the green treatment of mushroom residue, thus remedying the market failure phenomenon.

In the context of green-oriented treatment of agricultural waste, in Yucheng City, Shandong Province, China, farmers, driven by the characteristics of the "rational economic man" to cut costs, often discharged manure from livestock and poultry farming in an improper way. This led to the degradation of the surrounding ecosystems, the exacerbation of negative externalities, and the occurrence of market failures in the allocation of environmental resources. The local government responded promptly, by formulating a regulatory strategy integrating constraints and guidance. At the constraint level, regular and comprehensive inspections and supervision were carried out in the farming areas of the city's 11 towns and streets. Issues such as the farming environment, sewage treatment facilities, the disposal of sick and dead livestock and poultry, and the operation of pollution-control facilities were addressed in a timely manner, and violators were punished. This effectively curbed unreasonable sewage discharge. In terms of guidance, the government vigorously promoted technologies such as natural accumulation and fermentation, organic fertilizer production, and biogas engineering. For instance, the 10,000-head dairy farm of the Vision Pastoral Industry introduced manure medium-temperature anaerobic-fermentation technology, achieving efficient recycling of waste. Meanwhile, with the support of the livestock- and poultry-manure resource utilization project, large-scale farms were harnessed to drive the city's farmers, promoting the comprehensive utilization of manure and constructing a green development model integrating planting and breeding. After the popularization of technologies and publicity and education efforts, farmers' awareness of green treatment methods has increased significantly. Driven by the government's initiatives, farmers have come to realize that the green treatment of manure can not only help them avoid fines, but also increase their income. Their business philosophy has shifted from the pursuit of short-term profits to long-term sustainable development, and they have started to actively adopt green treatment methods [22]. Government regulation has a positive impact on farmers' green treatment behavior of livestock manure. Then, the question is whether it can function in a similar way for mushroom farmers in the green treatment of mushroom residue. Therefore, based on theoretical analyses and practical cases, this study proposes the following hypotheses:

Hypothesis 1 (H1). *Government regulation is capable of reducing and transforming the negative externality that emerges from mushroom farmers' adoption of non-green mushroom residue treatment methods, thereby promoting the green residue treatment behavior of mushroom farmers.*

2.2. Mechanisms of the Role Played by Agricultural Socialized Services on Mushroom Farmers' Green Treatment Behavior of Mushroom Residue

In the realm of agricultural production, the adoption of green treatment methods for mushroom residue by mushroom farmers generates a significant positive externality in terms of protecting the public environment. However, under the market mechanism, this positive externality frequently fails to receive reasonable compensation. As a result, in the absence of direct economic incentives, mushroom farmers tend to refrain from adopting green treatment measures. This phenomenon originates from the nature of mushroom farmers as rational economic agents. In their production decisions, they assess the expected costs and benefits, and may overlook the long-term environmental benefits of green treatment when the anticipated returns fail to offset the costs. To address the challenge of internalizing externalities during the transformation process, in the theory of externalities, Coase emphasized that in the absence of transaction costs or when such costs are extremely low, resource owners can achieve optimal resource allocation through negotiation and contracting, thereby realizing the internalization of externalities. Moreover, institutions like agricultural social service organizations can substantially surmount the obstacles that farmers encounter in the management of agricultural waste by offering relevant agricultural service programs [23,24].

Therefore, the intervention of social service organizations in the edible fungi industry is of particular significance. Take Lushui Village in Jungles Town, Wansheng Economic Development Zone, Chongqing City, China, as an example. Lushui Village was a local coal-mining town. After the coal mine was closed, the village decided to introduce leading enterprises and help villagers establish a standardized and large-scale edible-fungi industry and cultivate edible-fungi planters. However, as the planting scale expanded, wastes such as mushroom dregs gradually became an "ecological burden". To address this issue, Lushui Village cooperated with enterprises to build a mushroom residue drying and processing plant. The waste sticks and mushroom dregs recovered from the family workshops of mushroom farmers were processed into products such as organic fertilizers and mushroom growth substrates through drying or fermentation treatment. Additionally, the newly-built edible-fungi seed breeding center has formed an "ecological closed-loop" by consuming local plant straws, livestock and poultry manure, and edible-mushroom residues. It has an annual output of 5 million mushroom sticks and approximately 3000 tons of edible mushrooms. The processing plant can handle nearly 10,000 tons of waste mushroom dregs each year. This not only solves the problem of mushroom dregs disposal, but also generates an income of CNY 100,000 for the village collective, achieving a "win–win" situation in terms of economic and ecological benefits [25]. This case demonstrates that agricultural social services, by providing relevant mushroom residue-related services, enable edible-fungi growers to effectively solve the problem of mushroom dregs at a relatively low cost and obtain additional income, thus effectively promoting the green treatment of mushroom residue. In the development process of the edible-fungi industry, agricultural socialization service organizations effectively reduce the cost burden of mushroom farmers during the green treatment process by providing mushroom dregs recycling and transportation services. That is, they internalize these external costs through services and promote the internalization of positive externality effects. In other words, they transform environmental benefits into the private benefits of mushroom farmers through the market mechanism. Specifically, the recycling service endows mushroom dregs with added value for mushroom

farmers, while the transportation service reduces the logistics costs in the treatment process. Together, these two aspects enhance the incentives for mushroom farmers to adopt green treatment measures. Therefore, the following hypotheses are proposed in this study:

Hypothesis 2 (H2). *Agricultural socialized services can reduce the costs associated with mushroom farmers' green treatment of mushroom residue. Through service programs, they can internalize the positive externality effects of such behavior and, consequently, facilitate the adoption of green treatment measures for mushroom residue by mushroom farmers.*

2.3. Mechanisms of the Interactive Effects of Government Regulation and Agricultural Socialized Services on the Green Treatment Behaviors of Mushroom Farmers

This study incorporates government regulation, agricultural socialized services, and mushroom farmers' green treatment behavior of mushroom residue into the same research framework. Government regulation and agricultural socialized services represent two distinct forms of influence channels. Their influence on farmers' decision-making during the agricultural production process unfolds at different stages and through different procedures, giving rise to a complex interaction between them. This, in turn, affects the decision-making behavior of mushroom farmers [26].

Government regulation plays a pivotal role in rectifying negative externalities within agricultural production, particularly in relation to the behavior of mushroom farmers when dealing with mushroom residue. By means of legislative and policy tools, governments can impose restrictions and offer guidance on behaviors that pose potential harm to the environment. This transforms the negative external costs that society would otherwise bear into the liability of individual producers. Government regulations encompass not only penalties for the improper handling of mushroom residue, but also education and training initiatives. These are designed to augment mushroom farmers' knowledge and skills regarding green handling methods, as well as to enhance their sense of responsibility for environmental protection. Consequently, policy guidance encourages mushroom farmers to factor in environmental considerations during their decision-making process and spurs them to adopt more environmentally friendly mushroom-residue handling procedures. At the same time, the emergence and development of agricultural socialized services offer robust support for mushroom farmers to embrace green treatment behavior. They effectively lower the barriers for mushroom farmers to adopt new technologies and treatment methods. In particular, the mushroom residue recycling and transportation services in the post-production stage of the edible-mushroom cultivation industry not only curtail the costs of mushroom residue treatment for mushroom farmers, but also generate additional economic benefits for them. The intervention of agricultural socialized services facilitates the internalization of the positive externality effect of mushroom farmers' green treatment behavior regarding mushroom residue. In other words, it enables the conversion of environmental benefits into private gains for mushroom farmers through the market mechanism.

Examining the potential synergies between government regulation and agricultural socialized services in spurring mushroom farmers to adopt green residue handling practices reveals crucial aspects. Government regulation endows mushroom farmers with norms and guidelines essential for embracing green behaviors. Meanwhile, agricultural socialized services equip them with specific means and the requisite support for actualizing green treatment behaviors concerning mushroom residue. It is probable that significant complementary effects exist between these two forces in facilitating the promotion of mushroom farmers' green treatment behaviors. Consequently, this study formulates the following hypotheses:

Hypothesis 3 (H3). *There exists an interaction effect between government regulation and agricultural socialized services with regard to mushroom farmers' green treatment behavior of mushroom residue. This interaction effect is primarily manifested as a complementary relationship.*

Combining the above research hypotheses, government regulation, agricultural socialized services, and mushroom farmers' green treatment behaviors of mushroom residue were incorporated into the same analytical framework, as illustrated in Figure 1.

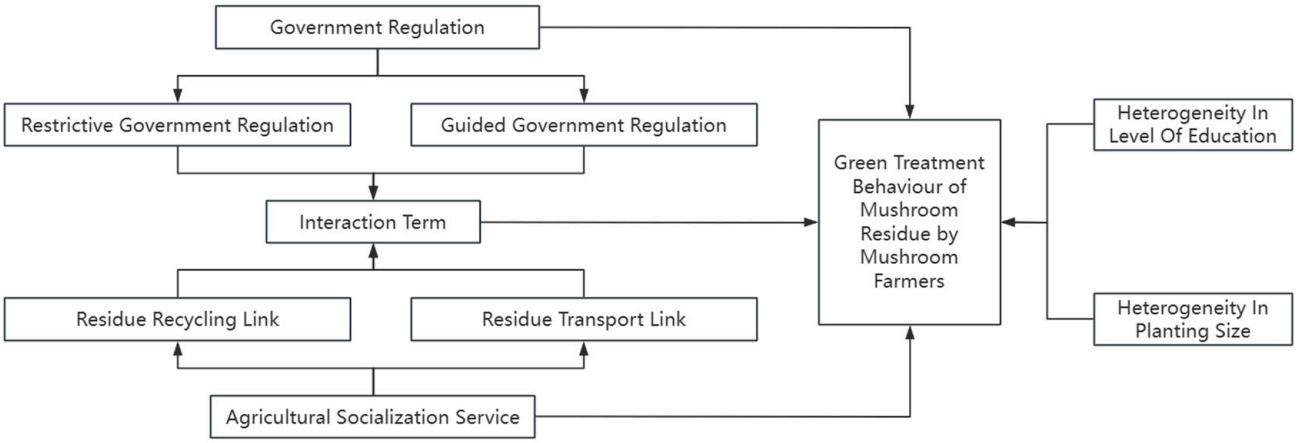

Figure 1. Theoretical analysis framework.

3. Data Sources, Variables and Empirical Models

3.1. Research Methodology

In order to address the topic of this research more effectively and elucidate the impact as well as the underlying mechanism of how government regulation and agricultural socialized services influence the green treatment behavior of mushroom farmers regarding mushroom residue, the adoption of a targeted research methodology constitutes a crucial step in resolving the research problem. To successfully tackle the specified research questions, it is imperative to choose methods that are appropriate for the relevant discipline and complement them with suitable techniques in light of the characteristics of the research field. This will guide the research to attain the anticipated results [27]. Therefore, this study draws inspiration from the methodology adopted by Peráček, T. et al. in their academic research, and integrates it with the unique characteristics of this particular study. Specifically, inductive analysis, questionnaire surveys, descriptive research, empirical analysis, and comparative analysis are employed [27].

3.1.1. Literature Research Method

Prior to commencing the research work, it is essential to establish a sufficient knowledge foundation to guarantee the scientific and systematic nature of the study. This study employs the literature review method. By meticulously examining the relevant literature concerning concept definition, classification systems, and measurement methods within the domains of government regulation and agricultural socialized services, it endeavors to offer an accurate and comprehensive measurement and evaluation of the key variables in the study. Additionally, this study will conduct an in-depth analysis of the extant literature on farmers' green production behavior, with the aim of comprehensively grasping the domestic and international research trends in this area and providing methodological references and theoretical support for the investigation of mushroom farmers' residue green behavior. Grounded in the externality theory, cost transaction theory, and farmers' behavior theory, this study will dissect the specific impacts of these two crucial factors on

mushroom farmers' green treatment behavior of mushroom residue from the perspectives of government regulation and agricultural socialized service.

3.1.2. Questionnaire Method

As a pivotal data collection instrument, the questionnaire survey holds irreplaceable significance in acquiring primary data. In this study, a field research questionnaire was designed in combination with the production practices of edible mushrooms and with regard to the factors that influence mushroom farmers' green treatment behavior of mushroom residue. To ensure the representativeness of the samples and the reliability of the data, this study adopted a stratified random sampling approach, designating Gutian County in Fujian Province as the research area. From this region, a specific number of villages and mushroom farmers were chosen as samples. Through the administration of comprehensive questionnaires and in-depth interviews, this study gathered the personal background information of mushroom farmers and the production and operation status of edible mushrooms, as well as their specific measures in the green treatment of mushroom residue. The collection of such data was essential for obtaining the micro-level data necessary for this study, laying a solid foundation for subsequent data analysis and the testing of research hypotheses.

3.1.3. Descriptive Research

Descriptive research, being one of the crucial methods in social science research, endeavors to delineate in meticulous detail the specific traits, behaviors, and phenomena of the research target, through observation and documentation. With mushroom farmers as the focal point of the research, this study amasses the characteristics and manifestations of mushroom farmers' green treatment behaviors of mushroom residue under the combined impacts of government regulation and agricultural socialized services. This is done in order to furnish the research topic with precise details regarding the current green treatment behaviors of mushroom farmers, and to erect a comprehensive cognitive scaffold for further exploration, thereby facilitating a more profound understanding of the essence of mushroom farmers' green treatment behaviors of mushroom residue.

3.1.4. Empirical Research Methodology

In this study, based on the questionnaire survey results, the collected valid questionnaires were systematically sorted and digitized, thereby converting the questionnaire data into analyzable numerical information. Subsequently, Stata 17.0 statistical analysis software was employed to carry out an empirical analysis on the obtained data. To quantify the varying degrees of mushroom farmers' green treatment behaviors regarding mushroom residue, an ordered dependent variable was established in this study, with its values spanning from 1 to 5. Specifically, "1" indicates that mushroom farmers did not adopt any green treatment measures for mushroom residue, whereas "5" signifies that they implemented all four mushroom residue green treatment measures. Given the ordinal nature of the dependent variable, the Ordered Probit model was selected in this study to investigate the impacts of government regulation and agricultural socialized services, as well as the interaction between the two, on mushroom farmers' green treatment behavior of mushroom residue. This model is capable of accommodating the ordinal characteristic of the dependent variable, and offers a fitting statistical framework for the analysis.

3.1.5. Comparative Analysis

This study conducts a comparison of the differences in mushroom farmers' green treatment behaviors of mushroom residue under diverse conditions. Specifically, it delves into the specific marginal effects of government regulations and agricultural socialized

services on the green behaviors of mushroom farmers. Subsequently, it compares the particular impacts of different government regulations and varying agricultural socialized services on mushroom farmers' behaviors. This endeavor contributes to a profound understanding of the roles that government regulations and agricultural socialized services play in fostering sustainable agricultural development, as well as the mechanism through which they operate. Moreover, by comparing the green treatment behaviors of mushroom farmers with distinct individual characteristics and family production conditions, this study can furnish a scientific basis for the government to formulate more efficacious intervention policies and for agricultural socialized services to devise more precise service programs.

3.2. Data Sources

The research data originated from a questionnaire survey implemented in June and July 2023 in Gutian County, Ningde City, Fujian Province. Referred to as the "Edible Mushroom Capital of China", Gutian County enjoys a solid foundation and an expansive scale in the edible-mushroom industry, holding a crucial position within China's edible-mushroom domain. As per the "Statistical Bulletin of National Economic and Social Development of Gutian County in 2023", by 2023, the production of edible fungi in Gutian County had soared to 160,055 tons, vividly demonstrating the industry's magnitude. Furthermore, the advanced technologies, diverse varieties, and innovative concepts pertaining to edible fungi in Gutian County have been diffused to other provinces, fulfilling the remarkable practice of China's 'Southern Mushroom Northward' strategy and affording an excellent opportunity for China's edible-fungus industry to metamorphose into one with a sturdy foundation and substantial scale. It has undeniably made a landmark contribution to the advancement of the edible-mushroom industry across the nation. Owing to such extensive industry-driven repercussions, all facets of the mushroom industry's development in Gutian County possess a nationwide exemplary effect. Consequently, the mushroom farmers' mushroom residue treatment modalities and technological selections in Gutian County are likely to be emulated and adopted by other regions. This renders Gutian County an optimal research locale for probing into the green treatment behavior of mushroom farmers' mushroom residue under the aegis of government regulation and agricultural socialized services, given its robust sample representativeness.

Due to variations in economic development and edible-mushroom cultivation varieties across different villages, mushroom farmers may exhibit diverse needs and preferences regarding the green treatment of mushroom residue. When the questionnaire sample is overly concentrated in a specific village, it becomes challenging to account for the multiple disparities among villages. This is because the social, economic, and cultural characteristics within a single village often display significant homogeneity, leading to a serious lack of sample representativeness. Consequently, the scope of application of the conclusions drawn from such a sample will be considerably restricted. Furthermore, given that the social structure and demographic characteristics of a single village are relatively stable and fixed, attempting to extrapolate the study's conclusions to other villages or a broader mushroom-cultivation area may weaken the accuracy of these conclusions. This is due to substantial changes in the external environment, which will cause a notable decline in the external validity of the study results. In addition, the non-response bias of survey respondents can impact the study's validity. The non-response bias among mushroom farmers can skew the sample, causing it to deviate from the original random sampling design. As a result, the selected sample may no longer accurately represent the target population. When analyzing the data, errors in estimating the overall parameters may occur. This is because the characteristics of non-responders may differ significantly from those of responders, and these differences can distort the estimation of the means,

proportions, and distributions of key variables. The resulting research conclusions may be misleading and fail to accurately reflect the actual situation of the study population, thereby affecting the scientific validity and reliability of decisions and inferences based on these research conclusions. Consequently, to minimize the impact of sample bias on the study results, this study adopted random stratified sampling. This method was employed to ensure that our sample was diverse enough to represent mushroom farmers across all regions of Gutian County. Moreover, to enhance the participation rate, incentives were provided and potential respondents were contacted multiple times during the research process. Through these means, we aimed to guarantee that the relationship between government regulation, agricultural socialized services, and mushroom farmers' green treatment behaviors could be accurately understood. The stratified random sampling method was employed in this research to ensure that, at each stage, there existed a known and non-zero probability of being selected as the research subject, thereby meeting the requirements of random sampling. The sampling process was carried out as follows: firstly, among all the townships in Gutian County, Ningde City, Fujian Province, seven townships were chosen via simple random sampling. The specific procedures were as follows: list all the townships in Gutian County and assign a unique identification number to each. Subsequently, utilize a random-number generator or lottery to randomly draw seven distinct numbers from these. Then, determine the seven selected townships based on the names of the townships corresponding to the drawn numbers, namely Dajia Township, Sanyang Township, Daxiao Township, Jixiang Township, Chengdong Street, Panyang Township, and Zhuoyang Township. Secondly, within each of the selected townships, stratified random sampling was implemented in accordance with the actual circumstances of each village, to guarantee the representativeness of the sample. The specific steps were as follows: classify the villages within each township using geographical location as the criterion. Within each classification, randomly select a certain number of villages through simple random sampling, ensuring that at least three villages are selected from each township. If the number of villages in a particular category was insufficient, they were supplemented from other categories. Finally, within each selected village, approximately 15 households were randomly selected by means of systematic sampling. The survey was carried out in the form of "one-on-one" face-to-face communication, for the purpose of obtaining the questionnaire data from mushroom farmers. The survey content primarily encompassed information regarding the characteristics of farmers, family characteristics, cultivation scale, government regulations, and agricultural socialized services. In this research, a total of 302 questionnaires were distributed, and all 302 were retrieved. After eliminating questionnaires with inconsistencies and omissions, 284 valid questionnaires were obtained, yielding a questionnaire validity rate of 94.04%.

3.3. Description of Variables and Descriptive Statistics

The descriptions of the variables, along with their descriptive statistics, are presented in Table 1.

3.3.1. Explained Variables

Green Treatment Behavior of Mushroom Residue (GTB). Currently, scholars tend to measure farmers' green technology-adoption behavior either by summing up the number of green technologies adopted by farmers or by determining whether farmers have adopted any single green technology [28,29]. Based on the relevant research concerning the green treatment of mushroom residue and the actual circumstances of the research site, we conduct a quantitative analysis of the green treatment behavior of mushroom farmers' mushroom residue by drawing inspiration from the research of Sanxia, D. et al.

(2024) [30]. Through the research, it was discovered that the green treatment behavior of mushroom residue among the sampled mushroom farmers encompasses four treatment methods, namely, the harmless combustion of mushroom residue, mushroom residue formula cultivation, mushroom residue composting, and mushroom residue feed preparation. In this study, the results of quantitatively summing up the green treatment methods of mushroom residue adopted by the mushroom farmers (i.e., "adopting 0 methods", "adopting 1 method", "adopting 2 methods", "adopting 3 methods", "adopting 4 methods") were utilized to quantify the overall green treatment behavior of the mushroom farmers. The variable's value range was set from 1 to 5.

3.3.2. Explanatory Variables

Government regulation (GR). In terms of the measurement of government regulation, it is currently mainly examined through two perspectives. One is measured from the perspective of farmers' exposure to regulation. When farmers are under the influence of government regulation during the production process, they will adjust their own production behaviors, thereby realizing the regulatory effect of the government [31]. The other is measured from the perspective of government behavior. The relevant government departments will offer farmers publicity, education, and technical training through relevant incentive or guidance measures to enhance farmers' awareness and subsequently prompt them to recognize and accept relevant green production methods [32]. In light of the actual circumstances of mushroom farmers' mushroom residue treatment, government regulation is categorized into restrictive government regulation and guided government regulation. Restrictive government regulation is gauged by the indicator of "whether the relevant departments of the government where mushroom farmers are located conduct patrols and supervision regarding the mushroom residue treatment"; guided government regulation is evaluated by the metric of "whether the government department where the mushroom farmers are located launches publicity or provides technical training on the green post-production treatment of edible mushrooms".

Agricultural socialization service (ASS). In the analysis of the research on the impact of government regulation on mushroom farmers' green treatment behavior of mushroom residue, agricultural socialized services are incorporated for further exploration, to clarify their role in promoting such green treatment. In the decision-making process concerning the treatment of mushroom residue, the behavioral choices of mushroom farmers are significantly influenced by future expected returns. Meanwhile, agricultural socialized services can alleviate financial constraints during the production process, reduce production costs, and encourage sustainable production practices [33]. By providing efficient recycling channels and optimized logistics solutions, the residue recycling and transportation component of agricultural socialized services can generate supplementary income streams for mushroom farmers and substantially diminish their economic expenditures related to residue disposal. Consequently, there exists a close correlation between the mushroom residue recycling and transportation stages and the treatment decisions formulated by mushroom farmers. Accordingly, agricultural socialized services can be segmented into two aspects: the post-production mushroom residue recycling stage and the post-production mushroom residue transportation stage. For the former, it is quantified by the indicator "whether the mushroom farmers engage in the post-production recycling stage of the edible mushroom within the agricultural socialized service"; for the latter, it is gauged by the metric "the convenience of the mushroom residue transportation stage in the mushroom farmers' village".

3.3.3. Control Variables

Mushroom farmers' production decisions are constrained by a plethora of factors and conditions. The characteristics of individual mushroom farmers, including personal attributes, family business elements, and other pertinent features, all contribute to influencing the choice of green treatment behavior for mushroom residue during the disposal process. In this study, age, gender, education level, years of cultivation, political affiliation, cooperative membership, cultivation variety, number of mushroom sheds, and cultivation scale are designated as control variables.

Firstly, in view of the individual characteristics of mushroom farmers, namely farmers' age, gender, education level, years of cultivation, and political affiliation, the following were considered. Currently, the aging trend within the agricultural labor force is growing increasingly prominent. Generally speaking, compared with younger farmers, most elderly farmers usually display a relatively lower capacity to accept or adopt new agricultural technologies. Therefore, to a certain extent, the age of the household head may have a negative impact on the green treatment behavior of mushroom residue. The education level of the household head reflects an individual's knowledge and skill proficiency. Typically, the higher the education level, the stronger the willingness to embrace and apply new technologies, and thus, the greater the probability of adopting green treatment methods for mushroom residue. Longer cultivation years often correspond to a deeper understanding of production and operating costs, as well as sustainable agricultural practices. Farmers with extensive cultivation experience tend to recognize that environmentally friendly management measures can not only reduce costs, but also promote the virtuous cycle of the agro-ecosystem, thereby facilitating the green treatment of mushroom residue. Usually, farmers who are members of the Communist Party of China or village cadres can play an exemplary role in the green treatment of mushroom residue. Given their positions, they are more likely to carry out timely green treatment of mushroom residue, and have a more comprehensive understanding of relevant technologies. Hence, if the household head is a member of the Communist Party of China or a village cadre, it may contribute to their green treatment behavior.

Secondly, with regard to the characteristics of mushroom farmers' family operations, we considered the following. Different edible mushroom varieties show differences in growth cycle, yield, bioconversion efficiency, and waste characteristics, among others. These discrepancies are directly related to the quantity of mushroom residue and its corresponding treatment requirements, which in turn affect farmers' treatment behaviors and preferences. In agricultural production practice, mushroom farmers with a large number of mushroom sheds in rural areas often have a dispersed, rather than centralized, distribution pattern of their sheds. Some of these sheds may be located near residential areas or other locations. If mushroom farmers adopt non-sustainable and random emission or disposal measures for mushroom residue, such actions are very likely to attract the serious attention and intervention of local communities and government environmental protection agencies. The combined effect of social supervision and administrative regulation, serving as an external incentive, can significantly prompt mushroom farmers to adopt and implement more environmentally friendly, green, and efficient mushroom residue treatment strategies. The cultivation scale also has a certain influence on mushroom farmers' treatment of mushroom residue. Specifically, large-scale production of edible mushrooms leads to a significant increase in the amount of mushroom residue. Consequently, mushroom farmers are inclined to adopt green treatment methods for mushroom residue to effectively manage the large volume of residue and avoid any potential negative environmental impacts.

Table 1. Description of variables and descriptive statistics.

Variable Type	Variable Name	Variable Meaning and Assignment	Average Value	(Statistics) Standard Deviation
Explanatory Variable	Green Treatment Behaviour of Mushroom Residue by Mushroom Farmers (GTB)	Number of green treatment measures for mushroom residues adopted by mushroom farmers: 1 = 0 items; 2 = 1 item; 3 = 2 items; 4 = 3 items; 5 = 4 items	2.232	0.739
Core Explanatory Variables	Restrictive Government Regulation (RGR)	Whether the relevant departments of the local government patrol and supervise the treatment of mushroom residue: 1 = yes; 0 = no	0.313	0.464
	Guided Government Regulation (GGR)	Whether the relevant departments of the local government carry out publicity or technical training on green post-production treatment of edible fungi: 1 = yes; 0 = no	0.352	0.478
	Residue Recycling Link (RRL)	Involvement in the sludge recycling component of agricultural social service organizations: 1 = yes; 0 = no	0.349	0.477
	Residue Transport Link (RTL)	Mushroom farmers' perception of the convenience of the mushroom residue transportation link in their villages: 1 = very inconvenient; 2 = quite inconvenient; 3 = average; 4 = more convenient; 5 = very convenient	2.412	0.926
Control Variable	(a person's) Age	Actual age of mushroom farmers (years)	54.004	9.836
	Gender	1 = Male; 0 = Female	0.715	0.452
	Educational Level	1 = never attended school; 2 = elementary school; 3 = junior high school; 4 = high school and middle school; 5 = college; 6 = graduate school and above	2.648	0.883
	Planting Year	Actual length of time mushroom farmers have been engaged in edible-mushroom cultivation (years)	20.521	11.032
	Political Identity	Whether he or she is a village official or party member: 1 = yes; 0 = no	0.092	0.289
	Joining Cooperatives	Whether or not they are members of a local agricultural cooperative: 1 = yes; 0 = no	0.074	0.262
	Plant Variety	The actual types of edible mushrooms grown by mushroom farmers: 1 = white fungus; 2 = southern poplar mushroom; 3 = shiitake mushrooms; 4 = hericium erinaceus; 5 = other	2.306	1.278
	Number of Mushroom Sheds	Number of mushroom farmers owning mushroom sheds (units)	2.310	1.433
	Planting Scale	Actual scale of mushroom cultivation by mushroom farmers: 1 = fewer than 5000 sticks; 2 = 5000 to 10,000 sticks; 3 = 15,000 to 20,000 sticks; 4 = 20,000 to 25,000 sticks; 5 = 25,000 rods or more	2.743	1.461

Source: Calculations based on research questionnaires.

3.4. Model Construction

Ordered Probit Regression Model. The dependent variable in this study is mushroom farmers' green treatment behavior of mushroom residue, which is a discrete variable measured by the composite value of the green treatment methods adopted by mushroom farmers for mushroom residue. It takes the values of 1, 2, 3, 4, and 5. That is to say, each successive value indicates a higher degree of green treatment or more positive environmental behavior compared to the previous one, and belongs to the multi-valued ordered categorical explanatory variables, which exhibit an obvious recursive relationship. Since the Ordered Probit model is suitable for handling ordered categorical data, it can capture the sequential differences between different treatments, allowing us to assess how various factors influence mushroom farmers to adopt higher levels of green treatment behaviors, and thereby enhance the accuracy of the results [34]. Meanwhile, the model provides consistent and efficient parameter estimates through the maximum likelihood estimation method, accommodates the nonlinear relationship between the independent and dependent variables, and can maintain a high level of robustness even when the sample size is not extremely large. In addition, the results of the Ordered Probit model are straightforward to interpret. The coefficients that elucidate the effect of the independent variables on the probability of the dependent variable falling into a particular category are conducive to understanding how diverse factors influence the green treatment behavior of mushroom farmers, and provide a foundation for policy formulation. When compared with the logistic regression model, from the perspective of model principles, logistic regression transforms linear predicted values into the 0–1 interval to discriminate between two classes in binary classification. In the context of a multi-classification unordered scenario, multinomial logistic regression is typically employed to decompose a multi-classification problem into multiple binary-classification problems. However, this approach disregards the ordinal information among classes. In this study, the green treatment behaviors of mushroom farmers regarding mushroom residue are quantified on a scale from 1 to 5, and there exists a recursive relationship. Multinomial logistic regression, unfortunately, treats each category independently, thus violating the inherent logic of the data. Regarding data feature fitting, multinomial logistic regression fails to capture a substantial amount of crucial information when processing the data in this study, as it cannot account for the order of the categories. For instance, when the independent variable is the education level of mushroom farmers, the Ordered Probit model can precisely evaluate how it facilitates the progression of mushroom farmers from lower to higher levels of green treatment behavior. In contrast, logistic regression can merely determine whether a treatment switch occurs or not, without reflecting the incremental increase in the degree of treatment. This results in a coarse representation of the variable relationships, and makes it difficult to mirror the actual situation. Additionally, analyzing the data of this study using logistic regression yields significantly less value in guiding policy-making. Policy-makers need to understand how to guide mushroom farmers to gradually enhance the level of green treatment behaviors. Nevertheless, logistic regression cannot provide information regarding the order and degree. For example, when formulating policies to encourage mushroom farmers to adopt more environmentally friendly treatments, policy-makers find it challenging to identify which factors to target and what intensity of measures to implement to promote the upward movement of mushroom farmers from lower to higher levels, since logistic regression does not disclose the progressive relationship. When compared with the linear regression model, in terms of model principles, the linear regression model postulates a linear relationship between the dependent variable and the independent variable, assuming that the dependent variable is a continuous numerical variable. It predicts the value of the dependent variable by minimizing the residual sum of squares

to determine the best-fitting straight line. However, in this study, the green treatment behavior of mushroom farmers regarding mushroom residue, serving as the dependent variable, is a discrete multi-valued ordered categorical variable that only takes on the values of 1, 2, 3, 4, and 5. This contradicts the linear regression's requirement for the continuity of the dependent variable. Regarding data feature fitting, when dealing with the data of this study, the linear regression model cannot reasonably define the boundaries of different categories of green treatment behaviors. When predicting the changes in mushroom farmers' handling practices, due to the absence of an effective mechanism for determining boundary-crossing, the prediction results are likely to fall into unreasonable intervals, which are difficult to align with the actual level of behavior, thereby leading to meaningless prediction outcomes. Consequently, the Ordered Probit model was chosen in this study to investigate the impacts of government regulation and agricultural socialized services on mushroom farmers' green treatment behavior of mushroom residue, and its basic regression model was the following:

$$GTB^* = \beta_0 + \beta_1 GR + \beta_2 ASS + \beta_3 X + \varepsilon \tag{1}$$

$$GTB^* = \beta_0 + \beta_1 \mathrm{GR} + \beta_2 \mathrm{ASS} + \beta_3 X + \beta_4 \mathrm{GR} \times \mathrm{ASS} + \varepsilon \tag{2}$$

In Equations (1) and (2), *GTB** represents an unobservable latent variable. *GR* stands for Government Regulation, which is specifically divided into Restrictive Government Regulation and Guiding Government Regulation, *ASS* stands for Agricultural Socialization Services, which is specifically divided into Mushroom Residue Recycling Link and Residue Transportation Link, X is a control variable, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ is a coefficient to be estimated, and ε is a random disturbance term. Furthermore, adding the interaction term between the government regulation and agricultural socialized service variables in Equation (1) yields Equation (2), which can be used to test the interaction effect of government regulation and agricultural socialized service on promoting the green treatment behavior of mushroom farmers regarding mushroom residue.

The following relationship exists between the observable mushroom farmers' mushroom-residue green-treatment behavioral variable Y and the unobservable latent variable GTB*.

$$GTB = \begin{cases} 1\ (\text{not adopted}),\ if\ GTB^* \le \gamma_0 \\ 2\ (1\ \text{kind adopted}),\ if\ \gamma_0 < GTB^* \le \gamma_1 \\ 3\ (2\ \text{kind adopted}),\ if\ \gamma_1 < GTB^* \le \gamma_2 \\ 4\ (3\ \text{kind adopted}),\ if\ \gamma_2 < GTB^* \le \gamma_3 \\ 5\ (4\ \text{kind adopted}),\ if\ GTB^* > \gamma_3 \end{cases} \tag{3}$$

In Equation (3), $\gamma_0, \gamma_1, \gamma_2, \gamma_3$ is the location split point of mushroom farmers' mushroom-residue green-treatment behavioral variables, respectively, and $\gamma_0 < \gamma_1 < \gamma_2 < \gamma_3$. This generates the probabilities of mushroom farmers not adopting, adopting one, adopting two, adopting three, and adopting four types of mushroom residue green treatment methods, respectively.

$$\begin{aligned} p(GTB = 1|x) &= \phi(\gamma_0 - \beta_1 GR - \beta_2 ASS - \beta_3 X) \\ p(GTB = 2|x) &= \phi(\gamma_1 - \beta_1 GR - \beta_2 ASS - \beta_3 X) - \phi(\gamma_0 - \beta_1 GR - \beta_2 ASS - \beta_3 X) \\ p(GTB = 3|x) &= \phi(\gamma_2 - \beta_1 GR - \beta_2 ASS - \beta_3 X) - \phi(\gamma_1 - \beta_1 GR - \beta_2 ASS - \beta_3 X) \\ p(GTB = 4|x) &= \phi(\gamma_3 - \beta_1 GR - \beta_2 ASS - \beta_3 X) - \phi(\gamma_2 - \beta_1 GR - \beta_2 ASS - \beta_3 X) \\ p(GTB = 5|x) &= 1 - \phi(\gamma_3 - \beta_1 GR - \beta_2 ASS - \beta_3 X) \end{aligned} \tag{4}$$

In Equation (4), ϕ is the cumulative density function of the standard normal distribution. Like the Binary Probit model, the Ordered Probit model will be estimated using the Great Likelihood estimation.

4. Results and Analysis

This study employs Stata 17 software to estimate the Ordered Probit model. To ensure the accuracy of model parameter estimation, the variance inflation factor (VIF) test is utilized to examine the model variables for multicollinearity. The variance inflation factors of each variable range from 1.06 to 2.00, all of which are less than 5. This indicates that the model is well-structured, with no serious multicollinearity issue among the model variables. It also implies that the variables are selected both reasonably and correctly, and the research data are valid.

4.1. Main Effect Analysis of the Impact of Government Regulation and Agricultural Socialized Services on Mushroom Farmers' Green Treatment Behavior of Mushroom Residue

For the main effect analysis, all three models adopt the Ordered Probit model as shown in Formula (1). Firstly, the indicator variables and control variables of restrictive government regulation and guided government regulation are incorporated into the model, respectively, yielding Model 1. Subsequently, the indicator variables and control variables of the mushroom residue recycling stage and the mushroom residue transportation stage of agricultural socialized services are introduced into the model, to obtain Model 2. Finally, all the indicator variables and control variables of government regulation and agricultural socialized services are simultaneously included in the regression, to derive Model 3. The regression results are presented in Table 2. Notably, the LR chi^2 values of all three models are significant at the 1% significance level, and the Pseudo R^2 has been significantly improved, indicating that the overall fitting effect of the models is satisfactory.

4.1.1. Estimation Results of the Impact of Government Regulation on Mushroom Farmers' Green Treatment Behavior of Mushroom Residue

As presented in Table 2, both the variables of restrictive government regulation and guided government regulation exert significant and positive effects on mushroom farmers' green treatment behavior of mushroom residue. Firstly, the restrictive government regulation significantly and positively influences mushroom farmers' green treatment behavior at the 1% statistical significance level. The negative reinforcement characteristic of the restrictive government regulation can subject the agricultural production entities to greater social pressure, effectively regulate the individuals' action intentions, and subsequently prompt the production entities to adopt appropriate measures [35]. In the process of edible-mushroom production, in the absence of government regulation, mushroom farmers generally do not take into account the environmental costs incurred during the disposal of mushroom residue in the post-production stage. Especially when the cost of disposing of waste mushroom residue is relatively low, it becomes very easy to trigger the speculative behavior of mushroom farmers. The government's administrative constraints, serving as an external driving force to regulate individual behavior, can influence individual decision-making. Therefore, when the government conducts unscheduled patrol inspections and supervision and continuously improves and enforces regulations regarding agricultural surface pollution, the cost for mushroom farmers to dispose of mushroom residue casually becomes greater than the cost of implementing green treatment methods. This spontaneously affects mushroom farmers' treatment behavior of mushroom residue, and prompts their shift towards green and environmentally friendly treatment. Thus, it can be concluded that restrictive government regulation will have a positive impact on mushroom farmers' green treatment behavior of mushroom residue.

Secondly, guided government regulation exerts a significant and positive effect on mushroom farmers' green treatment behavior of mushroom residue at the 1% statistical significance level. The guided policy tools make full use of the information dissemination mechanism established by agricultural technology promotion to steer agricultural production entities towards adopting green production behaviors, which plays a crucial role in achieving sustainable agricultural development [36]. Through publicity and technical training for the post-production treatment of edible mushrooms, the guided government regulation can enhance the impetus for mushroom farmers to attempt new methods of mushroom residue treatment, thereby facilitating the realization of the potential value of mushroom residue. When mushroom farmers recognize that the benefits of implementing green treatment of mushroom residue outweigh those of random disposal, their willingness to carry out the green treatment behavior of mushroom residue will be spurred on. Therefore, it can be concluded from the above results that Hypothesis 1 (H1) holds true.

Furthermore, it can be deduced that in the process of promoting mushroom farmers' green treatment behavior of mushroom residue, the measures in different dimensions under government regulation each play their roles and, simultaneously, are interrelated. The government's policy propaganda and technical guidance serve a dual purpose in promoting the green treatment behavior of agricultural waste. Through effective policy propaganda, education, training, and technical guidance, the government can enhance farmers' awareness and understanding of environmental issues, thereby alleviating the regulatory pressure on the government. Meanwhile, the technical guidance equips farmers with practical methods and skills, enabling them to better engage in the green management of agricultural wastes and motivating them to take the initiative to participate in green treatment. Thus, in the process of promoting the green development of agriculture, it is necessary to strengthen policy synergy and cooperation, formulate targeted policies for different agricultural industries, and give full play to the distinctive function of government regulation.

4.1.2. Estimation Results of the Impact of Agricultural Socialized Services on Mushroom Farmers' Green Treatment Behavior of Mushroom Residue

The mushroom-residue recycling link and transportation link of agricultural socialized services had a significant impact on mushroom farmers' green treatment behavior of mushroom residue. Agricultural socialized services can facilitate the adoption of sustainable agricultural technologies by smallholder farmers, thereby contributing to the transformation of traditional agriculture into sustainable agriculture. These results corroborate the findings of Huan, M. et al. (2022) and Zhou, Z. et al. (2023), which indicated that agricultural socialized services can promote the adoption of sustainable production technologies by smallholder farmers [16,37]. Based on the transaction cost theory, the mushroom-residue recycling link of agricultural socialized services boosts the economic income of mushroom farmers, while the transportation link cuts down cost expenditures, effectively motivating mushroom farmers to engage in the green treatment of mushroom residue. The targeted measures furnished by agricultural socialized services augment the utilization efficiency of resources, enhance cost-effectiveness and quality, and forge a closed-loop economic model, thereby propelling the development of green agriculture [24].

First, the mushroom-residue recycling stage is significant at the 1% statistical level, suggesting that this recycling stage significantly and positively impacts mushroom farmers' green treatment behavior of mushroom residue. From the perspective of edible mushroom cultivation in reality, mushroom farmers' behavioral decisions are predominantly driven by expected economic benefits. The economic compensation offered by the drying plant to mushroom farmers via the residue recycling link not only constitutes an additional income

stream, but also aligns with the economic expectations of mushroom farmers. This incentive mechanism effectively curtails their propensity to randomly dispose of discarded residue, and instead steers them towards the green treatment options provided by agricultural socialized service organizations like the drying plant, facilitating the green treatment of mushroom residue through participation.

Secondly, the mushroom-residue transportation link significantly and positively affects mushroom farmers' green treatment behavior of mushroom residue at the 1% statistical significance level. The possible explanations are as follows: mushroom farmers whose mushroom sheds are located in the neighboring areas of edible fungus socialized service organizations like drying factories can take advantage of the geographical proximity. They are able to access the mushroom-residue transportation service provided by these drying factories and enjoy the corresponding transportation convenience. This not only lowers the economic threshold for mushroom farmers to adopt green treatment technology but also, due to the close proximity of mushroom sheds to drying factories, leads to relatively low transportation costs. Consequently, mushroom farmers are more inclined to independently transport the mushroom residue to the drying plant for recycling treatment. This geographical closeness reduces transportation costs and boosts the enthusiasm of mushroom farmers to participate in the green treatment of mushroom residue, thus significantly promoting the green treatment behavior of mushroom residue. As a result, Hypothesis 2 (H2) holds true.

4.1.3. Estimated Results of Control Variables

In terms of individual characteristics, there is a positive correlation between the education level of mushroom farmers and their adoption of green treatment behavior of mushroom residue. The results indicate that the improvement in education level enriches the knowledge reserve of mushroom farmers and enhances their learning ability regarding new technology, as well as their cognitive level of environmental protection. In addition, more-educated mushroom farmers tend to have clearer planning and more forward-looking thinking about production and management activities. These factors combine to make mushroom farmers more likely to accept a variety of treatment methods during the post-production disposal of mushroom residue. There is also a significant positive relationship between the number of years mushroom farmers have been engaged in edible-mushroom cultivation and their adoption of green treatment behavior of mushroom residue. With the accumulation of cultivation experience, the mushroom farmers' cognitive level of environmental protection has been enhanced, and their long-term production practice has deepened their understanding of the environmental benefits of green treatment methods. As a result of the growth of experience and the deepening of cognition, mushroom farmers are prompted to be more inclined to choose environmentally friendly treatment methods when dealing with the disposal of mushroom residue, which significantly boosts their willingness to implement green treatment methods and behaviors.

In terms of operating characteristics, the diversity of edible-mushroom cultivars has a significant and positive impact on the green treatment behavior of their by-products—mushroom residue. Different varieties exhibit different conversion efficiencies of nutrient substrates during the growth process, and this variability is directly correlated with the chemical composition and structural characteristics of the waste-mushroom residue. For instance, the residue generated by shiitake varieties is suitable for conversion into organic fertilizer or for soil improvement, as it is rich in undecomposed cellulose and lignin. Meanwhile, the residue of enoki mushrooms is more appropriate for use as a raw material for animal feed, due to its high protein content. Consequently, for mushroom farmers capable of producing mushroom residue with high reuse value, they are more

inclined to adopt diversified green treatment methods to enhance the resource utilization of mushroom residue.

Table 2. Regression results of Ordered Probit model of government regulation on mushroom farmers' mushroom-residue green treatment behavior.

	Model 1	**Model 2**	**Model 3**
	Oprobit	**Oprobit**	**Oprobit**
RGR	0.934 ***		0.423 *
	(0.167)		(0.187)
GGR	0.468 **		0.347 *
	(0.159)		(0.170)
RRL		1.707 ***	1.541 ***
		(0.198)	(0.206)
RTL		0.375 ***	0.330 ***
		(0.088)	(0.090)
Age	0.003	0.005	0.003
	(0.008)	(0.009)	(0.009)
Gender	−0.011	0.073	0.056
	(0.155)	(0.163)	(0.164)
Educational Level	0.394 ***	0.292 **	0.264 **
	(0.092)	(0.098)	(0.099)
Planting Year	0.016 *	0.011	0.013
	(0.007)	(0.007)	(0.007)
Political Identity	−0.377	−0.153	−0.300
	(0.250)	(0.264)	(0.270)
Joining Cooperatives	−0.347	−0.431	−0.515
	(0.268)	(0.279)	(0.282)
Plant Variety	0.249 ***	0.154 *	0.169 **
	(0.060)	(0.063)	(0.064)
Number of Mushroom Sheds	−0.020	−0.082	−0.072
	(0.063)	(0.066)	(0.067)
Planting Scale	0.073	0.034	0.056
	(0.061)	(0.063)	(0.064)
N	284	284	284
LR chi	103.56	179.74	191.32
Prob > chi^2	0.000	0.000	0.000
pseudo R^2	0.170	0.294	0.313

Note: "*", "**", and "***" denote 10%, 5%, and 1% significance levels, respectively; numbers in parentheses are robust standard errors.

4.2. Marginal Effects of the Impact of Government Regulation and Agricultural Socialized Services on Mushroom Farmers' Green Treatment Behavior of Mushroom Residue

Table 3 presents the marginal-effect estimation results of the significant impacts of government regulation and agricultural socialized services on the probability of mushroom farmers' green treatment behavior of mushroom residue. The intensification of government regulation and the augmentation of agricultural socialized services both exerted a diminishing effect on the probability that mushroom farmers would not adopt any green treatment measures; that is, they decreased the likelihood of mushroom farmers persisting in a low level of green treatment behavior. Conversely, these factors had a positive promotional effect on the probability of mushroom farmers adopting two or more green treatment methods, which could enhance the probability of mushroom farmers engaging in high-level green treatment behavior of mushroom residue. As can be seen from Table 3, most of the marginal-effect coefficients of the independent variables were statistically significant at Y = 1, Y = 3, and Y = 4. Therefore, this study mainly analyzed the

marginal effects of each variable at Y = 1, Y = 3, and Y = 4, i.e., when the mushroom farmers did not adopt, adopted two, and adopted three mushroom-residue green treatment measures, respectively.

Government regulation exerts a positive influence on mushroom farmers' green treatment behavior of mushroom residue. In terms of restrictive government regulation, compared with mushroom farmers not under restrictive government regulation, the probability of those subject to it not adopting any green treatment measures for mushroom residue decreases by 7.1%. Meanwhile, their tendency to choose two or more green treatment measures for mushroom residue presents a positive probability, with the probabilities of choosing two and three treatment measures increasing by 4.8% and 2.6%, respectively. Regarding guided government regulation, in contrast to mushroom farmers not subject to guided government regulation, the probability of mushroom farmers under its influence not adopting any green treatment measures for mushroom residue decreases by 5.8%. However, although the probability of adopting two or more green treatment methods is positive, it fails to reach the level of significance. This may be attributed to the fact that guided government regulation mainly relies on education and publicity, aiming to enhance mushroom farmers' awareness of adopting green treatment behavior for mushroom residue. Yet such guided regulation cannot immediately generate economic benefits for mushroom farmers, causing them to have not truly transformed their traditional thinking about mushroom-residue treatment. As a result, under the influence of guided regulation, mushroom farmers' enthusiasm and initiative in adopting green treatment behavior for mushroom residue remain relatively low. The government adopts administrative punishment and other regulatory means of constraint, aiming to increase the cost for mushroom farmers regarding their unreasonable treatment of mushroom residue. Through the effect of economic leverage, it can effectively restrain the negative externality impact caused by such behavior. As the cost of irrational residue disposal goes up, mushroom farmers face stronger economic incentives to re-evaluate and adjust their behavioral patterns, thus shifting to greener and more-sustainable methods of residue disposal. In addition, the government strengthens guidance by means of technical training, publicity, and education, so as to prompt farmers to take the initiative to adopt green treatment measures during the agricultural production process. This indicates that government regulation can both constrain and guide the behavior of mushroom farmers, which consequently promotes the choice of sustainable solutions for mushroom-residue treatment.

Agricultural Socialization. The mushroom-residue services provided by agricultural socialized service organizations are the most reliable and convenient means for mushroom farmers to achieve the green treatment of mushroom residue. The probability of mushroom farmers conducting the green treatment of mushroom residue can be effectively enhanced by their participation in the mushroom-residue-related service links. Compared with mushroom farmers who did not participate in the residue-recycling link, the probability of those who participated in the recycling link not adopting the green treatment measures for mushroom residue decreases by 25.9%. Moreover, the probability of choosing two or more green treatment measures presents a positive probability. Among these, the probability of adopting two green treatment measures witnesses the largest increase, rising by 17.5%, and the probability of adopting three measures increases by 9.6%. For each level of convenience in the mushroom-residue transportation link, the probability of mushroom farmers not adopting any green treatment measures for mushroom residue decreased by 5.5%, and the probability of choosing two or more green treatment measures was positive. Specifically, the probabilities of adopting two and three treatment measures increased by 3.7% and 2.1%, respectively. This indicates that the convenience of participating in the residue-recycling link and the residue-transportation link effectively motivates mushroom farmers to engage

in the green treatment of residue through the incentives of economic gain and the reduction of transportation cost. Therefore, participation in the residue-recycling link and a higher level of convenience in the residue-transportation link would enhance mushroom farmers' green-residue treatment behavior.

Table 3. Marginal effects of mushroom farmers' mushroom-residue green treatment behavior.

Mushroom Farmer's Residue Green Treatment Behavior	P (Y = 1)	P (Y = 2)	P (Y = 3)	P (Y = 4)	P (Y = 5)
RGR	−0.071 *	−0.006	0.048 *	0.026 *	0.003
	(0.032)	(0.010)	(0.022)	(0.012)	(0.003)
GGR	−0.058 *	−0.005	0.039	0.022	0.002
	(0.029)	(0.008)	(0.020)	(0.011)	(0.002)
RRL	−0.259 ***	−0.023	0.175 ***	0.096 ***	0.011
	(0.049)	(0.033)	(0.022)	(0.022)	(0.009)
RTL	−0.055 ***	−0.005	0.037 **	0.021 ***	0.002
	(0.016)	(0.008)	(0.012)	(0.006)	(0.002)
Age	−0.001	−0.000	0.000	0.000	0.000
	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Gender	−0.010	−0.001	0.006	0.004	0.000
	(0.027)	(0.003)	(0.019)	(0.010)	(0.001)
Educational Level	−0.044 **	−0.004	0.030 *	0.016 *	0.002
	(0.017)	(0.006)	(0.012)	(0.007)	(0.002)
Planting Year	−0.002	−0.000	0.001	0.001	0.000
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
Political Identity	0.051	0.004	−0.034	−0.019	−0.002
	(0.046)	(0.008)	(0.031)	(0.017)	(0.003)
Joining Cooperatives	0.087	0.008	−0.058	−0.032	−0.004
	(0.047)	(0.012)	(0.033)	(0.018)	(0.004)
Plant Variety	−0.028 ***	−0.003	0.019 *	0.011 *	0.001
	(0.011)	(0.004)	(0.008)	(0.004)	(0.001)
Number of Mushroom Sheds	0.012	0.001	−0.008	−0.005	−0.001
	(0.011)	(0.002)	(0.008)	(0.004)	(0.000)
Planting Scale	−0.009	−0.001	0.006	0.004	0.000
	(0.011)	(0.002)	(0.007)	(0.004)	(0.001)

Note: "*", "**", "***" denote 10%, 5%, and 1% significance levels, respectively, and the numbers in parentheses are standard errors.

4.3. Impact Analysis of the Interaction Between Government Regulation and Agricultural Socialized Services on Mushroom Farmers' Green Treatment Behavior of Mushroom Residue

According to the extant academic research findings, only a few scholars have delved into the impact of government regulation and agricultural socialized services on farmers' behavior. Huang, Q. et al.'s study discovered that government regulation spurs farmers' green production behavior by influencing the market structure, and disclosed the mediating role of the market structure in the process of government regulation on farmers' green production behavior [8]. In addition, Zhiping, Z.'s study also examined the issue from the perspective of environmental regulation and green credit. The study indicates that government environmental regulation and the implementation of the green credit policy by banks effectively encourage farmers to adopt green production technology in agriculture [38]. From a new perspective, this study selects government regulation and agricultural socialized services as key variables to explore the path of the complementary relationship between them regarding mushroom farmers' green treatment behavior of mushroom residue, and reveals the synergistic relationship. As shown in Table 4, the interaction terms of government regulation and agricultural socialized services in relation

to mushroom farmers' green treatment behavior of mushroom residue are substituted into Equation (2). Subsequently, the interaction indicators of the two indicators of government regulation and the two indicators of agricultural socialized services are introduced respectively, to derive Model 5–8. It can be observed that the interaction terms of constrained regulation and residue recycling have a positive impact on mushroom farmers' green treatment behavior of mushroom residue, and are significant at the 10% statistical level. This indicates that there is a complementary relationship between constrained regulation and the mushroom-residue recycling link. From the perspective of restrictive government regulation, it provides mushroom farmers with mandatory incentives to adopt green treatment methods, by implementing unscheduled patrols and stipulating potential legal consequences. The existence of such restrictive regulation heightens mushroom farmers' awareness of their environmental responsibilities, and may prompt them to seek compliant mushroom-residue treatment methods. From the mushroom-residue recycling aspect, effective recycling services not only alleviate the burden on mushroom farmers in disposing of waste, but also diminish the illegal costs associated with random disposal of mushroom residue. Moreover, by offering financial incentives or convenient recycling channels, they generate additional income, thereby augmenting the motivation of mushroom farmers to engage in green treatment. When these two factors interact, mushroom farmers are more inclined to adopt green treatment of mushroom residue to fulfill regulatory requirements and reap practical benefits from recycling services.

The interaction term between restrictive regulation and mushroom-residue transportation has a positive impact on mushroom farmers' green treatment behavior of mushroom residue, and is significant at the 5% statistical level, signifying that there is a complementary relationship between the two. From the perspective of constrained regulation, the existence of mandatory regulations exerts external pressure on mushroom farmers to abide by environmental norms. This prompts them to adopt a more responsible stance in handling mushroom residue and heightens their willingness to adopt green treatment methods to evade potential legal risks and economic penalties. Simultaneously, the optimization of the mushroom-residue transportation link offers mushroom farmers practical conveniences and mitigates the transaction costs and transportation barriers associated with green treatment. Efficient transportation services alleviate mushroom farmers' direct economic burden in disposing of mushroom residue. Moreover, by providing convenient recycling channels, they augment mushroom farmers' incentives to engage in the green treatment of mushroom residue. The complementary relationship between binding regulation and the mushroom-residue transportation link underlines the significance of integrating policy instruments and market mechanisms. Regulation serves as the initial catalyst for behavioral change, while the enhancement of the transportation link furnishes mushroom farmers with practical means to actualize the green treatment of mushroom residue.

The interaction term between guided regulation and residue recycling has a positive impact on mushroom farmers' green-residue treatment behavior, and is significant at the 5% statistical level, signifying that there is a complementary relationship between the two. The guided regulation and the residue-recycling link offered by agricultural socialized service organizations reinforce one another, and jointly promote mushroom farmers' green-residue-treatment behavior. The guided regulation imparts information, education, and technical guidance to mushroom farmers through rural propaganda and technical training. It kindles the interest of mushroom farmers in the green treatment of mushroom residue, fortifies their fundamental understanding of such treatment, and spurs them to adopt green treatment measures voluntarily. Simultaneously, the mushroom-residue recycling link provided by agricultural socialized service organizations furnishes mushroom farmers with the practical pathway for green treatment of mushroom residue. The effective organization

and economic incentive mechanism of the recycling-service link augment the motivation of mushroom farmers to conduct green treatment of mushroom residue.

The interaction term between guided regulation and pomace transportation has a positive impact on mushroom farmers' pomace green-treatment behavior, and is significant at the 1% statistical level, signifying that there is a complementary relationship between guided regulation and pomace transportation. The significant positive interaction terms suggest that in the production process, relying solely on either guided regulation or agricultural socialized services might not suffice to achieve the expected outcomes, and the combination of the two proves more effective than either approach alone in promoting mushroom farmers' green-residue treatment behavior. Guided regulation kindles mushroom farmers' intrinsic motivation and prompts their self-driven compliance with green pomace treatment methods by imparting information, education, and technical guidance. Meanwhile, the accessibility and convenience of mushroom-residue transportation afford mushroom farmers practical conveniences, reducing the transportation and time costs of green treatment, and thus enhancing the feasibility of green treatment behavior.

Table 4. Analysis of the interaction effect of government regulation and agricultural socialization services on the green treatment behavior of mushroom residues.

	Model 4	**Model 5**	**Model 6**	**Model 7**	**Model 8**
	Oprobit	**Oprobit**	**Oprobit**	**Oprobit**	**Oprobit**
RGR	0.4231 **	0.2931	0.3483 *	0.4785 **	0.4857 **
	(0.1869)	(0.1992)	(0.1890)	(0.1894)	(0.1897)
GGR	0.3471 **	0.3962 **	0.4216 **	0.2676	0.2560
	(0.1703)	(0.1727)	(0.1733)	(0.1737)	(0.1736)
RRL	1.5412 ***	1.5081 ***	1.5759 ***	1.5074 ***	1.5762 ***
	(0.2065)	(0.2078)	(0.2083)	(0.2080)	(0.2097)
RTL	0.3298 ***	0.3188 ***	0.2362 **	0.3342 ***	0.2653 ***
	(0.0895)	(0.0901)	(0.0954)	(0.0905)	(0.0924)
RGR × RRL		0.6756 *			
		(0.3661)			
RGR × RTL			0.5301 ***		
			(0.1732)		
GGR × RRL				0.8528 **	
				(0.3329)	
GGR × RTL					0.6149 ***
					(0.1689)
Control Variable	Controlled	Controlled	Controlled	Controlled	Controlled
Sample Size	284	284	284	284	284
LR chi	191.32	194.74	200.87	197.98	204.96
Prob > chi^2	0.000	0.000	0.000	0.000	0.000
Pseudo R^2	0.313	0.319	0.329	0.324	0.336

Note: "*", "**", and "***" denote 10%, 5%, and 1% significance levels, respectively; numbers in parentheses are robust standard errors.

In summary, the synergy and complementary advantages between government regulation and agricultural socialized services effectively facilitate the green treatment behavior of mushroom farmers regarding mushroom residue. Government regulation furnishes a favorable institutional environment and legal safeguards for agricultural socialized services. By devising explicit policy guidance and regulatory mechanisms, the government can steer agricultural socialized services towards a more standardized and professional trajectory. Simultaneously, agricultural socialized services can also offer robust support to government regulation. They assist farmers in better comprehending and adhering to government regulations by providing technical guidance, market information, and other

services. Moreover, government regulation and agricultural socialized services possess unique strengths in their respective arenas. Government regulation is mandatory and normative at the macro level, guaranteeing the overall direction and stability of agricultural development. In contrast, agricultural socialized services are flexible and innovative at the micro level, tailoring personalized services to meet the specific requirements of mushroom farmers. Consequently, Hypothesis 3 (H3) holds true.

4.4. Robustness Tests

In order to verify the rationality of the above model settings as well as the selection of estimation methods, and to further examine the robustness of the mechanism of action, this study employs the approach of replacing econometric models. Specifically, the OLS model is utilized to re-perform regression analysis on the effects of government regulation and agricultural socialized services on the green treatment behavior of mushroom farmers' mushroom residue, thereby enhancing the persuasiveness of the regression. The regression results are presented in Table 5. Four indicators of government regulation and agricultural socialized services are incorporated simultaneously into the regression, to yield Model 9. Subsequently, the interaction terms of two indicators of government regulation and two indicators of agricultural socialized services are included in the regression, to obtain Models 10–13. Observation of Models 9–10 indicates that both constraining and guided government regulations have a significant positive impact on mushroom farmers' green treatment behaviors of mushroom residue at a 5% statistical significance level. Additionally, agricultural socialized services also have a significant impact.

Table 5. Estimates of the replacement econometric model.

	Model 9	**Model 10**	**Model 11**	**Model 12**	**Model 13**
	OLS	**OLS**	**OLS**	**OLS**	**OLS**
RGR	0.1716 **	0.1153	0.1386 *	0.1984 **	0.1900 **
	(0.0800)	(0.0829)	(0.0788)	(0.0791)	(0.0781)
GGR	0.1581 **	0.1837 **	0.1841 **	0.1312 *	0.1229 *
	(0.0726)	(0.0728)	(0.0714)	(0.0719)	(0.0713)
RRL	0.6988 ***	0.6702 ***	0.6922 ***	0.6675 ***	0.6826 ***
	(0.0812)	(0.0814)	(0.0795)	(0.0804)	(0.0792)
RTL	0.1580 ***	0.1481 ***	0.1090 ***	0.1508 ***	0.1255 ***
	(0.0380)	(0.0379)	(0.0396)	(0.0374)	(0.0379)
RGR × RRL		0.3651 **			
		(0.1542)			
RGR × RTL			0.2552 ***		
			(0.0705)		
GGR × RRL				0.4403 ***	
				(0.1367)	
GGR × RTL					0.2710 ***
					(0.0690)
Constant Term	1.6082 ***	1.5665 ***	1.6558 ***	1.6392 ***	1.5500 ***
(math.)	(0.2866)	(0.2847)	(0.2807)	(0.2819)	(0.2796)
Control Variable	Controlled	Controlled	Controlled	Controlled	Controlled
N	284	284	284	284	284
adj. R^2	0.5010	0.5094	0.5224	0.5177	0.5263

Note: "*", "**", and "***" denote 10%, 5%, and 1% significance levels, respectively; numbers in parentheses are robust standard errors.

4.5. Heterogeneity Test

In this study, the comparative research method enables a clear comparison of the effects of relevant policies and services among different groups of mushroom farmers. It can also better evaluate the effectiveness and applicability of these policies and services. This will assist relevant governmental departments in formulating more precise policies targeted at specific groups of mushroom farmers, help relevant agricultural service organizations to develop and provide technologies and services that are more attuned to the needs of the mushroom farmers, and enable the farmers to adjust their own production behaviors based on the comparison results, so as to enhance economic benefits. Specifically, the mushroom farmers can modify their production behavior in accordance with the comparison results, to improve economic efficiency. In the context of the current rapid development of urbanization and industrialization, China's rural society is witnessing significant changes in its social and economic structure at this stage. Meanwhile, farmers' groups have become highly heterogeneous and differentiated. Against this backdrop, this study views mushroom farmers as a heterogeneous group, and adopts a comparative approach to examine whether there are differences in the green treatment behaviors of mushroom residue among mushroom farmers with distinct individual characteristics and family business characteristics under the influence of government regulation and agricultural socialized services. Moreover, the impacts of government regulation and agricultural socialized services on mushroom farmers' green treatment behavior of mushroom residue are explored from the perspectives of their individual characteristics and family business characteristics.

4.5.1. Analysis of Heterogeneity Based on the Education Level of Mushroom Farmers

Educational level is an important factor influencing farmers' cognitive ability to learn. Farmers with a high educational level are more aware of sustainable development than those with a low educational level [39]. In this study, mushroom farmers with an elementary school education or below were categorized into the low-education group of mushroom farmers, while those with a junior high school education or above were classified into the high-education group. Subsequently, the four indicators of government regulation and agricultural socialized services were incorporated into Formula (1) for regression, and Model 14 and Model 15 were obtained, respectively. The regression results presented in Table 6 indicate that the group of mushroom farmers with a higher education level possesses a greater cognitive ability to learn. In the context of guided regulation, as well as mushroom residue recycling and transportation, they exhibit more significant effects in promoting the green treatment behavior of mushroom residue. This phenomenon can likely be ascribed to the fact that mushroom farmers with a high education level have a deeper comprehension and awareness of environmental policies, laws, and regulations. Consequently, they are more inclined to respond positively to the guided regulation, which is based on incentives and education, and spontaneously adopt environmentally friendly mushroom-residue treatment measures. However, the group of less-educated mushroom farmers demonstrated more significant green treatment behaviors under constrained regulation. This might reflect their relatively low awareness and acceptance of the guided regulation. In addition, the low-education mushroom farmers may have relied more on the coercive aspects of regulation to trigger their behavioral change, implying that they could be more sensitive to the direct economic and reputational incentives or penalties associated with constraint-based regulation.

Table 6. Differences in the effects of government regulation and agricultural socialization services on the green treatment behavior of mushroom farmers with mushroom residue at different levels of education.

	Model 14	**Model 15**
	Low-Education-Level Group (≤Elementary School)	**Higher-Education-Level Group (>Primary)**
RGR	0.843 *	0.155
	(0.353)	(0.235)
GGR	0.366	0.462 *
	(0.289)	(0.232)
RRL	1.479 ***	1.560 ***
	(0.356)	(0.274)
RTL	0.088	0.510 ***
	(0.143)	(0.126)
Age	−0.005	0.005
	(0.013)	(0.013)
Gender	0.305	−0.004
	(0.246)	(0.251)
Educational Level	−0.325	0.824 ***
	(0.335)	(0.225)
Planting Year	0.006	0.031 **
	(0.011)	(0.012)
Political Identity	−0.943	−0.279
	(0.524)	(0.345)
Joining Cooperatives	−1.045	−0.620
	(0.918)	(0.318)
Plant Variety	0.192	0.196 *
	(0.103)	(0.089)
Number of Mushroom Sheds	0.077	−0.173
	(0.106)	(0.094)
Planting Scale	−0.076	0.160
	(0.097)	(0.093)
N	133	151
pseudo R^2	0.289	0.385

Note: "*", "**", and "***" denote 10%, 5%, and 1% significance levels, respectively; numbers in parentheses are robust standard errors.

4.5.2. Heterogeneity Analysis Based on Mushroom Farmers' Cultivation Scale

Mushroom farmers with different cultivation scales will respond differently to government regulation and agricultural socialized services. In this study, mushroom farmers are categorized into two sample groups: the small- and medium-scale group (with a cultivation scale less than or equal to 10,000 rods) and the large-scale group (with a cultivation scale greater than 10,000 rods). Subsequently, the four indicators of government regulation and agricultural socialized services are incorporated into Equation (1) to obtain Models 16 and 17, respectively. Table 7 presents the results. It shows that constrained government regulation has a significant and positive impact on the green treatment behavior of mushroom residue by mushroom farmers in the small- and medium-scale group at the 10% statistical level. However, it has no significant effect on the large-scale group. A possible explanation is that, compared with the large-scale group, mushroom farmers in the small- and medium-scale group may produce less mushroom residue, due to their relatively small scale of production. This might lead to a lack of sufficient attention and standardization in their mushroom residue treatment. Small- and medium-scale mushroom farmers may also face more acute resource and space constraints, making them more sensitive to cost–benefit considerations when handling mushroom residue. Binding regulations can provide the necessary external pressure and incentives for them to recognize the importance of regulating the handling of mushroom residue, thus helping them avoid potential environmental risks

and possible legal consequences. Consequently, binding regulation has a greater marginal impact on small- and medium-scale mushroom farmers, prompting them to adopt more standardized green treatment measures. The guided regulation has a significant positive influence on the green treatment behavior of mushroom residue by the large-scale group of mushroom farmers at the 5% statistical level, while it has no significant effect on the small- and medium-scale group of mushroom farmers. A possible explanation is that, due to their large production scale, the large-scale group of mushroom farmers generates a relatively large amount of mushroom residue. This results in a more urgent need for the effective management and resource utilization of these by-products, thus motivating them to place greater emphasis on maximizing the expected benefits during the decision-making process. On the other hand, the guided regulation enhanced the knowledge and application of green treatment methods among mushroom farmers through the provision of relevant knowledge and skills. This enhancement in knowledge and skills enabled the large-scale group of mushroom farmers to more effectively identify and adopt green treatment methods that could augment the residual value of mushroom residue. In contrast, mushroom farmers in the small- and medium-scale groups might have smaller production scales and produce less mushroom residue, leading to differences in their expected benefits and resource allocation considerations compared to the large-scale group.

Table 7. Differences in the effects of government regulation and agricultural socialization services on the green treatment behavior of mushroom sludge by mushroom farmers of different cultivation scales.

	Model 16	**Model 17**
	Small and Medium-Sized Group (≤10,000 Rods)	**Large-Scale Group (>10,000 Rods)**
RGR	0.627 *	0.536
	(0.275)	(0.307)
GGR	0.104	0.809 **
	(0.230)	(0.310)
RRL	0.992 ***	2.352 ***
	(0.284)	(0.429)
RTL	0.391 **	0.408 **
	(0.133)	(0.143)
Age	−0.012	0.011
	(0.013)	(0.015)
Gender	−0.060	0.229
	(0.232)	(0.271)
Educational Level	0.141	0.431 **
	(0.144)	(0.157)
Planting Year	0.016	0.017
	(0.010)	(0.014)
Political Identity	−0.537	−0.251
	(0.450)	(0.372)
Joining Cooperatives	−0.443	−1.203 **
	(0.430)	(0.446)
Plant Variety	0.030	0.407 ***
	(0.091)	(0.118)
Number of Mushroom Sheds	−0.038	−0.143
	(0.120)	(0.092)
	−0.077	−0.332 *
Planting Scale	(0.221)	(0.144)
N	145	139
pseudo R^2	0.237	0.500

Note: "*", "**", and "***" denote 10%, 5%, and 1% significance levels, respectively; numbers in parentheses are robust standard errors.

5. Discussion and Conclusions

5.1. Discussion

The adoption of sustainable agricultural production practices by individual agricultural producers is influenced by a diverse array of factors [40]. Existing research has explored farmers' green-oriented behavior towards agricultural waste from multiple dimensions and perspectives, including institutional elements [41], psycho–social factors [42], individual perceived value [3], as well as agricultural training and demonstration [43]. Additionally, certain scholars have conducted in-depth investigations and analyses of the factors that impact farmers' treatment of agricultural waste [44]. In the context of current research, the incentive mechanisms implemented by the government, such as lenient policies tailored for farmers, have the potential to stimulate farmers' engagement in green production activities. This study comprehensively integrates the implementation of practical policies and refines the sub-dimensions of government regulation into constraint-based and guidance-oriented aspects. By drawing upon the externality theory and the theory of farmers' behavior, it delves into the exploration of the paths of government negative reinforcement, as well as educational and guiding measures for promoting the green behavior of mushroom farmers. The study's findings demonstrate that government regulation exerts a significantly positive influence on mushroom farmers' green treatment of mushroom residue. These results are congruent with previous research on livestock manure management, straw utilization, and the promotion of low-carbon agricultural technologies. For example, Qian et al. propose that by enhancing the the dissemination and publicity of livestock-manure resource utilization, the government can effectively raise farmers' awareness of relevant policies, thereby prompting their active and enthusiastic participation in waste recycling [45]. Moreover, government-sponsored education and training programs serve as an efficacious policy instrument for bridging the knowledge gap and facilitating farmers' adoption of sustainable agricultural production practices [46,47]. Centner, T.J. et al. assert that mandatory disincentive measures can effectively discourage farmers from engaging in activities that cause diffuse pollution. This approach can thus address the problem of diffuse pollution stemming from manure application by small-scale livestock producers, and contribute to the promotion of sustainable agricultural production among farmers [48]. Hou et al. find that through the demonstration of low-carbon agriculture, extensive agricultural training, and on-site guidance provided by agricultural technicians, the government can encourage farmers to embrace sustainable agricultural production [49]. Chen et al. and Liu et al. also uncover the fact that government regulation plays a crucial role in promoting farmers' adoption of green agricultural practices. Through the demonstration of low-carbon agricultural models, the popularization of agricultural training, and on-farm guidance by agricultural technicians, they reveal the mechanisms by which exogenous factors, such as government regulation, influence farmers' adoption of straw-returning practices from the perspectives of policy incentives and administrative interventions [11,20]. This indicates that the role of government regulation in promoting the treatment of various crop wastes is similar to its role in mushroom farmers' green treatment of mushroom residue. Policy intervention, guidance, and other means can effectively stimulate the motivation of all relevant stakeholders. This is consistent with the mechanism of government regulation observed in this study regarding mushroom farmers' treatment of mushroom residue.

Against the backdrop of government regulation, this study amalgamates the real-world social circumstances of the edible-mushroom industry and incorporates agricultural social services that are tasked with the recycling and transportation of agricultural waste. The high-quality and comprehensive service projects provided by these services effectively promote the implementation of mushroom farmers' green treatment of mushroom residue.

Wang et al. contend that the incentive mechanism of market-based instruments lies in the preponderance of benefits over costs, which, in turn, stimulates farmers' propensity to utilize such instruments [50]. The interest-based relationship forged between social service organizations and the principal entities in edible-mushroom production creates income-generating avenues for mushroom farmers, thereby enabling them to more proactively embrace the green treatment of mushroom residue. Agricultural social service organizations constitute a pivotal force in advancing sustainable agricultural development. They not only contribute to the green-oriented treatment of agricultural waste, but also tackle the root causes underlying agricultural green development. Within the extant research in the fruit and vegetable domain, Cooper, G. S. et al. have demonstrated that producers' engagement in market-based service organizations can facilitate the dissemination of green-production practices and resources. Consequently, the knowledge base of participants regarding green production is augmented, and the adoption of appropriate safety-related practices is propelled [51]. In the realm of research on reducing pesticide and chemical-fertilizer application, Chen et al. and Begum, I. A. et al. have revealed that the cost-efficiency and specialization-related advantages of market-based social services can optimize the allocation of agricultural production factors. This effectively curtails the uneven and inappropriate manual application of fertilizers, thereby minimizing soil pollution by pesticides and chemical fertilizers [52,53]. In the sphere of coffee cultivation, Bro et al.'s research has indicated that producers affiliated with agricultural social-service organizations can gain access to a diverse range of services [54]. This empowers producers to evaluate costs and benefits, thereby facilitating and strengthening the sustainable-production behaviors of coffee producers. This suggests that agricultural social services can facilitate the implementation of green-production practices, commencing from the inception of agricultural production and extending to subsequent processing stages, in the course of promoting sustainable agricultural development. Agricultural social services can mitigate environmental pollution and resource wastage at the source during the cultivation of a broad spectrum of crops by furnishing environmentally friendly planting guidance, precision-fertilizer application, and other technologies. In the post-production phase, these services curtail post-production losses and enhance resource-utilization efficiency through processing and other measures, thereby effectuating the green transformation of the entire agricultural industry chain.

Meanwhile, this study conducts an in-depth exploration of the synergistic effects between government regulation and agricultural socialized services, and discovers that there is a complementary relationship between them. The study results indicate that the aforementioned effects and complementary relationships hold true. This also implies that a single policy instrument is scarcely capable of comprehensively resolving environmental problems; instead, multifaceted and comprehensive measures are required [55,56]. It implies that when formulating agricultural environmental protection policies, the government and relevant departments ought to take into account fully the role of socialized services and promote the establishment and enhancement of agricultural socialized service systems via policy guidance and support. Meanwhile, agricultural socialized service institutions should also actively answer the government's call and offer more professional and comprehensive services to assist mushroom farmers in realizing the green treatment of mushroom residue. The benign interaction between the government and social sectors will contribute to creating a favorable atmosphere for the entire society to engage in agricultural environmental protection and propel the sustainable development of agriculture [57,58]. In addition, owing to the differences in the education levels and production scales of mushroom farmers, government regulation and agricultural socialized services exert varying effects in promoting the green treatment of mushroom residue by mushroom farmers. It

can be concluded that the synergistic relationship between government regulation and agricultural socialized services not only offers policy formulation ideas during the development of the edible-mushroom industry, but also serves as a reference for policy formulation and the improvement of social service systems in fields such as forestry and the flower industry. Moreover, when promoting green development, emphasis should be placed on the potential complementary and synergistic effects among different policy measures, scientific research departments, enterprises, and other entities.

Taking individual edible-mushroom production as the research object, this study delves into the influence of government regulation and agricultural socialized services on mushroom farmers' behavior. It enriches the theoretical application of the externality theory and the farmers' behavior theory in the domain of agricultural production, and provides a certain theoretical foundation for promoting the development of sustainable agriculture in the future. From the perspective of the externality theory, this study investigates how the synergy between government regulation and agricultural socialized services effectively internalizes the positive externalities of green behaviors during the process in which mushroom farmers adopt green treatment measures for mushroom residue. The interaction between government regulation and the market service offered by agricultural socialized services bolsters mushroom farmers' understanding and application of green treatment measures for mushroom residue and promotes their green treatment behavior, thereby internalizing the positive environmental protection externality generated by the green treatment behavior of mushroom residue. From the perspective of the farmers' behavior theory, the traditional theory posits that farmers generally tend to consider economic interests when making production decisions. However, based on the original theory, this study discovers that the behavioral motives of mushroom farmers during agricultural production are influenced by a multiplicity of factors. Moreover, the behavioral decision-making of mushroom farmers is also readily susceptible to the impact of government policies. This finding extends the explanatory scope of the farmers' behavior theory, to a certain extent. Therefore, this study furnishes a novel perspective and an explanatory framework for the farmers' behavior theory, which facilitates a more comprehensive understanding of the logic underlying farmers' behavior and decision-making processes in modern agricultural development.

5.2. Conclusions of the Study

This study elaborates on the mechanism through which government regulation and agricultural socialized services influence mushroom farmers' green treatment behavior of mushroom residue. Based on 284 questionnaires collected from the field research on mushroom farmers in Gutian County, Ningde City, Fujian Province, we constructed measurement indexes for government regulation, agricultural socialized services, and mushroom farmers' green treatment behavior of mushroom residue. Subsequently, we empirically analyzed the influence of government regulation and agricultural socialized services on mushroom farmers' green treatment behavior by employing the Ordered Probit Measurement Analysis method. Additionally, the interaction term of government regulation and agricultural socialized services was incorporated into the model to explore the potential complementary effects between them. By using the Ordered Probit econometric analysis method, we carried out an empirical analysis of the impacts of government regulation and agricultural socialized services on mushroom farmers' green treatment behavior of mushroom residue, and added the interaction term of government regulation and agricultural socialized services to the model to probe into the potential complementary effect between the two. Based on the results of the empirical analysis of this study, we mainly drew the following conclusions:

Firstly, both government regulation and agricultural socialized services are crucial factors contributing to mushroom farmers' green treatment of mushroom residue. The implementation of government regulation and the provision of agricultural socialized services can effectively enhance mushroom farmers' willingness and prompt their behavior in conducting the green treatment of mushroom residue. Given the negative externality of mushroom farmers' mushroom-residue treatment behavior, which is characteristic of the "rational economic man", it is essential to regulate their behavior through the constraining and guiding functions of government regulations. This is to steer mushroom farmers towards adopting the green treatment of mushroom residue, thereby realizing the internalization of negative externality effects. The provision of relevant agricultural socialized services can effectively compensate for the costs incurred by mushroom farmers during the green treatment process and offer a practical pathway for them to carry out such treatment. In this way, the internalization of the positive externality effect of mushroom farmers' green treatment behavior can be achieved.

Secondly, there exists a certain complementary effect between government regulation and agricultural socialized services. The interaction between the two effectively promotes the green treatment behavior of mushroom farmers regarding mushroom residue. The coordination of government and socialized service measures constructs an integrated management framework for mushroom-residue resource utilization and environmental sustainability. Government regulations offer norms and directions for mushroom farmers to adopt green behaviors, while agricultural socialized services provide specific means and support to achieve the green treatment of mushroom residue. In terms of both normative behaviors and problem-solving, these complementary measures effectively ensure the feasibility of the green treatment of mushroom residue in reality.

Thirdly, the differentiation of mushroom farmers in terms of education level and production scale exerts a significant impact on their green treatment behavior of mushroom residue. The differentiation among mushroom farmers, stemming from individual characteristics and production characteristics, leads to diverse green treatment behaviors of mushroom residue. It was discovered that there were discrepancies in the green treatment behavior of mushroom residue among mushroom farmers with varying education levels and production scales. Moreover, the influence of government regulation and the level of agricultural socialized services tended to intensify as the education level and production scale increased

6. Suggested Responses, Research Limitations and Future Prospects

6.1. Recommendations for Countermeasures

Based on the empirical analysis of the influential relationship among government regulation, agricultural socialized services and mushroom farmers' green treatment behavior of mushroom residue, the following policy recommendations are put forward, in light of the study findings:

Firstly, improve relevant policies and institutional mechanisms and actively enable the government to play its role in macro-control. The improvement of environmental policies is of great significance in agricultural waste management. Legislation should be adopted to clarify the standards and procedures for agricultural waste disposal and to strengthen law enforcement, to ensure strict implementation of policy provisions. Improve the supervision and management mechanism within the policy framework. By establishing a stricter supervision system, it can be ensured that the waste generated during agricultural production is handled reasonably and in compliance with regulations, thus reducing the negative impact on the environment. Increase the penalties for farmers who dispose of agricultural waste randomly, including financial fines, revocation of compliance certifica-

tions, and restrictions on market access. The increased cost of penalties can significantly raise the risk of non-compliance for farmers, prompting them to adopt a more cautious and responsible attitude when handling agricultural waste. At the same time, improve the technical guidance and other support mechanisms of agricultural technology extension departments. Strengthen the innovation and promotion of agricultural waste treatment technologies to assist farmers in adopting more environmentally friendly waste treatment methods, enhance farmers' acceptance and utilization of green treatment technologies, and reduce their non-compliance caused by technological constraints. Consideration should also be given to introducing incentive mechanisms. For example, rewarding farmers who adopt sustainable waste-management practices can stimulate farmers' intrinsic motivation and promote their active participation in environmental protection actions. Government departments should encourage, support, and guide agricultural socialized service organizations to implement the advanced concepts of green production and green services, integrate the requirements of environmental protection throughout the entire service process, and reinforce their role in publicizing and promoting green technologies.

Secondly, the agricultural socialized service system should be improved to fully unleash the environmental benefits of agricultural socialized services. By modernizing the infrastructure for collection, transportation, treatment, and resource utilization, technological innovation and system optimization in agricultural waste treatment can be achieved, enhancing the efficiency and effectiveness of agricultural waste treatment and ensuring the timely and effective management of waste. Moreover, the agricultural socialized service system should be continuously refined and perfected. Through resource integration, process optimization, and service quality improvement, a service system covering the entire process of agricultural production can be constructed to meet the diversified service needs of farmers, resolving the dilemma of farmers having "nowhere to dispose of and being unable to dispose of" agricultural waste, and improving the effectiveness and efficiency of the green treatment of agricultural waste. The benefits and convenience of green agricultural-waste treatment can further arouse the enthusiasm of farmers to participate. Higher efficiency implies that farmers can obtain economic returns from waste treatment, while enhanced convenience lowers the threshold for farmers to participate, making green treatment more feasible to implement.

Thirdly, policy synergy and integration ought to be strengthened, to propel the standardization and professional development of services. Policy synergy can guarantee the consistency of government regulation and agricultural socialized services in terms of objectives, directions, and measures. It can form a policy synergy to optimize policy resources, diminish policy conflicts and duplications, and enhance the efficiency of policy implementation. Future policy practice should comprehensively take into account the demand for policy synergy between government regulation and agricultural socialized services. It should clarify the priorities among the various segments with respect to the goal of green treatment of agricultural waste, and formulate operable policy measures. Meanwhile, a policy synergy mechanism should be established to reinforce the communication and collaboration between government departments, ensuring the effective implementation of policies and their timely adjustment. On the other hand, government regulation offers a normative framework for agricultural socialized services, facilitating the standardization and professional development of such services. During the standardization process, agricultural socialized services must adhere to the standards and norms stipulated by the government, to guarantee service quality and safety. Meanwhile, professional development can augment the competitiveness and influence of agricultural socialized services, catering to the diversified and individualized demands of farmers. Future policymaking should intensify support for the standardization and professionalization of agricultural socialized

services. It is necessary to formulate and refine relevant standards and norms, strengthen the training and management of service personnel, and enhance service quality and level. At the same time, agricultural socialized service organizations should be encouraged to conduct technological innovation and service-model innovation, to prompt the upgrading and transformation of services.

Fourthly, it is essential to enhance the targeting of government regulatory measures, to guarantee the maximization of regulatory efficiency. Owing to the diverse characteristics of individual farmers and their production processes, farmers' individual perceptions and behavioral logics vary. As a result, when confronted with the green treatment of agricultural waste, they display different levels of initiative. Therefore, targeted government regulation should be implemented in response to the phenomenon of farmer differentiation. Considering the disparities in farmers' education levels, and taking into account the varying degrees of acceptance of constraint-based and guidance-based regulations by farmers with different educational backgrounds, we should focus on intensifying the enforcement of constraint-based regulation for those with lower education levels. This will effectively regulate the agricultural waste-treatment behaviors of less-educated farmers. Meanwhile, for farmers with higher education levels, we should strengthen guidance-based regulation. By employing more educational propaganda, technical training, and other means, we can enhance their green treatment behaviors regarding agricultural waste. Additionally, in view of the scale differences between small- and medium-scale farmers and large-scale farmers, from the perspective of different regulatory targets, restrictive regulation should be more weighted towards small- and medium-scale farmers, to curtail their opportunistic behaviors in agricultural waste disposal. For large-scale farmers, the emphasis on guidance-based regulation should be increased to comprehensively promote the green treatment behaviors of agricultural waste for farmers of all planting scales.

6.2. Limitations of the Study and Future Research Perspectives

This study endeavored to disclose the mutually reinforcing effects of government regulation and agricultural socialized services on mushroom farmers' green treatment behavior of mushroom residue. Nevertheless, certain limitations remain. On the one hand, the study areas were circumscribed and predominantly concentrated in Gutian County, Ningde City, Fujian Province. Such a narrow geographical scope might impede the generalizability and representativeness of the findings. Future research ought to augment the number of study sites, endeavoring to encompass as many edible-mushroom production and cultivation regions as feasible, so as to corroborate the conclusions drawn in this study. On the other hand, the data collection period in this study was relatively brief, and concentrated within a short timeframe. This rendered it arduous to explore the dynamic alterations in mushroom farmers' green treatment behavior of mushroom residue ensuing from the substitution and renewal of government regulations, as well as the continuous enhancement of the agricultural socialized service system. Future investigations could enhance the reliability of the results by implementing a long-term tracking survey approach, focusing on fixed mushroom farmers over multiple years. In brief, albeit this study has achieved some headway in elucidating the influence of government regulation and agricultural socialized service on mushroom farmers' green treatment behavior of mushroom residue, deficiencies still exist in terms of the number of research sites and the temporal span. It is anticipated that these two shortcomings can be rectified in subsequent research, thereby furnishing a more comprehensive scientific foundation.

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