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The Government–Farmer Cooperation Mechanism and Its Implementation Path to Realize the Goals of Optimizing Grain Planting Structure

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Abstract: In order to alleviate the grain supply–demand structural contradictions and ensure the realization of grain planting structure optimization goals, it is necessary to clarify the interactive relationship between multiple entities, establish a cooperation mechanism, and explore its implementation paths. To this end, a differential game model is built to compare and analyze the optimal strategies, optimal benefits, and overall system outcomes for both the government and farmers under three scenarios: the Nash non-cooperative game, the Stackelberg game, and the collaborative cooperation game. Then, key factors and their influencing mechanisms that affect the government–farmer cooperation mechanism are revealed. Finally, the csQCA model is used to explore the implementation paths for different stakeholders to ensure the sound operation of the cooperation mechanism. The results show the following: (1) The government–farmer cooperation mechanism should consist of an inner core system with the government–farmer interaction as the core and an outer system comprising the market environment, cooperation environment, and institutional environment. These two systems should coordinate with each other, respond to each other, and drive progress together. (2) The cooperation mechanism can optimize behavioral enthusiasm, resulting in individual and overall benefits for both the government and farmers. However, its scientific and orderly implementation is affected by factors such as the cost coefficient. Additionally, subsidies serve as a powerful policy tool to enhance farmers' enthusiasm, thereby increasing the benefits for both parties and maximizing the effectiveness of the cooperation mechanism. (3) There are three implementation paths corresponding to large-scale farmers, rural elites, and small-scale farmers: being led by external policy tools, linkage guidance between decision-making environment and willing subjects, and factor allocation and environmentally driven decision-making. These findings can provide theoretical support and case reference for marginal farmland management and planting structure optimization management in underdeveloped areas.

Keywords: grain planting structure optimization; government–farmer cooperation mechanism; implementation paths; underdeveloped rural areas

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1. Introduction

The rational and efficient utilization of cultivated land is an important way to stabilize the supply–demand balance of grains, achieve sustainable agricultural development, and ensure national food security, which are a common concerns around the world [1,2]. However, being affected by climate change and human activities, the resource and environmental constraints have been stringent; especially with the impact of COVID-19, the Russia–Ukraine war, and international trade frictions, the supply of international grain markets has become increasingly uncertain [3]. Meanwhile, the rising economic levels and upgrading the food consumption structure of citizens have led to more diverse and complex demands for different crop types, putting significant pressure on food production management. As a major grain-producing country, China's total grain supply and demand are basically balanced, but structural contradictions are prominent [4], which are manifested in the oversupply of maize. According to data from the National Bureau of Statistics, China's corn imports have been steadily increasing, with corn imports exceeding the quota by 1.13 in 2020 and 2021, respectively: 11.3 million tons, 28.35 million tons [5]. At the same time, in order to meet the rigid demand for edible vegetable oil and animal feed, the external dependence on soybean imports has risen from 36.26% in 2000 to 92% in 2020. Therefore, it is necessary to further optimize the planting structure and regional layout to enhance the efficiency and sustainability of agricultural development.

In order to optimize the planting structure, the Chinese government launched the grain planting structure optimization system in 2016, exemplified by the "Sickle Bend" maize structure adjustment policy. This policy set a target to reduce the maize planting area in the "Sickle Bend" region by over 50 million acres by 2020. Additionally, the government focused on promoting a new-type planting structure that integrates planting and breeding, as well as a new-type industrial structure that integrates production and marketing, which aims at creating a grain production system that aligns with spatial–temporal layout [6]. In the new era, the planting structure optimization policies have further clarified the type, quantity, area, and farming mode of grain planting in different regions. The government has guided farmers to adjust their grain planting structure in accordance with optimization goals through subsidy policies, price policies, and demonstration guidance. However, facing new requirements of crop types and planting models, farmers may face challenges in breaking away from their original planting behaviors, so it is difficult for them to show strong enthusiasm as expected. Meanwhile, problems such as an uneconomic production model, vulnerable farmer livelihoods, inadequate allocation of agricultural production factors, and insufficient provision of socialized services for agricultural production have gradually become apparent [7], making it difficult for the Chinese government to achieve grain planting structure optimization goals. Therefore, it is of more practical significance to identify the reasons behind the failure of government guidance and policy regulation and explore effective ways to encourage farmers to adjust their planting structure to achieve national grain planting structure optimization goals.

At present, studies on ensuring the realization of grain planting structure optimization goals mainly focused on goal-setting standards for planting structure optimization [8,9], the improvement of technical methods [10], driver factor analysis [11], management strategies [10], and implementation effect evaluation [12] from the macro perspective. However, this kind of macro-level theoretical discussion not only fails to clarify the collective action logic of planting structure optimization but also has difficulties providing specific implementation paths based on the characteristics of different subjects. In essence, the decision-making process of farmers to adjust their planting structure in compliance with optimization goals is a process of reallocating factors such as land, labor, and capital to maximize the overall household utility [13]. Some studies at the micro-level have explored the impact of factor endowments and their characteristics on farmers' behavior in adjusting their planting structure [13–16]. Firstly, in terms of land factor, on the one hand, the land is a semi-natural and semi-artificial production system, and the crop characteristics grown on land and production conditions determine the possible directions for adjusting the farmers' planting structure [17]. On the other hand, land is a production factor; its circulation, transfer, fragmentation, and location can also prompt farmers to adjust crop planting [18]. For example, small-scale farmers who rent agricultural land tend to reduce the area planted for food crops. Secondly, in terms of the labor factor, with the increase in rural labor migration and rising labor costs, farmers tend to increase land use intensity and expand the cultivation scale of cash crops, and the increase in non-agricultural income of labor in some areas has promoted a shift toward "non-grain" behavior [19]. Thirdly, at the level of capital factor, the comparative returns and production costs of different crops constrain farmers' capital investment, including machinery and equipment, fertilizers, and pesticides. These factors also affect the effectiveness of planting structure adjustment [20]. To sum up, a variety of complex factors can affect farmers' perceptions of resource allocation costs and values, their assessment of risks, and their expectations of future returns. Therefore, only by fully understanding the interactive and cumulative effects of various influencing factors on farmers' decision-making can we effectively address the conflicts and dilemmas and guide farmers toward a scientific and orderly adjustment of their planting structure.

Furthermore, farmers' decisions to adjust the planting structure are not only based on cost–benefit considerations but also influenced by interactions with other stakeholders. The conflict and coordination among multiple subjects in the process of optimizing the planting structure are the key core that deserve more attention. The conflict between farmers and the government is the most representative. On the one hand, farmers, as the main executive body for achieving planting structure optimization goals, often find themselves in a disadvantaged position within the market due to limited market sales channels, transaction costs, and low educational levels. Information asymmetry between farmers, the government, and the market further contributes to blind and delayed decision-making regarding planting behavior. Additionally, the instability of grain prices and subsidy rates, coupled with increasing agricultural risks and labor costs, undermine farmers' motivation to respond to the government's goals of optimizing the planting structure. On the other hand, the government, as the main body of governance and policy formulation, plays a crucial role in guiding farmers to optimize their planting structure. To increase farmers' enthusiasm, the Chinese government provides farmers with subsidies. However, over-reliance on agricultural subsidy policies can put huge pressure on local finances and even cause profit compression in the downstream agricultural industry chain, which can restrict the effective use of market mechanisms and exacerbate conflicts between the government and farmers [7]. Therefore, to ensure the realization of grain planting structure optimization goals, it is crucial to consider the conflicts and cooperation between the government and farmers and establish an effective cooperation mechanism. Furthermore, considering the heterogeneity of farmers, farmers with different cognitive levels lack various degrees of technical guidance, sales channel expansion, and market dynamic information acquisition means. Therefore, beyond the cooperation mechanism, diversified mechanism implementation paths that meet the demands of different farmers should also be established [21,22].

The construction of the government–farmer cooperation mechanism is essentially a process that involves the government, farmers, and village collectives, where the achievement of the system equilibrium depends on the interest balancing mechanism among multiple subjects. In this regard, game models are commonly used in research on multi-agent cooperation mechanisms [23]. For instance, the evolutionary game analysis of farmers, government, and e-commerce platforms in the context of farmers' participation in green production sheds light on the action logic of multiple agents in the transformation of agricultural green production [24]. Dynamic game analysis has also been applied to examine farmers' participation in agricultural non-point source pollution control mechanisms [25]. The above studies provide valuable insights into the construction of cooperation mechanisms, but they either focus on the field of grain planting or only emphasize the impact of single-period government subsidies on farmers' planting behavior. The long-term, dynamic, and complex characteristics of grain planting structure optimization require the government to carry out continuous grain planting structure adjustments for long-term food security. As a result, continuous time variables are important factors affecting the decision-making of the government and farmers. Differential game models cannot only involve the impact of time dynamics on decision-making but can also better introduce development environment factors into the model, which is suitable for studying the government–farmer cooperation mechanism to ensure the realization of grain planting structure optimization goals.

In addition, in the process of optimizing the planting structure, the implementation paths of the government–farmer cooperation mechanism are also multi-factor and multiconfiguration. However, current scholars mostly employed econometric methods and panel data to explore the impact of certain factors at the macro or intermediate level on the changes of farmers' planting behavior [26,27]. They fail to capture the joint effects and interactions of different factors across multiple subjects. To address this limitation, csQCA (Comparative Configurational Analysis) offers a systematic approach to examining the causes of events, the interactive relationships, and possible relationship combinations between internally generated factors. It can deepen the understanding of the complex causal relationships resulting from the optimization goals of planting structure and is useful for proposing targeted governance paths. The application of the csQCA model opens up new possibilities for this study.

To achieve these objectives, we attempt to use the differential game models to analyze the government–farmer cooperation mechanism to ensure the realization of grain planting structure optimization goals. Under three game scenarios—the Nash non-cooperative game, the Stackelberg game, and the collaborative cooperation game—we investigate the optimal strategies and incomes of the government and farmers, as well as the overall income of the system. Further, we explore the key factors and mechanisms that affect farmers' planting structure adjustment, pay attention to the government's cost subsidies to farmers, and find a government–farmer cooperation plan that achieves overall Pareto optimality. Additionally, taking the main grain-producing areas in Northeast China as an example, with farmers serving as the basic executive subjects of agricultural planting, the csQCA model is used to explore the complex impact mechanism of the joint action and interaction of various influencing factors on the government–farmer cooperation mechanism. Through this analysis, we will propose specific implementation paths for different types of farmers.

The rest of this paper is organized as follows. Section 2 explains the connotation of the government–farmer cooperation mechanism to ensure the realization of grain planting structure optimization goals. The establishment process of the cooperation mechanism is in Section 3. Section 4 analyzes the specific path for the implementation of the cooperation mechanism. Section 5 discusses and analyzes the above model results and finally draws conclusions in Section 6.

2. The Theoretical Framework of Government–Farmer Cooperation Mechanism

In the process of optimizing the planting structure, the stakeholders mainly involve the local government, farmers, and village collectives. Among them, the village collective is both an agent of the government and a representative of farmers' interests and takes the responsibility to distribute interests and safeguard farmers' rights and interests [28]. Therefore, the realization of grain planting structure optimization goals is essentially the result of the interaction between farmers and the government, and the strengthening of the cooperation mechanism between them is a key concern.

2.1. *The Connotation of Government–Farmer Cooperation Mechanism*

The government–farmer cooperation mechanism to ensure the realization of grain planting structure optimization goals means that the government establishes a cooperative relationship with farmers by providing subsidies for adjusting planting structure, providing agricultural production services, and building demonstration projects, thereby motivating and constraining farmers' planting behavior, and further adjusting cooperation based on farmers' feedback and planting structure optimization progress to ensure that the optimization goals are completed scientifically and in an orderly manner and produce certain social, economic and ecological benefits. Meanwhile, the risk cost and benefit distribution are the basis for decision-making, and finding the value of adjusting the planting structure is the key to promoting cooperation between the government and farmers.

We divide the government–farmer cooperation mechanism into two parts: the inner core system with government–farmer interaction and the outer system composed of various influencing factors, including the market environment, cooperation environment, and institutional environment. The internal system and external system coordinate and respond to each other to jointly drive progress and form a cooperation mechanism (See Figure 1).

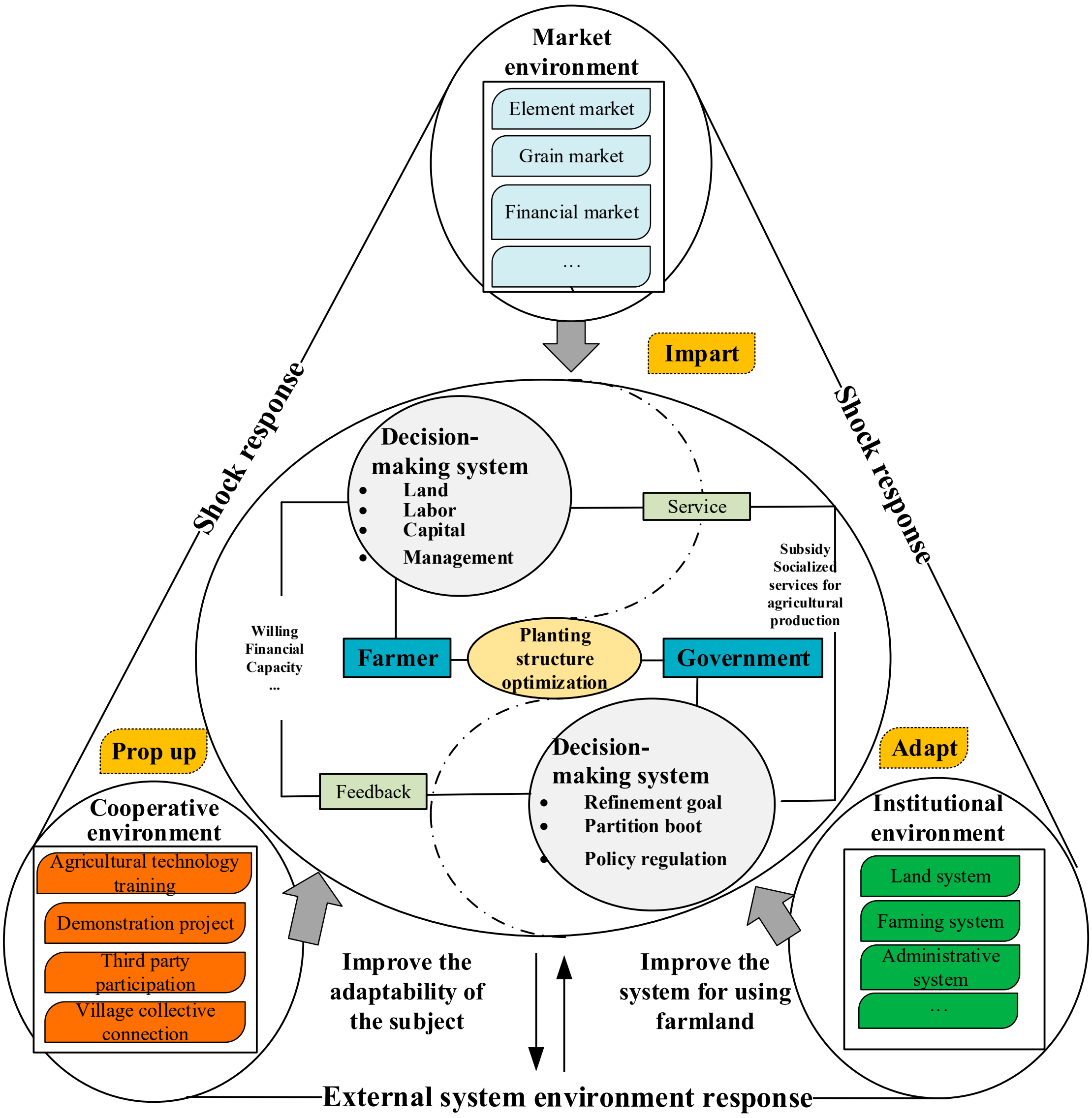

Figure 1. Conceptual framework of government–farmer cooperation mechanism.

2.2. The Inner Core System of Government–Farmer Cooperation Mechanism

To realize the grain planting structure optimization goals, the government needs to refine the specific planting plans according to regional agricultural production practices and give farmers clear planting guidance. Further, to encourage farmers to actively cooperate, the government generally adopts a series of incentive policies with agricultural subsidies as the core tool by designing reasonable subsidy standards, models, and details. Meanwhile, to ensure smooth cooperation with farmers, strong regulatory policies and reasonable benefit distribution mechanisms are also key tasks of the government. In this process, ensuring the realization of grain planting structure optimization goals is the political responsibility and value demand of local governments, and further, the social stability and ecological benefits brought about by the rational utilization and protection of cultivated land are the growth points of the government's enthusiasm. However, when faced with the dual pressures of economic development and promotion assessment, the government maybe change the agricultural production order at will and blindly induces farmers to adjust crops without considering the reasonable long-term utilization of cultivated land, which is not in line with the original intention of optimizing the planting structure [29,30]. In addition, over-reliance on agricultural subsidies puts the government under tremendous pressure from higher-level government supervision and management.

Grain planting can be considered as the farmers' profit-driven market behavior. Any changes in planting patterns and crop types inevitably affect the allocation of labor, land, and capital to rural households. Although farmers with general rationality could allocate various factors based on maximizing utility, their willingness, ability, and cognition need to be improved through a cooperative mechanism and effective professional management guidance due to farmers' poor bargaining ability and information asymmetry. In addition, farmers' endowments are heterogeneous. Different farmers have different channels for obtaining information, market game capabilities, and means of resisting agricultural risks, which require different methods and content of guidance. It is necessary to scientifically and orderly arrange their participation in the planting structure optimization based on their characteristics and attributes and explore different implementation paths of cooperation mechanisms.

2.3. The Outer System of Government–Farmer Cooperation Mechanism

The realization of grain planting structure optimization goals requires the subjects to face an external decision-making environment with continuity and uncertainty. The external environment includes the market environment, institutional environment, and cooperation environment. The institutional environment interacts with the market environment and cooperation environment, resulting in the exchange of information flow, material flow, and value flow, which affects the adaptability of each subject and the development direction of the cultivated land utilization management system.

First, the market environment mainly includes the grain price market, factor market, financial market, and so on. Changes in the grain price market and factor market are the main external manifestations that induce the urgency of optimizing the planting structure. And the agricultural factor market is a transaction network system in which land, labor, capital, and other factors are interconnected. Second, the institutional environment includes formal institutions such as land systems and administrative management, as well as informal institutions such as cultural values. Third, the cooperative behavior of farmers and the government can be directly or indirectly affected by village collectives and other production service entities. Government financial expenditures and policy preferences can promote increases in human resources, institutional costs, time costs, and information costs in government. Therefore, the cooperation environment includes a management environment with multi-party participation and a trust foundation formed by agricultural technology training and demonstration projects.

3. The Government–Farmer Cooperation Mechanism to Ensure the Realization of Grain Planting Structure Optimization Goals

Referring to existing research [31–35], this paper intends to use the differential game to simulate the government–farmer cooperation mechanism in the process of optimizing and adjusting the planting structure. Consider a cooperation chain consisting of a government and a farmer. The government guides farmers to adjust the planting structure by providing subsidies and reducing farmers' production costs to realize planting structure optimization goals, while farmers maximize their own benefits by deciding their degree of participation in the project. The three scenarios of the Nash non-cooperative game, the Stackelberg game, and the collaborative cooperation game are constructed respectively to analyze the optimal strategies, optimal benefits, and overall benefits of the system and further to reveal the key influencing factors so as to build a government–farmer cooperation mechanism.

3.1. Models

3.1.1. Assumptions

(1) Assume that $S_g(t)$ is the degree of government's (represented by g) efforts or behavioral motivation to guide and regulate farmers' planting and promote information sharing with farmers, which, in reality, includes the promotion of socialized agricultural services, subsidies to producers, the organization of farmland flow, the expansion of information and communication channels for farmers, the dissemination of information and instructions on agricultural policy, innovation orientation in the food subdivision, cultivation and management models, optimizing the detailed planning, and optimizing the detailed design of agricultural subsidy policies to regulate farmers' behavior. $S_p(t)$ measures the farmers' (represented by p) enthusiasm for accepting government guidance and regulation and expressing their feedback on planting behavior. Then, the cost paid C by government g and farmer p can be expressed as follows:

$$Cg(t) = \frac{1}{2}\mu_g S_g(t)^2 \; Cp(t) = \frac{1}{2}\mu_p S_p(t)^2 \tag{1}$$

where u_g and μ_p represent government's and farmers' cost coefficients of promoting self-participation in cooperation respectively, they are both convex functions of $S_g(t)$ and $S_p(t)$ respectively. Therefore, the more efforts the government and farmers make to promote cooperation, the greater the cost.

(2) Assume that $D(t)$ is the realization degree of planting structure optimization goals. Consultation and cooperation between the government and farmers are more conducive to the goal of optimizing the planting structure. Therefore, we use stochastic differential equations to express the change over time of the realization degree of planting structure optimization goals under government–farmer cooperation:

$$D(t) = \frac{\mathrm{d}D(t)}{dt} = \alpha S_g(t) + \beta S_p(t) - \delta D(t) \tag{2}$$

where $D(0) = D_0 > 0$ is the initial state for achieving the required level of planting structure optimization. α and β represent the impact of the efforts of the government and farmers on achieving the goal of optimizing the planting structure, respectively. Δ means that as the cooperation mechanism progresses, the growth rate of the total effect generated by the optimization of planting structure will weaken after reaching a certain level, that is, the diminishing marginal effects.

(3) The total benefit achieved by the system can be described as the total benefit of realizing grain planting structure optimization goals, which includes economic benefits and social and environmental impacts.

$$\pi(t) = \varepsilon S_g(t) + \gamma S_p(t) + \eta D(t) \tag{3}$$

where ε and γ are the influence degrees of the efforts of each party on the overall benefit of the system, which can be known as the marginal effect coefficient. H is the improvement coefficient of the overall benefit of the system from the realization of the planting structure optimization goals.

(4) Assume that the benefits generated by farmers and government after participating in the cooperative system are only distributed between the two parties, which are λ and $1-\lambda$. The former refers to the policy support farmers can receive due to adjusting the grain planting structure, as well as the increased income, improved ecological benefits of cultivated land, and the realization of the social security value. The latter refers to the long-term benefits brought about by promoting the rational utilization and protection of cultivated land.

(5) Assume that for farmers who actively participate in planting structure optimization, the government will take the initiative to bear part of the cost $\omega(t)$. Based on this, the objectives function of the government and the farmers F_g and F_p are as follows.

$$F_g = \int_0^\infty e^{-\rho t}\left[(1-\lambda)(\varepsilon S_g(t) + \gamma S_p(t) + \eta D(t)) - \frac{1}{2}\mu_g S_g(t)^2 - \omega(t)\frac{1}{2}\mu_p S_p(t)^2\right]dt \quad (4)$$

$$F_\mathrm{p} = \int_0^\infty e^{-\rho t}\left[\lambda(\varepsilon S_g(t) + \gamma S_p(t) + \eta D(t)) - \frac{1}{2}(1-\omega(t))\mu_p S_p(t)^2\right]dt \quad (5)$$

where F_g and F_p respectively represent the objective functions for optimizing the planting structure implemented by the government and farmers, and ρ of both parties is the same discount rate and set as a positive number, $\omega(t)$ is a "subsidy factor" with a value of 0–1.

The $S_g(t)$, $S_p(t)$, and $\omega(t)$ by the government for farmers included in the above equation are the control variables, $D(t)$ is the state variable. Considering the difficulty of solving dynamic parameters, it is assumed that the above parameters are constants greater than 0 and are not related to time t [36]. Meanwhile, from the perspective of the game process between the government and farmers, the control variables and state variables can be considered independent of time.

3.1.2. Scenario Design

(1) Nash non-cooperative game

We assume no additional subsidies from the government, and each party decides its own participation strategy independently. In this section, the principle of dynamic programming is used to analyze the operation process of this non-cooperative mechanism, and the Nash equilibrium strategy is solved. The objective function of each party is as follows.

$$F_g = \int_0^\infty e^{-\rho t}\left[(1-\lambda)(\varepsilon S_g + \gamma S_p + \eta D) - \frac{1}{2}\mu_g {S_g}^2\right]dt \quad (6)$$

$$F_\mathrm{p} = \int_0^\infty e^{-\rho t}\left[\lambda(\varepsilon S_g + \gamma S_p + \eta D) - \frac{1}{2}\mu_p {S_p}^2\right]dt \quad (7)$$

Assume that $U_g(D)$ and $U_p(D)$ are optimal benefit functions for the government and farmers (continuous bounded differentiable). They satisfy the Hamilton-Jacobi-Bellman equation for all $D \geq 0$.

$$\begin{aligned} \rho U_g(D) &= \max_{S_g \geq 0}\{(1-\lambda)(\varepsilon S_g + \gamma S_p + \eta D) - \tfrac{1}{2}\mu_g {S_g}^2 + U_g'(D)(\partial S_g + \beta S_p - \delta D)\} \\ \rho U_p(D) &= \max_{S_p \geq 0}\{\lambda(\varepsilon S_g + \gamma S_p + \eta D) - \tfrac{1}{2}\mu_p {S_p}^2 + U_p'(D)(\partial S_g + \beta S_p - \delta D)\} \end{aligned} \quad (8)$$

Solve the first-order partial derivatives of S_g and S_p for the right-hand parts of Equation (8), and we can obtain the following:

$$S_g = \frac{(1-\lambda)\varepsilon + \partial U_g'(D)}{\mu_g},\ S_p = \frac{\lambda\gamma + \beta U_p'(D)}{\mu_p} \quad (9)$$

By substituting Equation (9) into Equation (8), we can obtain the following:

$$\begin{aligned} \rho U_g(D) &= \left[(1-\lambda)\eta - \delta U_g'(D)\right]D + \tfrac{\left[(1-\lambda)+\partial U_g'(D)\right]^2}{2\mu_g} + \tfrac{\left[(1-\lambda)\gamma+\beta U_g'(D)\right]\left[\lambda\gamma+\beta U_p'(D)\right]}{\mu_p} \\ \rho U_p(D) &= \left[\lambda\eta - \delta U_p'(D)\right]D + \tfrac{\left[(1-\lambda)\varepsilon+\partial U_p'(D)\right]\left[\lambda\varepsilon+U_p'(D)\right]}{\mu_g} + \tfrac{\left[\lambda\gamma+\beta U_p'(D)\right]^2}{2\mu_p} \end{aligned} \quad (10)$$

Equation (10) indicates that the solution of the HJB equation should be a one-variable linear function containing D.

Assuming that $U_g(D) = a_1 k + a_2$ and $U_p(D) = b_1 k + b_2$, we find that $U_g'(D) = a_1$ and $U_p'(D) = b_1$. By substituting the relevant variables and D = 0 into the HJB equation, the following equation can be solved.

$$\begin{gathered} a_1 = \frac{(1-\lambda)\eta}{\rho+\eta},\ a_2 = \frac{(1-\lambda)^2[\varepsilon(\rho+\eta)+\partial\eta]^2}{2\rho\mu_g(\rho+\delta)^2} + \frac{\lambda(1-\lambda)[\gamma(\rho+\delta)+\beta\eta]^2}{\rho\mu_p(\rho+\delta)^2} \\ b_1 = \frac{\lambda\eta}{\rho+\delta},\ b_2 = \frac{\lambda(1-\lambda)[\varepsilon(\rho+\delta)+\partial\eta]^2}{\rho\mu_g(\rho+\delta)^2} + \frac{\lambda^2[\gamma(\rho+\delta)+\beta\eta]^2}{2\rho\mu_p(\rho+\delta)^2} \end{gathered} \tag{11}$$

Further, we obtain ${S_g}^*$ and ${S_p}^*$ as follows:

$${S_g}^* = \frac{(1-\lambda)[\varepsilon(\rho+\delta)+\partial\eta]}{\mu g(\rho+\delta)}, {S_p}^* = \frac{\lambda[\gamma(\rho+\delta)+\beta\eta]}{\mu_p(\rho+\delta)} \tag{12}$$

And ${U_g}^*(D)$ and ${U_p}^*(D)$ are as follows:

$$\begin{gathered} {U_g}^*(D) = \frac{(1-\lambda)\eta}{\rho+\delta}D + \frac{(1-\lambda)^2[\varepsilon(\rho+\delta)+\partial\eta]^2}{2\rho\mu_g(\rho+\delta)^2} + \frac{\lambda(1-\lambda)[\gamma(\rho+\delta)+\beta\eta]^2}{\rho\mu_p(\rho+\delta)^2} \\ {U_g}^*(D) = \frac{\lambda\eta}{\rho+\delta}D + \frac{\lambda(1-\lambda)[\varepsilon(\rho+\delta)+\partial\eta]^2}{\rho\mu_g(\rho+\delta)^2} + \frac{\lambda^2[\gamma(\rho+\delta)+\beta\eta]^2}{2\rho\mu_p(\rho+\delta)^2} \end{gathered} \tag{13}$$

Accordingly, we can obtain the optimal benefit function of the system generated by the implementation of the government and farmers' participation in the management mechanism.

$$U^*(D) = {U_g}^*(D) + {U_p}^*(D) = \frac{\eta}{\rho+\delta}D + \frac{(1-\lambda)^2[\varepsilon(\rho+\delta)+\partial\eta]^2}{2\rho\mu_g(\rho+\delta)^2} + \frac{\lambda(2-\lambda)[\gamma(\rho+\delta)+\beta\eta]^2}{2\rho\mu_p(\rho+\delta)^2} \tag{14}$$

(2) Stackelberg game

To encourage farmers to participate in this process, the government always first bears part of the economic and institutional costs of establishing a management mechanism, thus forming a Stackelberg game with the government as the leader and farmers as followers. Specifically, the government first determines the subsidies for farmers and improves farmers' policy awareness, value awareness, and risk prevention capabilities through policy publicity, promotion demonstrations, and social services. Then, farmers decide whether to follow the government's call to adjust their planting structure to maximize their own benefits.

Assume that both government and farmers have optimal benefit functions $U_{\mathrm{g}}(D)$ and $U_p(D)$, which are continuous, bounded, and differentiable and satisfy the HJB equation for all $K \geq 0$. The HJB equation is obtained by stepwise regression:

$$\rho U_p(D) = \max_{S_p \geq 0}\left\{\lambda(\varepsilon S_g + \gamma S_p + \eta D) - \frac{1}{2}\mu_p(1-\omega){S_p}^2 - U_p\prime(D)(\partial S_g + \beta S_p - \delta D)\right\} \tag{15}$$

As above, the condition for maximizing the HJB equation is solved. That is, the following holds: $S_p = \frac{\lambda\gamma + \beta U_p\prime(D)}{(1-\omega)\mu_p}$.

In this scenario, the government reflects rationally on its optimal strategy and pro poses a subsidy factor to maximize its own benefits. Therefore, we obtain the HJB equation for optimal control.

$$\rho U_g(D) = \max_{S_g \geq 0}\left\{(1-\lambda)(\varepsilon S_g + \gamma S_p + \eta D) - \frac{1}{2}\mu_g{S_g}^2 - \frac{\omega\mu_p}{2}U_p(D)^2 + U_g'(D)(\partial S_g + \beta S_p - \delta D)\right\} \tag{16}$$

S_p is substituted into the government's HJB equation. S_g and ω at the right end of the equation are each evaluated for one-step derivation, with both derivations zero.

$$S_{\mathrm{g}} = \frac{(1-\lambda)\varepsilon + \partial U_g\prime(D)}{\mu_g},\ \omega = \frac{\gamma(2-3\lambda) + \beta(2U_g\prime(D) - U_p'(D))}{\gamma(2-\lambda) + \beta(2U_g'(D) + U_p\prime(D))} \tag{17}$$

Then, S_p and Equation (17) are substituted into the government–farmer HJB equation, which yields the following equation.

$$\rho U_{\mathrm{g}}(D) = \left[(1-\lambda)\eta - \delta U'_{\mathrm{g}}(D)\right]D + \frac{\left[(1-\lambda)\varepsilon + \partial U'_{\mathrm{g}}(D)\right]^2}{2\mu_g} + \frac{\left[(2-\lambda)\gamma + \beta(2U'\mathrm{g}(D) + U'_{\mathrm{p}}(D))\right]^2}{8\mu_p}$$
$$\rho U_{\mathrm{p}}(D) = \left[\lambda\eta - \delta U'_{\mathrm{p}}(D)\right]D + \frac{\left[(1-\lambda)\varepsilon + \partial U'_{\mathrm{g}}(D)\right]\left[\lambda\varepsilon + \partial U'_p(D)\right]}{\mu_g} + \frac{\left[\lambda\gamma + \beta U'_p(D)\right]\left[(2-\lambda)\gamma + \beta(2U'_g(D) + U'_p(D)\right]}{4\mu_p} \quad (18)$$

As above, we still assume that $U_g(D) = a_1 k + a_2$ and $U_p(D) = b_1 k + b_2$. So $U'_g(D) = a_1$ and $U'_p(D) = b_1$. The relevant variables, as well as D = 0, are substituted into the HJB equation again. The following could be found:

$$a_1 = \frac{(1-\lambda)\eta}{\rho+\delta},\ \mathrm{a}_2 = \frac{(1-\lambda)^2[\varepsilon(\rho+\delta)+\partial\eta]^2}{2\rho\mu g(\rho+\delta)^2} + \frac{(2-\lambda)^2[\gamma(\rho+\delta)+\beta\eta]^2}{8\rho\mu_p(\rho+\delta)^2}$$
$$\mathrm{b}_1 = \frac{\lambda\eta}{\rho+\delta},\ \mathrm{b}_2 = \frac{\lambda(1-\lambda)[\varepsilon(\rho+\delta)+\alpha\eta]^2}{\rho\mu_g(\rho+\delta)^2} + \frac{\lambda(2-\lambda)[\gamma(\rho+\delta)+\beta\eta]^2}{4\rho\mu_p(\rho+\delta)^2} \quad (19)$$

Furthermore, the relevant variables are substituted into S_g, S_p, and ω. The optimal effort strategy and optimal subsidy factor for the government and farmers are as follows.

$$S_{\mathrm{g}}{}^{**} = \frac{(1-\lambda)[\varepsilon(\rho+\delta)+\partial\eta]}{\mu_g(\rho+\delta)},\ S_p{}^{**} = \frac{(2-\lambda)[\gamma(\rho+\delta)+\beta\eta]}{2\mu_p(\rho+\delta)}$$
$$\omega^{**} = \begin{cases} \frac{2-3\lambda}{2-\lambda}, & 0 \prec \lambda \prec \frac{2}{3} \\ 0, & \frac{2}{3} \leq \lambda \prec 1 \end{cases} \quad (20)$$

Since $0 \prec \omega \leq 1$ and $0 \prec \lambda \prec 1$, we find that $0 \prec \lambda \prec \frac{2}{3}$. This results in the optimal benefit for both parties, which are as follows:

$$U_g{}^{**}(D) = \frac{(1-\lambda)\eta}{\rho+\delta}D + \frac{(1-\lambda)^2[\varepsilon(\rho+\delta)+\partial\eta]^2}{2\rho\mu_g(\rho+\delta)^2} + \frac{(2-\lambda)^2[\gamma(\rho+\delta)+\beta\eta]^2}{8\rho\mu_p(\rho+\delta)^2}$$
$$U_{\mathrm{p}}{}^{**}(D) = \frac{\lambda\eta}{\rho+\delta}D + \frac{\lambda(1-\lambda)[\varepsilon(\rho+\delta)+\partial\eta]^2}{\rho\mu_g(\rho+\delta)^2} + \frac{(2-\lambda)\lambda[\gamma(\rho+\delta)+\beta\eta]^2}{4\rho\mu_p(\rho+\delta)^2} \quad (21)$$

Furthermore, optimal benefits can be obtained by optimizing the planting structure by employing the management mechanism:

$$U^{**}(D) = \frac{\eta}{\rho+\delta}D + \frac{(1-\lambda)^2[\varepsilon(\rho+\delta)+\partial\eta]^2}{2\rho\mu_g(\rho+\delta)^2} + \frac{(4-\lambda^2)[\gamma(\rho+\delta)+\beta\eta]^2}{8\rho\mu_p(\rho+\delta)^2} \quad (22)$$

(3) Collaborative cooperation game

In this scenario, the farmers and government work together in a cooperative alliance. The government improves grassroots governance and promotes agricultural supply-side reform through a series of management systems. Farmers can improve their farmland management and management levels by optimizing the planting structure, optimizing the allocation of household factors, and improving their competitiveness. At this point, the government needs to bear part of the cost of planting restructuring for the farmers. As an intra-system problem, the "subsidy factor" ω can be taken as a random number from 0 to 1, and the objective function is as follows.

$$F = F_{\mathrm{g}} + F_p = \int_0^\infty e^{-\rho t}\left[(\varepsilon S_g + \gamma S_p + D\eta) - \frac{\mu_g}{2}S_g{}^2 - \frac{\mu_p}{2}S_p{}^2\right]dt \quad (23)$$

In order to obtain the collaborative equilibrium state under this scenario, the optimal benefit function $U(D)$ of the government and farmers jointly participating in the management mechanism to implement the planting structure optimization is assumed and continuously bounded differentiable for $K \geq 0$ satisfying the HJB equation.

$$\rho U(D) = \max_{S_g \geq 0; S_p \geq 0} \left\{ (\varepsilon S_g + \gamma S_p + D\eta) - \frac{\mu_g}{2} {S_g}^2 - \frac{\mu_p}{2} {S_p}^2 + U\prime(D)(\alpha S_g + \beta S_p - \delta D) \right\} \quad (24)$$

We find the one-step derivation of the right-hand side U_g and S_p of Equation (24), make the result equal to 0, and obtain the following.

$$U_g = \frac{\varepsilon + \partial U'(D)}{\mu_g} \quad (25)$$

Equation (25) is substituted into Equation (24), and we find that its solution is already a quadratic equation. We suppose that $U(D) = m_1 D + m_2$ and $U'(D) = m_1$, and substitute them into the HJB equation, resulting in Equation (24).

$$\rho(m_1 D + m_2) = (\eta - m_1\delta)D + \frac{(\varepsilon + \partial m_1)^2}{2\mu_g} + \frac{[\gamma + \beta m_2]^2}{2\mu_p} \quad (26)$$

$K = 0$ is substituted into Equation (24) to obtain the following.

$$\mathrm{m}_1 = \frac{\eta}{\rho + \delta}, \ \mathrm{m}_2 = \frac{[\varepsilon(\rho + \delta) + \alpha\eta]^2}{2\rho\mu_g(\rho + \delta)^2} + \frac{[\gamma(\rho + \delta) + \beta\eta]^2}{2\rho\mu_p(\rho + \delta)^2} \quad (27)$$

$U'(D)$ is substituted to solve for the degree of motivation of government and farm household behavior.

$${S_g}^{***} = \frac{\varepsilon(\rho + \delta) + \partial\eta}{\mu_g(\rho + \delta)}, \ {S_p}^{***} = \frac{\gamma(\rho + \delta) + \beta\eta}{\mu_p(\rho + \delta)} \quad (28)$$

Meanwhile, the optimal system benefits can be obtained as follows.

$$U^{***}(D) = \frac{\eta}{\rho + \delta} D + \frac{[\varepsilon(\rho + \delta) + \partial\eta]^2}{2\rho\mu_g(\rho + \delta)^2} + \frac{[\gamma(\rho + \delta) + \beta\eta]^2}{2\rho\mu_p(\rho + \delta)^2} \quad (29)$$

Distributing the optimal benefits of the system according to the allocation ratio of $1 - \lambda$ and λ yields the following: ${U_g}^{***}(D) = (1 - \lambda)U^{***}(D)$; ${U_p}^{***}(D) = \lambda U^{***}(D)$.

3.2. Comparison of Equilibrium Results under Different Scenarios

By comparing the optimal strategies of the government and farmers in three game scenarios, we can obtain the following proposition.

Their respective optimal benefits and the optimal benefits of the system as a whole are as follows:

$$\begin{gathered} {S_\mathrm{g}}^{**} - {S_g}^{**} = 0, {S_\mathrm{g}}^{***} - {S_g}^{**} = \tfrac{\lambda[\varepsilon(\rho+\delta)+\partial\eta]}{\mu_g(\rho+\delta)} \succ 0; \\ {S_\mathrm{p}}^{**} - {S_p}^{*} = \tfrac{(2-\lambda)[\gamma(\rho+\delta)+\beta\eta]}{2\mu_p(\rho+\delta)} \cdot \tfrac{2-3\lambda}{2-\lambda} = {S_p}^{**} \cdot \omega^{**} \succ 0 \\ {S_p}^{***} - {S_p}^{**} = \tfrac{\lambda[\gamma(\rho+\delta)+\beta\eta]}{\mu_p(\rho+\delta)} \succ 0 \end{gathered} \quad (30)$$

Proposition 1. *When the income distribution coefficient between the government and farmers is 0~2/3, the effort level of farmers to participate in planting structure optimization in the Steinberg game scenario is higher than that in the Nash non-cooperative game scenario, and the improvement intensity is equal to the government's cost-sharing ratio for farmers, which indicates that as an incentive tool, subsidies can greatly improve farmers' enthusiasm without dampening the govern-*

ment's efforts. In the case of the collaborative cooperation game, the level of effort of the government and farmers reaches the maximum.

Proposition 2. *When the income distribution coefficient between the government and farmers is 0~2/3, the optimal returns of both parties are higher than those in the Nash non-cooperative game scenario, which shows that the government–farmer cooperation mechanism under the Stackelberg game is higher than that in the Nash non-cooperative game scenario.*

$$\begin{aligned} U_g^{**}(D) - U_g^{*}(D) &= \tfrac{(3\lambda-2)^2[\gamma(\rho+\delta)+\beta\eta]^2}{8\rho\mu_p(\rho+\delta)^2} \succ 0, \\ U_p^{**}(D) - U_p^{*}(D) &= \tfrac{\lambda(2-3\lambda)[\gamma(\rho+\delta)+\beta\eta]^2}{4\rho\mu_p(\rho+\delta)^2} \succ 0 \end{aligned} \tag{31}$$

Proposition 3. *In the Stackelberg game scenario, the respective benefits of the government and farmers are increased, while in terms of optimal system benefits, the Cooperative game has the best system benefits, followed by the Stackelberg game, and finally, the Nash game. In other words, if the government and farmers' benefit allocation scheme is reasonable and feasible, satisfying the feasibility and reasonable demands of both parties, the optimal benefits of each party in the Cooperative game scenario are higher than those of other games, and the Pareto optimum can be achieved.*

$$\begin{aligned} U^{**}(D) - U^{*}(D) &= \tfrac{(3\lambda-2)(\lambda-2)[\gamma(\rho+\delta)+\beta\eta]^2}{8\rho\mu_p(\rho+\delta)^2} \succ 0, \\ U^{***}(D) - U^{**}(D) &= \tfrac{\lambda^2[\varepsilon(\rho+\delta)+\partial\eta]^2}{2\rho\mu_g(\rho+\delta)^2} + \tfrac{\lambda^2[\gamma(\rho+\delta)+\beta\eta]^2}{8\rho\mu_p(\rho+\delta)^2} \succ 0 \end{aligned} \tag{32}$$

Proposition 4. *In order to coordinate the behavior of the government and farmers in the cooperation mechanism for optimizing the planting structure and to achieve optimal benefits and the optimal system income distribution coefficient, we ordered* $\theta_1 = [\varepsilon(\rho+\delta)+\partial\eta]^2$ *and* $\theta_2 = [\gamma(\rho+\delta)+\beta\eta]^2$*. And according to the size relationship of optimal strategies of the local government and farmers in different scenarios, we saw something as follows:*

$$\begin{cases} \tfrac{(1-\lambda)\theta_1}{2\rho\mu_g(\rho+\delta)^2} + \tfrac{(1-\lambda)\theta_2}{2\rho\mu_p(\rho+\delta)^2} - \left[\tfrac{(1-\lambda)^2\theta_1}{2\rho\mu_g(\rho+\delta)^2} + \tfrac{(2-\lambda)^2\theta_2}{8\rho\mu_p(\rho+\delta)^2}\right] \geq 0 \\ \tfrac{\lambda\theta_1}{2\rho\mu_g(\rho+\delta)^2} + \tfrac{\lambda\theta_2}{2\rho\mu_p(\rho+\delta)^2} - \left[\tfrac{\lambda(1-\lambda)\theta_1}{\rho\mu_g(\rho+\delta)^2} + \tfrac{\lambda(2-\lambda)\theta_2}{4\rho\mu_p(\rho+\delta)^2}\right] \geq 0 \end{cases} \tag{33}$$

If the respective benefits of subjects were optimal, the overall benefit of the system also was optimal. It was known from Formula (28) that $\frac{2\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g} \leq \lambda \leq \frac{4\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g}$, when $0 \prec \lambda \prec \frac{2}{3}$ was combined, $\frac{2\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g} \prec \frac{1}{2}$.

Then, there were the following two situations for the benefit distribution:

(1) If $\frac{4\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g} \geq \frac{2}{3}$, $\frac{2\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g} \leq \lambda \prec \frac{2}{3}$.

(2) If $\frac{4\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g} \prec \frac{2}{3}$, $\frac{2\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g} \leq \lambda \leq \frac{4\theta_1\mu_p}{4\theta_1\mu_p+\theta_2\mu_g}$.

4. The Implementation Path of Government–Farmer Cooperation Mechanism to Ensure the Realization of Grain Planting Structure Optimization Goals

Farmers are the core executors of planting structure optimization goals; their decision-making behaviors are affected by internal value and risk perceptions and the external environment. Therefore, beyond the cooperation mechanism, it is necessary to explore its specific implemented paths. The csQCA method, with the principle of analyzing the causal complexity of multi-factor concurrency by calibrating the attribution standards of different condition variables and outcome variables, is a powerful tool for exploring implemented paths [37]. Generally speaking, the main steps of csQCA are case selection, variable measurement, variable calibration, necessary condition analysis, and influencing factor configuration analysis.

4.1. Models

The results of the differential game revealed the key influencing factors of the government–farmer cooperation mechanism. First of all, willingness to cooperate is the crucial prerequisite, but the efforts that rural households can exert are mainly limited by their abilities and cognition to allocate agricultural production factors. Meanwhile, the costs and expected benefits are the main factors affecting decision-making. The government shares planting costs for farmers in the form of subsidies, which can effectively coordinate the interest-related issues with farmers and is an effective policy tool. In addition, internal and external decision-making environments such as rural household endowments and institutional settings can also play a vital role in achieving government–farmer cooperation. To this end, we propose an influencing factor configuration analysis model of the cooperation mechanism realization path from four aspects: subject willingness, factor allocation, policy tool, and decision-making environment (See Figure 2).

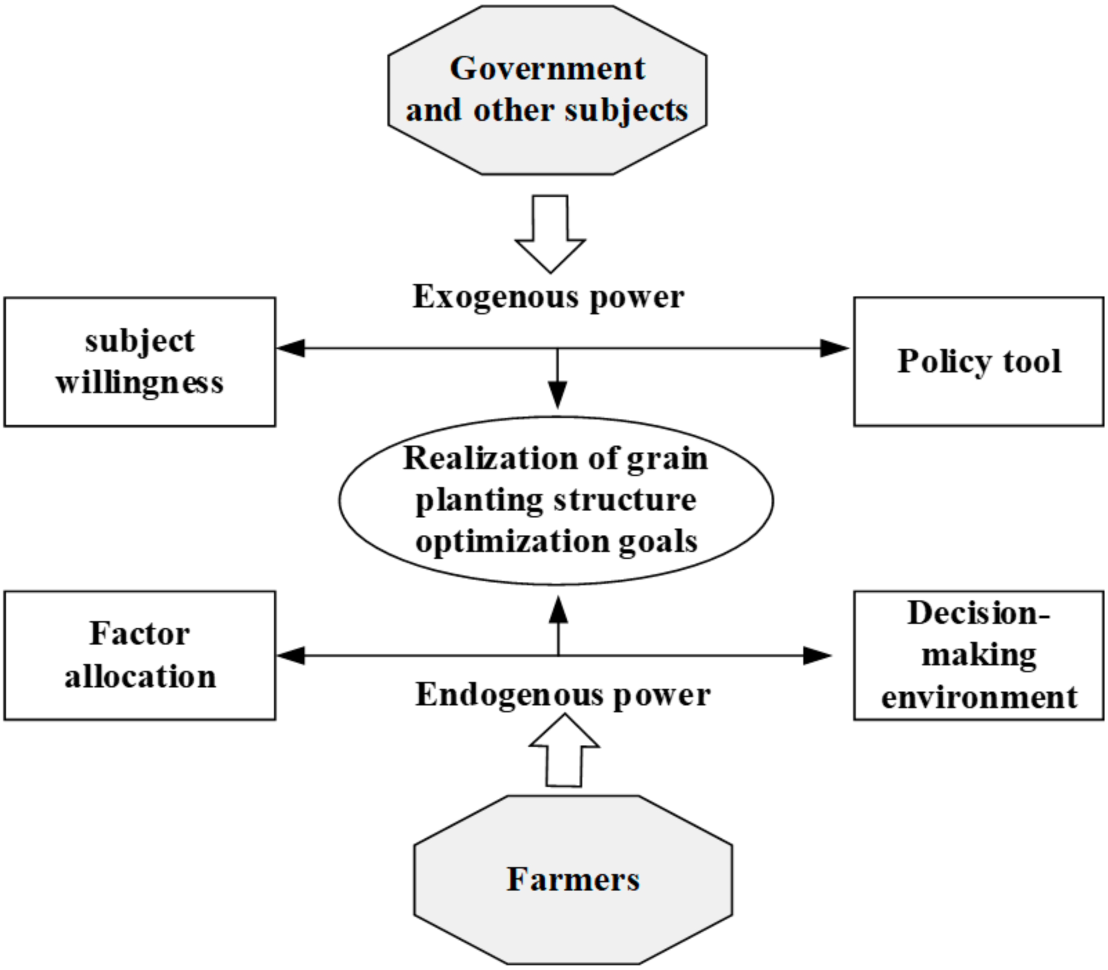

Figure 2. Influencing factor configuration analysis model of government–farmer cooperation mechanism realization path.

In terms of subject willingness in the practices of agricultural production, the policy tools or management strategies that can be applied in underdeveloped areas to encourage farmers to adjust their planting structure are relatively limited. Generally, most measures are taken to increase producer subsidies for a certain crop and reduce subsidies for competing crops. To expand this impact further, policies are often tilted toward large-scale operations. Therefore, non-spontaneous land transfer reflects the willingness of farmers to participate in the planting structure optimization to a certain extent, and it is generally believed that farmers' planting structure adjustment needs to last 2–3 years [38]. To this end, we choose to participate in land transfer for two consecutive years or to sign a formal contract as the indicator of the subject's willingness, which cannot only reflect the farmer's contract spirit [39] but also reflect the stability of the farmer's willingness to operate with the government. In addition, participation in agricultural technology training related to planting structure adjustment reflects farmers' positive attitudes, which can also be analyzed as indicators of the subject's willingness.

In terms of factor allocation, achieving grain planting structure optimization goals requires farmers to adjust factor allocation structure, and its quality and level can reflect the realization level of optimization goals to a certain extent. For the labor-intensive planting industry in underdeveloped areas, labor and land are the most important production factors for farmers' livelihood decision-making. Therefore, two observation variables are set in this paper: household labor allocation change and land management scale.

In terms of policy tools, subsidies, as a behavioral regulation mechanism, can effectively regulate farmers' behavior. As the differential game results, even in the case of non-cooperative games, as long as the government provides certain subsidies, it can also play a role in guiding farmers to optimize the planting structure. In addition, it is also effective in supporting farmers' participation in rural cooperatives and building demonstration projects. For example, Northeastern China has achieved good results by guiding farmers to join agricultural cooperatives or sublease land to agricultural cooperatives. Therefore, Producer subsidy policy and model policy can serve as effective expressions of policy tools.

In terms of the decision-making environment, the results of the differential game show that the costs and benefits farmers pay for optimizing their planting structure reflect their ability to resist risks and their expectations to maximize household benefits after participating in the cooperation mechanism. The non-agricultural income level of farmers can reflect their part-time work, family opportunity cost consumption, and their level of risk cost sharing, which can be regarded as the internal environment for decision-making on the optimization of planting structure. What is more, market sales prospects, especially changes in the sales methods of agricultural products, reflect the possibility of relying on Internet tools, rural financing, and so on to optimize agricultural product sales channels and improve bargaining power to increase sales revenue, which is the external decision-making condition. Therefore, we choose changes in non-agricultural income and marketing pattern changes to represent the decision-making environment.

4.2. Study Area and Data Source

4.2.1. Study Area

Keshan County in Heilongjiang Province, China, is located on the southern edge of the Lesser Khingan Mountains and the northern part of Songnen Plain (Figure 3). It has a temperate continental monsoon climate with an average annual temperature of 2.4 °C, and most of the rain falls between June and August. The deep and nutrient-rich black soil is suitable for the growth of various crops, making it dominated by traditional agriculture, with the main crops including corn, soybeans, potatoes, and rice. Hence, Keshan County becomes a key national commercial grain base. In order to further improve the agricultural and rural industrial structure and increase farmers' income, combined with the research results on the layout optimization of cultivated land utilization in Keshan County, Heilongjiang Province, in 2018 [40], towns and villages were used as the specific implementation units for the cultivated land utilization layout adjustment, and stable rice production areas, corn and soybean rotation areas, corn advantageous areas and soybean advantageous areas were respectively established.

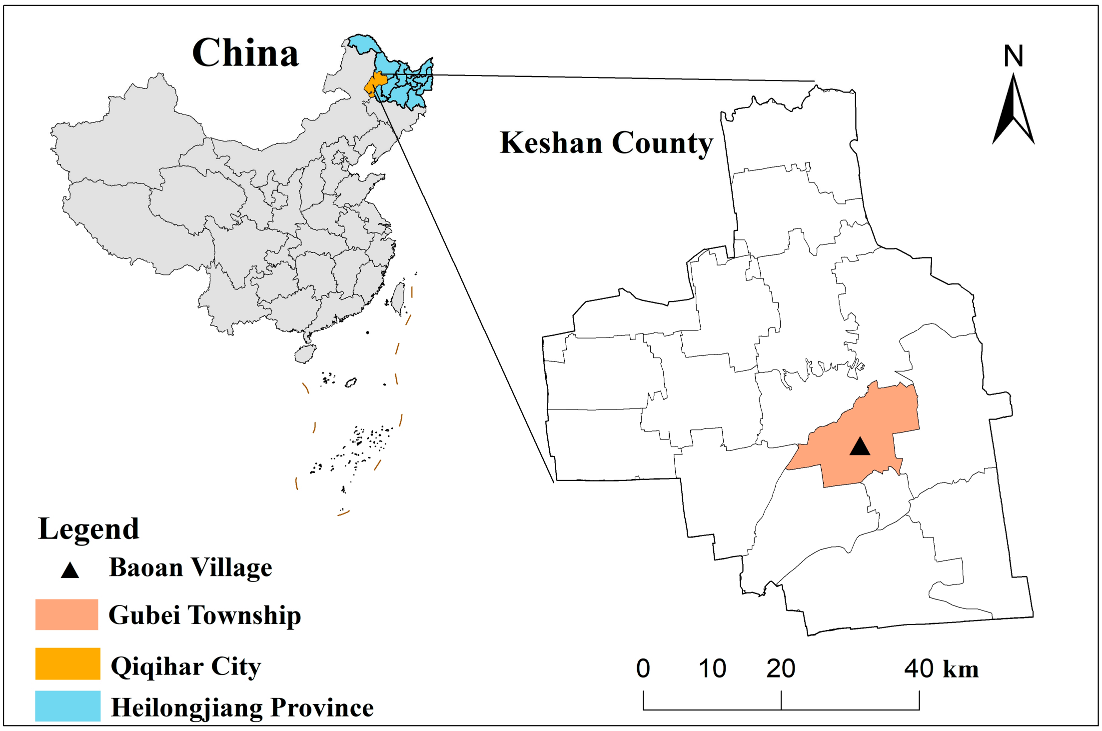

Figure 3. Study area.

4.2.2. Data Source and Processing

The data required for this paper are the variables selected in the above model, and the sample selection needs to follow the case selection principle of the QCA method to ensure sufficient homogeneity of the case population and the heterogeneity and depth of the cases. China Rural Fixed Observation Point Data is a year-by-year tracking survey database at the level of rural households led by the Ministry of Agriculture and Rural Development, which is nationally representative and authoritative. This data set includes individual and household endowments, agricultural production, and the land use of farmers. Further, in order to connect the research team's achievement on the optimization of planting structures in Keshan County, Baiquan County, and Yi'an County, Bao'an Village was selected as the research area of this paper since it is the only fixed observation point in the region. Meanwhile, Because of the path-dependent and lagging characteristics of farmers' behavior, 50 survey samples were selected from the target area of maize reduction-soybean expansion in Keshan County as cases from 2018–2020, forming a case bank. The connotation, measurement, and descriptive statistical analysis of these indicators are shown in Table 1.

According to the survey results of China Rural Fixed Observation Point Data of 50 households screened out, and related variables were refined into 1 and 0 dichotomous variables of Boolean values. And then, the attributive degree of the result variables and condition variables was calibrated (Table 2).

Table 1. The connotation, measurement, and descriptive statistics of variables.

Condition Variable	Measurement Items	Index Definition and Assignment	Mean	S.D.
Subject willing (SW)	Multi-agent participation (MAP)	Participation in agricultural training, agricultural vocational education, farmers' cooperative organizations, and service scale operation: none = 1, one = 2, two = 3, all included = 4	0.12	0.44
	Land transfer contract (LTC)	Land transfer out for two consecutive years or more = 1, land transfer in for 2 consecutive years or more = 2, self-farming or land transfer in or not or less than 1 year = 3	1.36	0.63
Factor allocation (FA)	Household labor force (HLF)	Stable increase in household labor = 1, stable decrease in household labor = 2, stable constant household labor = 3, either increase or decrease in household labor = 4	3.24	0.89
	Land management scale (LMS)	Maximum operation scale (contracted land scale + transferred in land − transferred out land); (0, 2] = 1, (2, 5] = 2, (5, 10] = 3, over 10 = 4	1.68	1.20
Decision-making environment (DE)	Non-agricultural income (NAI)	Change in non-agricultural income; stable increase = 1, stable decrease = 2, stable no change = 3, or increase or decrease = 4	1.86	1.31
	Marketing pattern changes (MPC)	Largest proportion of sales that have shifted from land negotiation to booking contract sales or company + farmers form; (0, 0.25] = 1, (0.25, 0.5] = 2, (0.5, 0.75] = 3, (0.75, 1] = 4	2.12	0.80
Policy tool (PT)	Producer subsidy policy (PSP)	Whether there is a production subsidy policy such as subsidies for the purchase of agricultural machinery and the subsidies for production chain operation to guide soybean cultivation; yes = 1, no = 0	0.90	0.30
	Model policy (MP)	Is a demonstration project to guide the optimization of planting structure; yes = 1, no = 0	0.18	0.39

Table 2. Definition of condition variable and its binary encoding.

Variable Type	Variable Name		Define Variables and Code	
			Coded as 1	Coded as 0
Outcome variable	Realize the optimization of planting structure (RO)		Consistent with the goals	Other
Condition variable	Subject willing (SW)	Multi-agent participation (MAP)	Intervention by other subjects	Less help from other subjects
		Land transfer contract (LTC)	Two or more consecutive years of land transfer out or in	Self-cultivated or transferred land in and out for less than one year
	Factor allocation (FA)	Household labor force (HLF)	Stable family workforce scale	Decrease or increase in household labor force
		Land management scale (LMS)	Maximum land operation scale < 1/3 hectare	Maximum land operation scale ≥ 1/3 hectare
	Decision-making environment (DE)	Non-agricultural income (NAI)	Steady increase in non-agriculture income	Other
		Marketing pattern changes (MPC)	Over half of the agricultural products are sold under pre-order contracts or as company–farmer sales.	Land is maintained primarily for the purposes of negotiating sales.
	Policy tool (PT)	Producer subsidy policy (PSP)	Subsidies are available to assist with optimizing the planting structure	Subsidies without guided planting structure optimization
		Model policy (MP)	Demonstration projects for guided planting structure optimization	No planting structure optimization demonstration project

4.3. Empirical Results

The consistency can reflect the extent to which the antecedent conditions are necessary conditions for the outcome, while the coverage rate can reflect how many cases can explain the necessity of the antecedent conditions [41]. When the consistency is 1, the antecedent condition is an absolutely necessary condition for the outcome. However, the data in social science often deviate from the perfect subset relationship, so we set the baseline of consistency to 0.9.

Table 3 shows the consistency and coverage of the antecedent condition necessary for three different paths. Since the consistency of the producer subsidy policy (PSP) exceeds 0.9, it becomes necessary to achieve the grain planting structure optimization goals. The coverage rates of other conditional variables are lower than 0.75, which indicates that the sufficiency of the outcome variables is still dependent on the condition variables configuration analysis.

Table 3. Analysis of the necessity of condition variables.

Condition Variable	Consistency	Coverage
Multi-agent participation (MAP)	0.413793	0.631579
Land transfer contract (LTC)	0.862069	0.543478
Household labor force (HLF)	0.413793	0.705882
Land management scale (LMS)	0.586207	0.531250
Non-agricultural income (NAI)	0.620690	0.580645
Marketing pattern changes (MPC)	0.379310	0.578947
Producer subsidy policy (PSP)	0.931035	0.600000
Model policy (MP)	0.137931	0.444444

After using fsQCA 3.0 software to perform standard analysis on the calibrated variables, three types of solutions for different paths can be obtained: complex solutions, concise solutions, and optimized solutions. We set the consistency threshold to 0.8 and conducted core–auxiliary condition analysis on the antecedent condition configurations of the three types of solutions [42]. "●", "•", "⊗" and space represent core conditions, auxiliary conditions, no condition variables and variables dispensable respectively. The condition variables in the parsimonious solution are set as core conditions, and the conditions that appear in the intermediate solution but are eliminated by the parsimonious solution are set as auxiliary conditions to obtain six configurations. In terms of the substitution relationship between NAI and ~HLF in Configurations 5 and 6, the effective configurations to achieve the grain planting structure optimization goals could be simplified to 5. Configurations 5 and 6 have the same parsimonious solution, and both follow the same core path, LMS*~PSP. Therefore, these two configurations were combined into the Configuration 5 (~HLF*LMS*~PSP/LMS*NAI*~PSP $\rightarrow$ LTC*~HLF* LMS*NAI*~MPC*~PSP*MP). Table 4 shows the configuration analysis results of the core–auxiliary conditions for realizing the government–farmer cooperation mechanism.

The results of the Configuration analysis in Table 4 show that the overall solution has a coverage and consistency of 0.8 or more, indicating that the combination of the conditional variables has a high explanatory power for the outcome variables. Increasing the consistency threshold to 0.9 resulted in a coverage of 0.862019 with a consistency of 1. The results of the combination of the conditional variables did not differ from the original combination, proving that the results of the histological analysis were robust [41,43].

Table 4. Configuration analysis results.

Condition Variable		Configuration 1	Configuration 2	Configuration 3	Configuration 4	Configuration 5
Subject willing (SW)	Multi-agent participation (MAP)	⊗	●	⊗	•	
	Land transfer contract (LTC)	•	•	•	⊗	•
Factor allocation (FA)	Household labor force (HLF)	•	⊗	●		⊗
	Land management scale (LMS)	⊗			●	●
Decision-making environment (DE)	Non-agricultural income (NAI)	⊗	●	●	●	●
	Marketing pattern changes (MPC)		⊗	⊗	●	⊗
Policy tool (PT)	Producer subsidy policy (PSP)	●	•	•	•	⊗
	Model policy (MP)	⊗	⊗	⊗	⊗	•
Consistency		1	1	1	1	1
Raw coverage		0.206897	0.241379	0.206897	0.172414	0.068965
Unique coverage		0.137931	0.103448	0.103448	0.103448	0.103448
Solution consistency				0.962963 (1)		
Solution coverage				0.896552 (0.862019)		

4.4. Implementation Path Analysis of Government–Farmer Cooperation Mechanism

In order to better identify the differences between different paths, we further summarize the implementation paths of the government–farmer cooperation mechanism into three categories based on the logical characteristics displayed by the above five configurations.

Path 1: Led by external policy tools. This path corresponds to the Configuration 1. It is believed that productive subsidies are conducive to increasing farmers' enthusiasm to participate in planting structure optimization, including agricultural machinery purchase subsidies and production operation subsidies [44–46]. Meanwhile, in this path, "subject willing + factor allocation" should be the auxiliary conditions, which indicates that strengthening multi-agent collaboration, guiding multi-agent cooperation through scientific and technological investment, agricultural technology promotion, farm protection training, and new-type farmer cultivation, optimizing the scale of the labor force and implementing scientific and orderly land transfer are all effective ways to optimize the planting structure. This path is suitable for large-scale farmers since the scale economy effect brought about by scale production under the influence of producer subsidies can resist the internal and external environment of farmers' decision-making.

Path 2: Linkage guidance between decision-making environment and subject willingness. This path corresponds to the Configuration 2. In this path, subject participation willingness and the non-agricultural income increase in farmers are the core conditions for optimizing grain planting structure. The analysis of this configuration highlights that the subject participation and the increase in non-agricultural income are the core conditions [47], meaning their planting restructuring decisions are not only influenced by household decision-making environments but also highly correlated with external factors [48,49]. On the one hand, under the cooperation among multiple subjects, guidance measures such as agricultural extension and training, cultivated land protection training, and new farmer cultivation are conducive to optimizing farmers' planting behavior. On the other hand, raising the non-agriculture income of farm households in impoverished areas is also an essential and sufficient condition. Some studies have demonstrated that increasing farmers' income levels significantly impacts the expansion of soybean planting areas, yield, and income [50]. Improving the linkage guidance between non-agricultural income and agricultural production is an effective means to optimize the planting structure when there is limited room for adjustment of the planting structure [51,52]. Therefore, this path is particularly suitable for farmers or rural elites with higher levels of human capital and fewer aging problems. These farmers can serve as the leaders in optimizing the planting structure and exert the demonstration effect and scale effect of grain planting. In addition, when comparing Configuration 2 and Configuration 3, the substitution between multi-agent participation (MAP) and Household labor force (HLF) indicates that a higher degree of subject participation can relax the constraint of labor force size and the stability of labor force size is also beneficial for reducing the organizational cost brought about by multi-subject collaboration.

Path 3: Factor allocation and environmentally driven decision-making. This path corresponds to Configuration 3–5. In this path, the increase in non-agricultural income is the core condition, which aligns with the current views that increasing farmers' income has a significant impact on the expansion of soybean planting area, yield, and income [53]. The government should comply with the adjustment mechanisms and constraints of farmers' factor input structure and create a good decision-making environment. In situations where agricultural labor has not significantly decreased, orderly promoting land transfer, stabilizing the scale of family labor, and improving agricultural product marketing models are practical approaches to achieving an optimal land use layout. Small-scale farmers are ideally suited for this path because of the current land transfer situation, the willingness to produce food, and the availability of non-agricultural employment in the Northeast of China [54,55]. Additionally, for small-scale farmers, moderate producer subsidies and demonstration policies can play a role in guiding farmers' behavior toward optimizing planting structures. Moreover, by comparing this path with Configuration 1, we can find that the factor allocation and decision-making environment optimization for farmers can overcome the challenges associated with higher system costs and organizational costs brought about by producer subsidies. In addition, the substitution of Non-agricultural income (NAI) and Household labor force (HLF) shows that when it is difficult to increase non-agricultural income for small-scale farmers, optimizing household labor allocation is also an alternative to ensure the realization of planting structure optimization goals.

5. Discussion

The challenges faced by farmers and the government in realizing grain planting structure optimization goals can be viewed from two aspects. Firstly, from the perspective of farmers, according to the externality theory and agricultural production practices, optimizing planting structure is beneficial for promoting rational utilization and protection of cultivated land. However, this benefit cannot significantly increase farmers' short-term income, and the imbalance between cost internalization and benefit externalization can hinder the realization of grain planting structure optimization goals and diminish farmers' enthusiasm for adjusting their planting behaviors [56]. Secondly, from the perspective of government, the performance appraisal systems that primarily prioritize economic development tend to encourage unreasonable competitive behavior in which local governments pay too much attention to grain production while neglecting the rational utilization and protection of cultivated land. This, in turn, hinders non-grain governance and land protection efforts as the government lacks motivation in policy implementation and administrative supervision [57]. Therefore, to ensure the realization of grain planting structure optimization goals, it is difficult to rely solely on the farmers' own willingness to limit the methods and levels of agricultural inputs, given the level of agricultural development and farmers' cognition. It is necessary to regulate farmers' production by restricting the basic policy benefits and reduce negative externalities in the process of production. Meanwhile, constraining the agricultural production process is inseparable from the implementation of government policies and the adjustment of management strategies, thereby establishing a government–farmer cooperation mechanism where both parties coordinate, respond to each other, and drive progress together.

Regarding the connotation of the government–farmer cooperation mechanism, previous research has predominantly focused on some fields, including rural grassroots governance [58], farmland green protection [59], and agricultural industry development [60]. These studies have explored the allocation of rights, responsibilities, and interests among farmers, the government, and other stakeholders, aiming to depict the logic of their interaction. However, achieving the goals of optimizing planting structure is not limited to the adjustment of farmers' planting structure on a single plot of land but occurs at any time within the framework of the interrelation and joint interaction of regional natural, economic, and social subsystems spurred by human activities. To this end, we divided the intricate system of government–farmer cooperation mechanism into two components: an inner system with the "man-land" composite system as the core and an outer system composed of natural, economic, and social subsystems. The inner core and outer fringe systems, along with their constituent factors, as well as the coordination and mutual responsiveness between the internal and external systems, collectively drive the achievement of the goals. This theoretical framework serves as a foundation for constructing an effective government–farmer cooperation mechanism.

The related literature is rich in discussion on cultivated land utilization and management in conjunction with optimization of planting structure. Among them, the majority of these studies focused on examining the influence of climate and market changes, farmers' endowments and personal preferences, and tenure stability on planting behaviors [61,62]. Despite this body of research, there is a lack of systematic integration of various complex influencing factors to provide specific recommendations that can be practically implemented. What is more, existing research has shown that achieving the optimization goals and improving the cultivated land utilization management mechanism requires analysis of multi-stakeholder interactions, internal and external decision-making environments, and natural resource endowments [40]. Although some have explored the two perspectives of individual behavior and group behavior interaction, there is a need to further analyze how to pay more attention to the behavioral characteristics of individuals and groups in the context of collective action., and analyze the specific implementation path of management plans.

To this end, on the basis of clarifying the connotation of the government–farmer cooperation mechanism, we designed interactive scenarios between farmers and the government, analyzed the influencing intensity and pathways through which various factors influence the mechanism, and revealed the practical pathways of government–farmer cooperation mechanism under differentiation and heterogeneity of farmers and environments. Similar to existing research, we also affirmed the key role of policy factors in promoting the optimization of grain planting structure and further take into account the lag in information collection, risk-averse personality, and lag in the decision-making behavior of farmers in economically underdeveloped areas [63]. In addition, although there has been extensive research on farmers' differentiation and heterogeneity, this impact is not singular, and the adjustment of planting structure itself embodies the differentiation characteristics and heterogeneity of farmers. Therefore, the government should focus on adaptive management strategies during policy implementation and conduct path analysis for small farmers, elites, and large-scale operators. Moreover, our findings reinforced the impact of non-agricultural income, policy factors, and farmland transfer on planting structure adjustment decisions in previous studies [64], which further clarified the necessity of differentiated paths for policy implementation.

These findings have some policy implications.

Firstly, the government should place importance on monitoring cultivated land use activities to ensure the scientific goal of optimizing the planting structure. Regular monitoring of actual cultivated land use through remote sensing is essential, particularly in areas where there is a high likelihood of marginal cultivated land conversion. A balanced and collaborative analysis of the relationship between food security and regional development is also allowed, with specific attention given to replanning marginal cultivated land in less developed areas. Starting from the one-to-one correspondence between crop planting and cultivated land use, establish systematic methods and standards for planting structure optimization, dynamically take into account the production objectives, environmental factors, management techniques, and multi-subject interest coordination of cultivated land use, determine the suitability range and acceptable change interval of planting optimization, and form a development idea of gradual promotion and dynamic feedback.

Secondly, the government should actively explore and integrate socialized service providers in agricultural production and scientifically guide farmers to carry out production factor allocation. Meanwhile, the government should also provide guidance to farmers on the scientific and organized cultivation of food, thereby establishing an agricultural service chain that systematically guides them in adopting scientific planting methods, fine cultivation management practices, and advanced cultivation technologies. Additionally, the government should prioritize the demonstration planting of new varieties of target crops and the implementation of dense planting techniques to ensure high yields and quality during the planting stage. To promote sustainable crop planting, comprehensive efforts should be made to combine and implement agricultural production technologies such as water-saving irrigation and ecological agriculture. It is important to research, develop, and promote efficient, convenient, and environmentally friendly pesticides and herbicides with minimal losses. Moreover, increasing the application of organic and ecological fertilizers as alternatives to conventional fertilizers is crucial. The optimization of cultivated land use and management practices, tailored to regional resource advantages and market conditions, should be pursued. This entails determining the appropriate scale of operations based on local circumstances, as well as strengthening the overall allocation and systematic development of all elements involved in cultivated land use. These actions will contribute to the true promotion of "grain storage through technology".

Thirdly, the government should optimize the management system of policy subsidies. On the one hand, it is necessary to coordinate the policies for cultivated land protection and subsidies for grain producers by introducing a dual evaluation system that considers the actual situation of cultivated land protection. This system should also include a stronger emphasis by local governments on achieving the goal of optimizing the planting structure. In addition, it is important to explore the implementation of a regional transfer payment system for subsidies. On the other hand, the grain planting subsidy policy should be directed toward supporting the transformation toward large-scale operations. This can be accomplished by differentiating the yield characteristics and quality traits of grain crops, thereby enhancing the role of agricultural subsidy policies in promoting further advancements in grain production. Furthermore, efforts should be made to promote the dissemination and popularization of different varieties of crops and guide farmers in selecting and applying new varieties. Other policy incentives, such as narrowing the profit gap between grain planting and cash crop cultivation, restraining the expansion of non-grain crops, and increasing farmers' willingness to participate in the optimization of planting structure, can also be implemented.

Fourthly, farmers' property income should be increased. By considering the regional characteristics of resources, innovative models of agricultural development benefits such as village collectives and farmers' share cooperation, joint savings, and equal shares should be implemented. These models can effectively guide industrial and commercial capital investment while reducing the demand for labor costs and human capital during the process of optimizing grain production and planting structure. This will contribute to improving the livelihood capital conditions of rural farmers. Furthermore, efforts should be made to identify the complex social issues in impoverished areas and support the transfer of the rural labor force. By leveraging agricultural economic development and structural adjustments to drive employment growth, a stable labor supply can be ensured. This will help optimize the scale and quality of agricultural practitioners.

6. Conclusions

Optimizing the planting structure is a crucial measure to address the structural imbalance between national grain supply and demand. However, simply focusing on improving planting technologies or implementing management strategies is insufficient for effectively guiding farmers. In particular, by relying solely on the effect of policy subsidies, it is difficult to find a focus in the actual work to promote the goal realization of optimizing the planting structure. To address this challenge, we examined optimal strategies, benefits, and overall system benefits for both the government and farmers within three different scenarios: the Nash non-cooperative game, the Stackelberg game, and the collaborative cooperation game. We developed a cooperative mechanism to ensure the achievement of goals related to optimizing the planting structure. Additionally, by conducting a case study on the behavior of farmers at the village level, we employed the csQCA method to explore various pathways that ensure the smooth functioning of the cooperative mechanism. This approach aligns with the principle of upholding the central role of farmers and promoting coordination among social, economic, and natural environments and farmers' livelihoods.

The game analysis results demonstrate that several key factors influence the establishment of the cooperative mechanism. These factors include the costs for farmers to adjust their planting structure and government management, the participation willingness of farmers and government, and the impact of the efforts or passive participation of the government and farmers on the cooperation mechanism. Of particular importance is the focus on the costs borne by farmers when adjusting their planting structure. If the government can share a portion of these costs in the early stages, it will enhance farmers' motivation to participate in the project. This, in turn, will lead to increased optimal benefits and system benefits for both parties. In addition, compared to a non-cooperative relationship, a controller–worker relationship between the government and farmers may not alter the government's efforts significantly. However, it can significantly enhance farmers' efforts to adjust the planting structure. The magnitude of improvement is directly proportional to the government's subsidy ratio to farmers' costs, which shows that the government's optimal subsidy is beneficial in reducing system costs. Furthermore, government–farmer cooperation surpasses non-cooperative relationships in terms of participation efforts from both parties and overall system benefits. This cooperative approach achieves strict Pareto optimality for the system. Therefore, prioritizing the establishment of collaborative cooperation is crucial for ensuring the realization of goals related to optimizing the planting structure.

Furthermore, in economically underdeveloped grain-producing areas, there are three distinct paths for different types of farmers to adapt to the optimization of planting structures. These paths include the following: being led by external policy tools, linkage guidance between the decision-making environment and willing subject, factor allocation, and environmentally driven decision-making. Among them, the producer subsidy-led type is well-suited for large-scale operating farmers who possess extensive planting areas. Subsidies can significantly reduce their production operation costs, mitigate market risks, and alleviate financial risks. The decision-making environment and subject cooperation linkage type are more suitable for farmers with a high level of household human capital, minimal aging issues, or those who are considered rural elites. These farmers can serve as effective demonstration models, and the non-agricultural income generated from this type of cooperation can also enhance their families' livelihoods. The factor allocation and environmentally driven decision-making type is suitable for small-scale farmers. In this study case, the cultivated land of small-scale farmers is loosely distributed but large in quantity. Farmers often have the right to use marginal cultivated land. Promoting land transfer, rational use of basic conditions such as relatively high institutional costs for cultivated land, and a stable family labor force can effectively reduce the organizational cost problems caused by the coordination of multiple entities.

This study still has several limitations that could be addressed and improved upon in future research. First of all, we only explored the static relationship between the configuration of various influencing factors and farmers' participation in planting structure optimization, but its dynamic and continuous process is also worth exploring. We can use the time series QCA method to deeply explore the complex impact of the evolution of different condition configurations on farmers' participation in planting structure optimization. Secondly, since the data collected by the questionnaire have the advantage of being structured, they also have the disadvantage of not yielding a more in-depth analysis and detailed display of the cases. In the future, one could use grounded theory or combine it with public case libraries to collect and analyze data.

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Institutional Review Board Statement: Ethical review and approval were waived for this study due to: 1. This survey from which the historical data relevant to our research comes is formulated in accordance with the relevant provisions of the "Statistics Law of the People's Republic of China" and is officially approved and implemented by the National Bureau of Statistics. (The approval code is国统制〔2016〕149号). 2. It is a nationwide fixed work with strong support from the central government and local governments (see the official website of the Ministry of Agriculture and Rural Affairs of China: https://www.moa.gov.cn/nybgb/2015/shiyiqi/201712/t20171219_6103892.htm (accessed on 7 March 2024)). 3. The historical data in this survey have been published in books, and its ethical issues have been reviewed by various departments before release (ISBN: 9787109232242). 4. This is an anonymous social survey only for adults, which only involves information such as age, work, and living conditions, does not involve personal privacy and state secrets or endangers the personal mental and physical health of adults. Adults have full cognitive ability. This research was conducted when adults fully understood the purpose of the research and was voluntary. It may not involve ethical issues.

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References

1. Liu, Y.S. Introduction to land use and rural sustainability in China. *Land Use Policy* **2018**, *74*, 1–4. [CrossRef]
2. Su, M.; Guo, R.Z.; Hong, W.Y. Institutional transition transition and implementation path for cultivated land protection in highly urbanized regions: A case study of Shenzhen, China. *Land Use Policy* **2019**, *81*, 493–503. [CrossRef]
3. Yan, S.; Yao, X.; Ma, B. Chinese transnational corporations in the Ukraine crisis: Risk perception and mitigation. *Transnatl. Corp. Rev.* **2022**, *4*, 371–381. [CrossRef]
4. Guo, Q.H. A Discussion on the Quality of Farm Land in the Primary Grain Producing Areas in Northeast China. *Agric. Econ.* **2019**, *40*, 89–99.
5. Ministry of Agriculture and Rural Affairs of the People's Republic of China. *Guiding Opinions of the Ministry of Agriculture on the Adjustment of Corn Structure in the "Sickle Bend" Region*; 2017. Available online: http://www.moa.gov.cn/nybgb/2015/shiyiqi/201712/t20171219_6103893.htm (accessed on 7 March 2024).
6. Liu, M.G.; Fang, X.M.; Ren, J.R. Accelerating the modernization of agriculture and rural areas in China. *China Agric. Econ. Rev.* **2023**, *10*, 92. [CrossRef]
7. Bertram, D.; Chilla, T.; Wilhelm, C. Short Value Chains in Food Production: The Role of Spatial Proximity for Economic and Land Use Dynamics. *Land* **2021**, *10*, 979. [CrossRef]
8. Yang, Q.; Zhang, D. The influence of agricultural industrial policy on non-grain production of cultivated land: A case study of the "one village, one product" strategy implemented in Guanzhong Plain of China. *Land Use Policy* **2021**, *108*, 105579. [CrossRef]
9. Ma, X.; Huo, X. Empirical Analysis of Influence of External Regulation on Farmers' Standardized Production Compliance Behavior—A Case Study of Apple Growers. *J. Northwest AF Univ. Soc. Sci. Ed.* **2018**, *18*, 123–130.
10. Huang, L.; Huang, Z.F. Application of in inexact two-phase fuzzy multi-objective programming method to crop area planning. *Resour. Sci.* **2016**, *38*, 2157–2167.

11. Wu, L.; Tian, J.; Liu, Y.; Jiang, Z. Multi-Objective Crop Planting Structure Optimization Based on Game Theory. *Water* **2022**, *14*, 2125. [CrossRef]
12. Liu, J.; Sun, B.; Shen, H. Crop Water Requirement and Utilization Efficiency-Based Planting Structure Optimization in the Southern Huang-Huai-Hai Plain. *Agronomy* **2022**, *12*, 2219. [CrossRef]
13. Peng, J.; Chen, J.; Su, C.; Wu, Z.; Yang, L.; Liu, W. Will land circulation sway "grain orientation"? The impact of rural land circulation on farmers' agricultural planting structures. *PLoS ONE* **2021**, *16*, e0253158. [CrossRef] [PubMed]
14. Song, G.; Ren, G.F. Spatial response of cultivated land use efficiency to the maize structural adjustment policy in the "Sickle Bend" region of China: An empirical study from the cold area of northeast. *Land Use Policy* **2022**, *123*, 106421. [CrossRef]
15. Liu, S.; Zhang, P.; Marley, B.; Liu, W. The Factors Affecting Farmers' Soybean Planting Behavior in Heilongjiang Province, China. *Agriculture* **2019**, *9*, 188. [CrossRef]
16. Habarurema, E.; Steiner, K.G. Soil suitability classification by farmers in southern Rwanda. *Geoderma* **1997**, *75*, 75–87. [CrossRef]
17. Zhong, F.N.; Lu, W.Y.; Xu, Z.G. Is it not conducive to grain production for rural labor to go out for work—Analysis of the Behavior and Constraints of Farmer Factor Substitution and Planting Structure Adjustment. *Chin. Rural. Econ.* **2016**, *7*, 36–47.
18. Moniruzzaman, S. Crop choice as climate change adaptation: Evidence from Bangladesh. *Ecol. Econ.* **2015**, *118*, 90–98. [CrossRef]
19. Feng, X.L.; Liu, M.Y.; Huo, X.X. Influence of Adaptive Behavior to Climate Change and its Spatial Effects on Farmers' Income: Based on the Survey Data of Apple Farmers from 4 Provinces. *J. Agro For. Econ. Manag.* **2016**, *15*, 570–578.
20. Xie, H.L.; Ouyang, Z.Y.; Chen, Q.R. Does Cultivated Land Fragmentation Promote "Non-grain" Utilization of Cultivated Land: Based on a Micro Survey of Farmers in the Hilly and Mountainous Areas of Fujian. *China Land Sci.* **2022**, *36*, 47–56.
21. Cheng, X.Y. Ongoing Land Administration System in China:Reflection and Reconstruction. *China Land Sci.* **2013**, *27*, 15–20.
22. Ying, R.Y.; Zheng, X.Y. Resources Endowment, Factor Substitution and the Transformation of Agricultural Production and Operation: Example from Food Production in Jiangsu and Zhejiang. *Issues Agric. Econ.* **2013**, *34*, 12–24.
23. Yuan, S.; Li, X.; Du, E. Effects of farmers' behavioral characteristics on crop choices and responses to water management policies. *Agric. Water Manag.* **2021**, *247*, 106693. [CrossRef]
24. He, Q.; Guo, M.; Luo, X. Evolutionary Game Analysis of Farmers' Green Production Behavior from the Perspective of the E-Commerce Value Chain. *Econ. Manag.* **2023**, *37*, 40–49.
25. Yan, Y.; Wang, S. Research of agro-ecological non-point source pollution from the perspective of the stakeholder. *J. Chin. Agric. Mech.* **2020**, *41*, 160–167.
26. Shi, Z.; Zhang, K. Effects of social norms on farmers' willingness to plant green manure and behavioral disobedience: From the perspective of resource endowment heterogeneity. *J. China Agric. Univ.* **2022**, *27*, 297–308.
27. Johnson, D.G. Government and Agricultural Adjustment. *Am. J. Agric. Econ.* **1973**, *55*, 860–867. [CrossRef]
28. Po, L. Redefining Rural Collectives in China: Land Conversion and the Emergence of Rural Shareholding Co-operatives. *Urban Stud.* **2008**, *45*, 1603–1623. [CrossRef]
29. Tan, R.; Zhou, T. Decentralization in a centralized system: Project-based governance for land-related public goods provision in China. *Land Use Policy* **2015**, *47*, 262–272. [CrossRef]
30. Chen, Y.; Zhang, P.; Liu, S.; Tan, J. The Spatio-temporal Pattern Change and Optimum Layoutof Grain Production in the West of Northeast China. *Sci. Geogr. Sin.* **2016**, *36*, 1397–1407.
31. Jorgense, S.; Zaccour, G. Time consistent side payments in a dynamic game of downstream pollution. *J. Econ. Dyn. Control* **2001**, *25*, 1973–1987. [CrossRef]
32. Xie, G.; Wang, S.G.; Lai, K.K. Quality improvement in competing supply chains. *Int. J. Prod. Econ.* **2011**, *134*, 262–270. [CrossRef]
33. Zhu, G.J.; You, D.M. Ecological R&D Strategy and Coordination Mechanism in the Green Supply Chain Based on Differential Games. *Oper. Res. Manag. Sci.* **2017**, *26*, 62–69.
34. Yanase, A. Global environment and dynamic games of environmental policy in an international duopoly. *J. Econ.* **2009**, *97*, 121–140. [CrossRef]
35. Xu, S.H.; Han, C.F. Study on Basin Ecological Compensation Mechanism based on Differential Game Theory. *Chin. J. Manag. Sci.* **2019**, *27*, 199–207.
36. Steffen, J.; Sihem, T.; Georges, Z.; Georges, Z. Retail promotions with negative brand image effects: Is cooperation possible? *Eur. J. Oper. Res.* **2003**, *150*, 395–405.
37. Rihoux, B.; Ragin, C.C. *Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques*; Sage Publications: New York, NY, USA, 2008.
38. Lu, N.; Wei, H.; Fan, W.; Xu, Z.; Wang, X.; Xing, K.; Dong, X.; Viglia, S.; Ulgiati, S. Multiple influences of land transfer in the integration of Beijing-Tianjin-Hebei region in China. *Ecol. Indic.* **2018**, *90*, 101–111. [CrossRef]
39. Xie, H.; Lu, H. Impact of land fragmentation and non-agricultural labor supply on circulation of agricultural land management rights. *Land Use Policy* **2017**, *68*, 355–364. [CrossRef]
40. Zhang, H.; Song, G. Cultivated Land Use Layout Adjustment Based on Crop Planting Suitability: A Case Study of Typical Counties in Northeast China. *Land* **2021**, *10*, 107.
41. Ragin, C.C. *Redesigning Social Inquiry: Fuzzy Sets and Beyond*; University of Chicago Press: Chicago, IL, USA, 2008.
42. Fiss, P.C. A Set-Theoretic Approach to Organizational Configurations. *Acad. Manag. Rev.* **2007**, *2*, 1180–1198. [CrossRef]
43. Du, Y.; Liu, Q.; Cheng, J. What Kind of Ecosystem For doing Business Will Contribute to City-level High Entrepreneurial Activity? A Research Based on Institutional Configurations. *J. Manag. World* **2020**, *36*, 141–155.

44. Young, C.E.; Westcott, P.C. How decoupled is US agricultural support for major crops? *Am. J. Agric. Econ.* **2022**, *82*, 762–767. [CrossRef]
45. Pan, T.; Zhang, C.; Kuang, W.; Luo, G.; Du, G.; DeMaeyer, P.; Yin, Z. A large-scale shift of cropland structure profoundly affects grain production in the cold region of China. *J. Clean. Prod.* **2021**, *307*, 127300. [CrossRef]
46. Gutner, T. The political economy of food subsidy reform: The case of Egypt. *Food Policy* **2002**, *27*, 455–476. [CrossRef]
47. Popkin, S.L. *The Rational Peasant*; University of California Press: Berkeley, CA, USA, 1979.
48. Ye, C.S.; Ma, Y.T. How Do Human Capital and its Adaptability to Technological Progress Affect Agricultural Planting Structure? *Chin. Rural. Econ.* **2020**, *4*, 34–55.
49. Tian, C.Y.; Xiao, H.F. Producer Subsidies and Planting Structure Adjustment-Based on Simulation Analysis of Farmer Households in "Sickle Bend" Regions. *J. Harbin Inst. Technol. Soc. Sci. Ed.* **2018**, *20*, 132–140.
50. Zhang, J. A Study on the Impact of Soybean Target Price Subsidy System on Farmers' Income: A Quantitative Analysis Based on DID Model. *Financ. Econ.* **2022**, *5*, 77–86.
51. Hayami, Y.; Ruttan, V.W. *Agricultural Development: An International Perspective*; Johns Hopkins University Press: Baltimore, MD, USA, 1985.
52. Liu, X. Non-Farm Income, Labor Transfer and Planting Structure Adjustment. *Econ. Probl.* **2017**, *3*, 66–69.
53. Zhang, H.; Song, G.; Yao, S. Research on Regulation of Cultivated Land Use Structure in Black Soil Region of Northeast China: Based on Perspective of Grain Planting Structure. *Trans. Chin. Soc. Agric. Mach.* **2022**, *54*, 198–209.
54. Cheng, Y.Q.; Zhang, P.Y.; Zhang, H.M. Variation character of grain yield per unit area in main grain-producing area of Northeast China. *Chin. Geogr. Sci.* **2007**, *17*, 110–116. [CrossRef]
55. Ren, G.F.; Song, G.; Wang, Q.X.; Sui, H. Impact of "Non-Grain" in Cultivated Land on Agricultural Development Resilience: A Case Study from the Major Grain-Producing Area of Northeast China. *Appl. Sci.* **2023**, *13*, 3814. [CrossRef]
56. Zhu, H.J.; Lou, J.; Tian, Z.H. Adjustment of Agricultural Planting Structure: Policy Response, Relative earnings vs. agricultural machinery services-evidence from the adjustment of corn planting area of 541 farmers in Hubei Province. *J. Agrotech. Econ.* **2018**, *1*, 111–121.
57. Li, Y.H.; Du, G.M.; Liu, Y.S. Transforming the Loess Plateau of China. *Front. Agric. Sci. Eng.* **2016**, *3*, 181–185. [CrossRef]
58. Zhang, H.Y.; Li, C.J. Research on risk prevention of multiple subjects participating in rural governance. *Agric. Econ.* **2019**, *3*, 6–8.
59. Sheng, J. The Crops Straw Opening Burning Control Research Based on the government-farmer-enterprise cooperation game. *Chin. J. Agric. Resour. Reg. Plan.* **2015**, *36*, 48–53+66.
60. Lane, B.; Kastenholz, E. Rural Tourism: The Evolution of Practice and Research Approaches—Towards a New Generation Concept? *J. Sustain. Tour.* **2015**, *23*, 1133–1156. [CrossRef]
61. Liu, S.; Zhang, P.; Liu, W.; He, X. Key Factors Affecting Farmers' Choice of Corn Reduction under the China's New Agriculture Policy in the 'Sickle Bend' Areas, Northeast China. *Chin. Geogr. Sci.* **2019**, *29*, 1039–1051. [CrossRef]
62. Tu, Q.L.; Zou, X.Q. The Difference of Subjective Cognition of the Peasants Towards the Security Function of Agricultural Land and its Influence Factors: Based on 506-PeasantsSurvey in Zhejiang, Jiangxi, and Guangxi Provinces. *China Land Sci.* **2012**, *26*, 60–67.
63. Shi, Q.H.; Zhuo, J.W. Farm Household Management Behavior in Grain Production. *Issues Agric. Econ.* **2005**, *4*, 18–22+79.
64. Lindsay, C.; Todman, K.C.; Alice, E.M.; Gil, J.D.B.; Reidsma, P.; Schwoob, M.-H.; Treyer, S.; Whitmore, A.P. Multi-objective optimization as a tool to identify possibilities for future agricultural landscapes. *Sci. Total Environ.* **2019**, *687*, 535–545.