

Article

Impact of Land Trusteeship Interest Linkage Mechanism on Farmers' Income: Based on Contract Theory Perspective

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Abstract

Farmers' income growth is a central issue in consolidating the achievements of poverty alleviation in China and advancing common prosperity. It is also crucial for addressing the imbalance between urban and rural development and promoting agricultural and rural modernization. Based on theoretical analysis and mathematical modeling, this study develops a series of research hypotheses. A two-way fixed-effects model is employed to examine the impact of the land trusteeship interest linkage mechanism on farmers' income growth. Furthermore, heterogeneity analyses are conducted from the perspectives of farmer characteristics, income levels, and crop types, followed by a series of robustness tests. The main findings are as follows: (1) The land trusteeship interest linkage mechanism has a significant positive effect on farmers' income, and this conclusion remains robust after a series of robustness and endogeneity tests. Among the three core components, namely value cocreation, profit sharing, and risk division, all are found to effectively increase farmers' income, with their marginal effects decreasing in sequence. (2) In terms of heterogeneity analysis, from the perspective of farmer types, the interest linkage mechanism has the most significant income-enhancing effect on large-scale specialized farmers, followed by small-scale full-time farmers and part-time farmers. From the perspective of income structure, the effect is mainly reflected in the increase in agricultural operating income, followed by wage income and transfer income. Regarding crop types, the income growth effect is more pronounced for vegetable producers than for wheat and maize producers. Based on these findings, efforts should focus on strengthening the interest linkage mechanism through enhanced value cocreation while implementing targeted and differentiated support measures for small-scale full-time farming households and vegetable growers. Particular attention should be paid to improving their operating income in order to maximize the income growth effects for farmers. This study provides important insights for improving mechanisms through which agricultural enterprises link with and benefit farmers, thereby contributing to the realization of China's strategic goal of common prosperity.

Keywords: interest linkage mechanism; land trusteeship; agricultural enterprises; farmers; income growth effect; common prosperity



Academic Editor: Hossein Azadi

Received: 16 June 2026

Revised: 15 July 2026

Accepted: 22 July 2026

Published: 23 July 2026

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1. Introduction

Achieving common prosperity for all people is an essential requirement of socialism, while agricultural and rural modernization and sustained farmers' income growth represent critical challenges in realizing this objective. In the context of comprehensively advancing the Rural Revitalization Strategy, guiding industrial and commercial capital entering rural areas has become an inevitable choice for activating rural resource factors, addressing weaknesses in agricultural development, and building a modern agricultural industrial system. Particularly within the broader context of common prosperity, the inflow of capital into rural areas not only follows the market logic of pursuing economic returns but is also entrusted with the social responsibility of linking with and benefiting farmers. In recent years, driven by both policy support and market incentives, capital has increasingly flowed into rural areas on a large scale, particularly into the field of land trusteeship [1]. However, an inherent tension exists between the profit-seeking nature of capital and the vulnerability of agriculture, as well as the relatively disadvantaged position of farmers. In practice, the inadequacy of the interest linkage mechanism often leads to situations where enterprise owners reap substantial benefits while farmers receive limited returns or even incur losses. As a result, the extent to which industrial and commercial capital entering rural areas has genuinely promoted farmers' income growth has become an urgent issue that warrants careful examination [2]. Whether industrial and commercial capital entering rural areas can generate positive outcomes for farmers largely depends on the establishment of a fair and effective interest linkage mechanism [3]. Existing income enhancement measures are often characterized as "transfusion-based" approaches that provide external support, whereas the interest linkage between farmers and land trusteeship enterprises constitutes a sustainable "blood-generating" mechanism that promotes long-term income growth [4]. Against the backdrop of the rapid development of land trusteeship, land trusteeship enterprises have gradually established interest linkage mechanisms with farmers. Therefore, an important question arises: To what extent does the land trusteeship interest linkage mechanism promote farmers' income growth? This constitutes the central research question of the study.

Scholars have extensively examined interest linkage mechanisms in land trusteeship from different perspectives, levels, and fields, focusing on its forms, challenges, operational mechanisms, and policy responses. Existing studies suggest that the forms of interest linkage are diverse and complex. Due to the low level of asset specific investment, high behavioral uncertainty, and relatively weak contract compliance awareness among smallholders, most forms of interest linkage between land trusteeship enterprises and farmers fail to establish stable contractual relationships [5]. Moreover, the degree of farmers' contract compliance significantly influences enterprises' land leasing decisions, thereby leading to dynamic adjustments in the operational boundaries of enterprise man-aged farmland [6]. To strengthen and stabilize the interest linkage between land trusteeship enterprises and farmers, scholars have argued that relationship governance mechanisms embedded within social networks are essential [7]. Based on this perspective, an "enterprise + village collective + farmers" interest linkage model, with the village collective serving as an intermediary, has been developed and explored [8]. However, existing interest linkage mechanisms still face several challenges, including inequitable benefit distribution arrangements, inadequate incentive or constraint mechanisms, and insufficient development of benefit protection systems [9]. To address these issues, it is necessary to broaden farmers' perspectives through service-based linkages and promote the expansion of the interest linkage mechanism from the production level to the broader industrial chain and value chain. Such efforts can enhance farmers' capacity to participate in development processes while prioritizing support for various business entities to accelerate the development of

agricultural producer services [10]. Research on farmers' income growth has primarily focused on three areas: the allocation of agricultural production factors at the household level, industrial and organizational development, and the income-enhancing effects of agricultural or rural policies. At the micro level, the optimal allocation of agricultural production factors constitutes an endogenous driving force for farmers' income growth, including labor factors [11], land factors [12], capital factors [13], and technological factors [14]. Improvements in the allocation and utilization efficiency of these factors can significantly enhance farmers' income generating capacity. At the meso level, the development of agriculture-related industries and rural organizations represents an important determinant of farmers' income. Existing studies have shown that the development of the land trusteeship service industry [15], rural e-commerce [16], and rural industrial integration [17] can significantly increase farmers' income. In addition, participation in rural organizations, such as farmers' specialized cooperatives [18] and rural professional associations [19], has also been found to promote farmers' income growth. However, some studies have found that cooperative-owned enterprises do not significantly promote farmers' income growth overall [20]. At the macro level, the implementation of agricultural and rural policies constitutes an important exogenous force driving farmers' income growth. Empirical evidence indicates that policies such as grain subsidies [21], the Grain for Green Program [22], education-based poverty alleviation initiatives [23], and farmland fallow programs [24] have generated significant income-enhancing effects for rural households. These findings highlight the important role of public policy interventions in improving farmers' income.

Despite the growing body of literature, several limitations remain. First, research examining the income effects of interest linkage is still limited. The existing studies primarily focus on interest linkage in the contexts of agricultural industrialization and organizational arrangements, whereas evidence regarding the income effects of service-oriented interest linkage remains scarce, particularly in land trusteeship. Second, previous studies have largely emphasized the role of new agricultural business entities in promoting farmers' income growth. However, their capacity to benefit farmers is often constrained. The role of land trusteeship enterprises remains controversial. In recent years, cases of enterprises withdrawing from rural projects before completion have occurred frequently, while concerns persist regarding the potential exploitation of smallholders by capital entering rural areas [25]. Consequently, empirical research on the income effects generated by interest linkage between land trusteeship enterprises and farmers remains insufficient. Third, most existing studies rely on linear regression models. However, relationships among variables in real-world settings are often nonlinear. Conventional regression models generally assume the absence of severe multicollinearity among explanatory variables, whereas substantial interaction effects frequently exist in practice. Machine learning approaches can effectively address regression problems characterized by small samples, multiple variables, and nonlinear relationships. As a result, they can partially mitigate endogeneity arising from omitted variables and reduce parameter estimation bias caused by model misspecification [26].

Based on the above research questions and gaps in the existing literature, this study focuses on the interest linkage mechanism between land trusteeship enterprises and farmers within the context of land trusteeship, with particular attention to its impact on farmers' income growth and the underlying mechanisms through which this impact is realized. Shandong Province, which is at the forefront of land trusteeship service development in China, is selected as the study area. Building upon theoretical analysis, this study develops a series of research hypotheses and constructs an analytical framework consisting of interest linkage level, value cocreation, risk division, and profit sharing. Empirically, a

fixed-effects model is employed to systematically examine the pathways through which the land trusteeship interest linkage mechanism promotes farmers' income growth. In addition, machine learning methods are employed as a complementary predictive exercise to assess the consistency of the empirical patterns identified in the baseline analysis. These analyses provide supplementary evidence on whether the empirical patterns identified in the baseline regression are also captured by alternative nonparametric and nonlinear modeling frameworks. This complementary exercise helps assess the consistency of the observed associations across different methodological approaches.

Compared with the existing literature, this study makes two primary contributions. First, it offers a novel perspective by arguing that the land trusteeship interest linkage mechanism constitutes a positive-sum game rather than a zero-sum game. Previous studies on interest linkage mechanisms have generally viewed the relationship between land trusteeship enterprises and farmers as a zero-sum game, suggesting that increasing farmers' benefits requires enterprises to transfer a larger share of value created along the agricultural value chain. In contrast, this study contends that the interest linkage mechanism not only enables farmers to share in the cooperative surplus but also allows land trusteeship enterprises to maintain or even increase their own returns. Therefore, the land trusteeship interest linkage mechanism can generate mutual benefits for both parties and should be regarded as a positive-sum game. Second, this study employs machine learning methods to validate the empirical findings. By incorporating approaches such as random forest, support vector machine, and neural network models, the analysis reduces the potential unreliability associated with traditional econometric methods that may arise from model misspecification and parameter estimation bias, thereby enhancing the robustness and credibility of the research conclusions.

2. Theoretical Analysis

2.1. Mechanisms Through Which the Land Trusteeship Interest Linkage Mechanism Promotes Farmers' Income Growth: Based on Contract Theory Perspective

Contract theory examines how economic agents coordinate interests and allocate risks through contracts. It holds that under information asymmetry, contracts are not merely exchange tools but governance mechanisms. Incomplete contract emphasizes that due to future uncertainty, contracts inevitably have gaps, making residual control rights crucial [27].

The land trusteeship interest linkage mechanism is a typical contract. The interest linkage mechanism between agricultural enterprises and farmers is a series of institutional arrangements superimposed on the pure market relationship. Through contractual incentives and constraints in terms of price, income, shares, standards, technology, services, organization, and mutual assistance, it regulates farmers' production and operation behaviors, integrates scattered farming operations into a unified and coordinated production and operation system, and thereby connects enterprises and farmers into a close community of shared interests. These arrangements are designed to incentivize and regulate farmers' production and management behaviors, integrate fragmented farming activities into a unified and coordinated production system, and ultimately form a closely connected community of shared interests between enterprises and farmers [28]. The interest linkage mechanism consists of three core dimensions: value cocreation, risk division, and profit sharing [29]. Among them, value cocreation serves as the foundation, risk division provides institutional safeguards, and profit sharing constitutes the core component. The interest linkage can generate significant income-enhancing effects, with the profit generating capacity of participants depending on both the structure of the cooperative alliance and their position within it [30]. Each dimension operates through a distinct pathway.

Value cocreation functions as a cooperative governance mechanism that facilitates joint decision making, information sharing, and production coordination between enterprises and farmers, thereby creating conditions for enhanced productive capacity. Risk division addresses the allocation of uncertainties, including natural, market, and operational risks, across participants through institutional arrangements such as agricultural insurance, risk funds, and contractual guarantees. Profit sharing governs the distribution of cooperative surplus among participants through pathways including guaranteed minimum returns, equity-based dividends, and surplus output sharing. While these three dimensions are complementary, they are conceptually and functionally distinct: value cocreation concerns the conditions under which value can be generated, whereas risk division and profit sharing concern how the generated value and associated uncertainties are distributed among participants. The income-enhancing effects of the interest linkage mechanism arise from the combined operation of all three dimensions, each contributing through its own channel. Therefore, interest linkage in the context of land trusteeship has the potential to promote farmers' income growth. Specifically, the land trusteeship interest linkage mechanism transforms the relationship between farmers and land trusteeship enterprises from a purely market-based transaction into a relatively stable alliance. Through the integration of value cocreation, risk division, and profit sharing, this alliance not only expands the total value created by cooperation but also enables a more favorable distribution of benefits toward farmers. As a result, farmers are able to obtain greater economic returns and achieve sustained income growth. The underlying pathways are discussed below.

First, in terms of value cocreation, farmers collaborate with agricultural enterprises to create value. Specifically, in accordance with the contract terms, farmers provide land resources and part of the labor force and entrust the land to service organizations for cultivation. Farmers contribute land use rights, local agricultural knowledge, and household labor, while trusteeship enterprises provide capital investment, technical expertise, market information, and management services [31,32]. This institutional arrangement facilitates mutual learning, reduces information asymmetry between the two parties, and aligns their production incentives through shared objectives and coordinated actions. The quality of collaboration and institutional coordination define the essence of value cocreation as a governance mechanism. Under this arrangement, productivity gains, technological upgrading, and efficiency improvements are potential consequences of a well-functioning value cocreation pathway. When farmers and enterprises effectively coordinate their production activities and share information and knowledge, the joint production process can generate additional value, thereby establishing an important foundation for farmers' income growth.

Second, regarding risk division, appropriate risk division arrangements and effective production organization models enable the reasonable allocation of natural, operational, financial, and market risks. Land trusteeship contracts generally specify specific measures for risk division. For example, agricultural insurance systems can be established through government policy support and economic compensation mechanisms [33], while the participation of village collectives can help alleviate information asymmetry and moral hazard problems in agricultural insurance. In addition, land trusteeship risk funds may be established, with village collectives taking the lead in allocating a certain proportion of land trusteeship profits to such funds. These risk division arrangements can reduce farmers' exposure to potential losses [34], thereby indirectly promoting income growth and providing an important safeguard for sustainable increases in farmers' income.

Third, regarding benefit sharing, the land trusteeship contract stipulates the objects and proportions of income distribution, including guaranteed minimum returns, share-based dividends, and surplus production sharing [35]. By improving production conditions, promoting large-scale contiguous cultivation, and widely adopting new crop varieties and

advanced technologies, land trusteeship enterprises can achieve both higher yields and greater economic returns. In addition, centralized procurement of agricultural inputs reduces farmers' purchasing costs, while mechanized operations lower labor costs and opportunity costs for full-time farmers and reduce work interruption costs for part-time farmers. Besides earning income from agricultural production and management, farmers may also choose to engage in off-farm employment or work for service organizations to obtain wage income. Regardless of the specific profit-sharing arrangement adopted, farmers are able to benefit from increased economic returns. Therefore, profit sharing represents the core pathway through which the land trusteeship interest linkage mechanism promotes farmers' income growth [3]. The conceptual framework of the relationship between the interest linkage mechanism and farmers' income is presented in Figure 1.

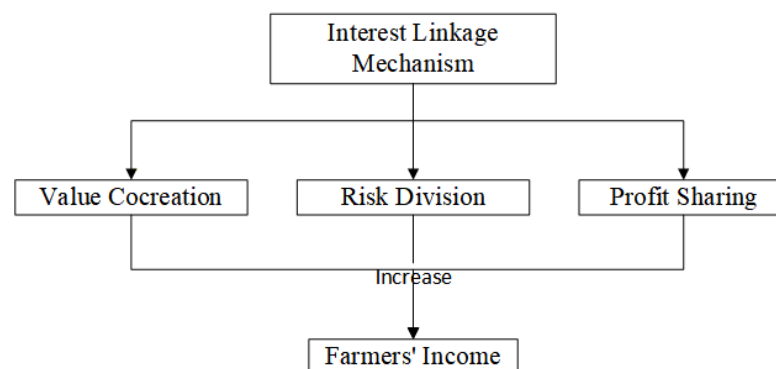


Figure 1. Conceptual framework of this study.

Based on the above analysis, the following hypotheses are proposed:

- H1.** *The land trusteeship interest linkage mechanism positively affects farmers' income.*
- H2.** *The level of value cocreation in land trusteeship positively affects farmers' income.*
- H3.** *The level of risk division in land trusteeship positively affects farmers' income.*
- H4.** *The level of profit sharing in land trusteeship positively affects farmers' income.*

2.2. Mathematical Analysis of the Income Growth Effects of the Land Trusteeship Interest Linkage Mechanism

(1) Model Construction of the Interest Linkage Mechanism Between Land Trusteeship Enterprises and Farmers.

Assumption 1. Existing studies have shown that service cost is a quadratic function of service level, whereas service price is a linear function of service level [36]. Based on this premise, this study assumes that the trusteeship cost incurred by land trusteeship enterprises is a quadratic function of service quality. Since the trusteeship fee charged per unit of land area is linearly related to service quality, the cost of trusteeship services can therefore be expressed as a quadratic function of the trusteeship fee per unit area. Let a represent the trusteeship fee per unit area charged by the agricultural enterprise. Then, the trusteeship cost function can be expressed as $c_1 = \frac{1}{2}b_1a^2$, where $b_1 (0 < b_1 \leq 1)$ represents the coefficient of diseconomies of scale for the agricultural enterprise. The revenue obtained by the agricultural enterprise is $s_1 = An\alpha$, where A denotes the number of farmers served by the trusteeship organization, and n denotes the land area under trusteeship for each farmer.

Assumption 2. Similarly, this study assumes that farmers' production costs are a quadratic function of output. Under self-cultivation, the production cost function of farmers is denoted

by $c_{21} = \frac{1}{2}nb_2q_1^2$, where $b_2(0 < b_2 \leq 1)$ represents the coefficient of diseconomies of scale in farmers' production, and q_1 denotes the output obtained by farmers under self-cultivation. After participating in land trusteeship, the farmers' production cost function is denoted by $c_{22} = \frac{1}{2}n\alpha q_2^2 + n\beta$, where q_2 represents the output obtained by farmers under the land trusteeship arrangement. Farmers are assumed to be price takers in the agricultural product market and therefore passively accept the market price p . Under this assumption, the economic return function of farmers under self-cultivation is denoted by $s_{21} = pq_1$, whereas the economic return function under the land trusteeship arrangement is denoted by $s_{22} = pq_2$. Furthermore, land trusteeship can alleviate agricultural non-point source pollution to a certain extent. Accordingly, the ecological benefit function of farmers is expressed as $s_{23} = \lambda n$, where λ denotes the amount of pesticide and chemical fertilizer inputs saved per unit area under the land trusteeship arrangement.

Assumption 3. Similarly, this study assumes that the coordination cost of intermediary organizations is a quadratic function of coordination quality. Since the coordination fee charged per unit area is linearly related to service quality, the coordination cost can therefore be expressed as a quadratic function of the coordination fee per unit area. Let β represent the service fee charged by the intermediary organization per unit area of trusteeship land. The coordination cost incurred by the intermediary organization is denoted by $c_3 = \frac{1}{2}b_3\beta^2$, where $b_3(0 < b_3 \leq 1)$ denotes the unit cost elasticity coefficient. The annual revenue generated from land trusteeship is denoted by $s_2 = An\beta$.

Based on the foregoing assumptions, the return function of farmers under the land trusteeship can be expressed as Equation (1).

$$\pi_2 = pq_2 + \lambda n - \frac{1}{2}n\alpha q_2^2 + n\beta - pq_1 + \frac{1}{2}nb_2q_1^2 \quad (1)$$

(2) Returns to Land Trusteeship Enterprises and Farmers in the Absence of an Interest Linkage Mechanism. In the absence of an interest linkage mechanism between land trusteeship enterprises and farmers, each party makes decisions independently based on the principle of utility maximization. Under such circumstances, the interactions among the parties exhibit the characteristics of a non-cooperative game. The returns obtained by each party in the absence of an interest linkage mechanism are analyzed below. Since $\partial^2\pi_1/\partial\alpha^2 = -b_1 < 0$, π_1 is strictly convex with respect to α . Therefore, the profit function of the agricultural enterprise possesses an optimal solution. By setting $\partial\pi_1/\partial\alpha = 0$, the optimal trusteeship fee in the absence of an interest linkage mechanism can be derived, as shown in Equation (2). Similarly, since $\partial^2\pi_3/\partial\beta^2 = -b_3 < 0$, π_3 is strictly convex with respect to β . Therefore, the profit function of the intermediary organization possesses an optimal solution. By setting $\partial\pi_3/\partial\beta = 0$, the optimal service fee in the absence of an interest linkage mechanism can be obtained, as presented in Equation (3). Likewise, since $\partial^2\pi_2/\partial q_1^2 = -nb_2 < 0$, π_2 is strictly convex with respect to q_1 . Therefore, the farmers' return function possesses an optimal solution. By setting $\partial\pi_2/\partial q_1 = 0$, the equilibrium output obtained by farmers under the self-cultivation mode in the absence of an interest linkage mechanism can be derived, as shown in Equation (4). Similarly, since $\partial^2\pi_2/\partial q_2^2 = -n\alpha < 0$, π_2 is strictly convex with respect to q_2 . Therefore, the farmers' return function possesses an optimal solution. By setting $\partial\pi_2/\partial q_2 = 0$, the equilibrium output obtained by farmers under the land trusteeship arrangement in the absence of an interest linkage mechanism can be derived, as presented in Equation (5).

$$\alpha^{*N} = An/b_1 \quad (2)$$

$$\beta^{*N} = An/b_3 \quad (3)$$

$$q_1^{*N} = p/2b_2 \quad (4)$$

$$q_2^{*N} = p/n\alpha = pb_1/An^2 \quad (5)$$

By substituting Equations (2)–(5) into the return function in Equation (1), the farmers' optimal return under the land trusteeship arrangement in the absence of an interest linkage mechanism can be derived, as shown in Equation (6).

$$\pi_2^{*N} = -\frac{A}{b_3}n^2 + \frac{p^2b_1}{2A}n^{-2} + (\frac{p^2}{8b_2} + \lambda)n \quad (6)$$

(3) Returns to Land Trusteeship Enterprises and Farmers with an Interest Linkage Mechanism. When an interest linkage mechanism exists between land trusteeship enterprises and farmers, all parties make decisions based on the principle of maximizing overall joint benefits. In this case, the interactions among the parties exhibit the characteristics of a cooperative game. Since $\partial^2\pi/\partial\alpha^2 = -b_1 < 0$, π is a strictly convex function with respect to α . Therefore, the profit function of the agricultural enterprise attains a maximum. By setting $\partial\pi/\partial\alpha = 0$, the optimal trusteeship fee under the presence of an interest linkage mechanism can be derived, as shown in Equation (7). Similarly, since $\partial^2\pi/\partial\beta^2 = -b_3 < 0$, π is a strictly convex function with respect to β . Therefore, the profit function of the intermediary organization attains a maximum. By setting $\partial\pi/\partial\beta = 0$, the optimal service fee under the presence of an interest linkage mechanism can be obtained, as shown in Equation (8). Similarly, since $\partial^2\pi/\partial q_1^2 = -nb_2 < 0$, π is a strictly convex function with respect to q_1 . Therefore, the farmers' profit function attains a maximum. By setting $\partial\pi/\partial q_1 = 0$, the equilibrium output under the self-cultivation mode with an interest linkage mechanism can be derived, as shown in Equation (9). Similarly, since $\partial^2\pi/\partial q_2^2 = -n\alpha < 0$, π is a strictly convex function with respect to q_2 . Therefore, the farmers' profit function attains a maximum. By setting $\partial\pi_2/\partial q_2 = 0$, the equilibrium output under the land trusteeship mode with an interest linkage mechanism can be derived, as shown in Equation (10).

$$\alpha^{*C} = (An - \frac{1}{2}nq_2^2)/b_1 \quad (7)$$

$$\beta^{*C} = (An + n)/b_3 \quad (8)$$

$$q_1^{*C} = p/nb_2 \quad (9)$$

$$q_2^{*C} = p/n\alpha \quad (10)$$

By substituting Equations (7)–(10) into the return function in Equation (1), the farmers' optimal return under the land trusteeship arrangement with an interest linkage mechanism can be derived, as shown in Equation (11).

$$\pi_2^{*C} = \frac{p^2}{2na} - \frac{p^2}{2nb_2} + \frac{An^2 + n^2}{b_3} + \lambda n \quad (11)$$

(4) Comparison of Returns Between Land Trusteeship Enterprises and Farmers Under the Two Scenarios. To verify the income-enhancing effect of the land trusteeship interest linkage mechanism, this study compares the returns of farmers under scenarios with and without an interest linkage mechanism. The resulting difference represents the income increment under the interest linkage mechanism. If the increment is greater than zero, it indicates that the interest linkage mechanism has a positive effect on income growth for farmers. The farmers' income increment $\Delta\pi_2$ is shown in Equation (12).

$$\Delta\pi_2 = \pi_2^{*C} - \pi_2^{*N} = \frac{n^2}{b_3} + p^2(\frac{1}{na} + \frac{4-n}{8b_2} - \frac{1}{2nb_2} - \frac{b_1}{An^2}) > 0 \quad (12)$$

From Equation (12), it can be observed that the farmers' income increment $\Delta\pi_2 > 0$, indicating that the land trusteeship interest linkage mechanism can effectively promote farmers' income growth.

3. Empirical Research Design

3.1. Data Sources

Shandong Province is selected as the primary study area for the following reasons: First, land trusteeship was initially pioneered as an innovative service model in China. As one of the earliest provinces to implement land trusteeship, Shandong has accumulated rich practical experience in addressing key issues such as “who will farm the land” and “how to farm the land”, providing valuable empirical evidence and data support for this study. Second, it holds a leading position in the development of land trusteeship. In recent years, it has achieved remarkable progress in this field, with both the scale of land trusteeship services and the total serviced area ranking among the highest nationwide. By 2020, the total serviced area under agricultural production trusteeship in Shandong exceeded 150 million mu. The number of service providers and the serviced area accounted for approximately 15% and 9% of the national total, respectively. The experience of Shandong has been widely promoted across China, making it a representative case for this study. Third, Shandong Province has a large number of land trusteeship providers and strong heterogeneity among service entities. More than 150 agricultural service enterprises have been established in the province, along with a large number of “agricultural service centers”, providing a diverse sample base for this research. In addition, since 2020, Shandong has actively promoted the deep integration of interest linkage between land trusteeship enterprises and farmers, offering high-quality empirical settings for analyzing the interest linkage mechanism. In summary, Shandong Province is highly representative and appropriate as the sample region for this study.

The data used in this study are derived from the “Basic Situation of Land Trusteeship” surveys conducted by the research team in Shandong Province, China, in 2021 and 2022. Based on the counties where land trusteeship service enterprises are located, farmers engaged in trusteeship cooperation with these enterprises were selected for the survey. In each sampled county, 3 to 5 townships were selected, and within each township, 2 to 3 villages were chosen for household surveys. Considering farmer heterogeneity and the actual implementation of land trusteeship, the sample was further screened. Face-to-face household interviews were conducted, and invalid questionnaires with missing or incorrect responses were removed. Ultimately, 816 valid panel observations were obtained.

Table 1 reports the basic characteristics of the sampled farmers. In terms of age, households with a household head aged 50 or above account for 71.26%, indicating that middle-aged and elderly individuals remain the main labor force in agricultural production. Regarding gender composition, male household heads account for 69.19%, suggesting that men still dominate decision making in farm production and management. In terms of educational attainment, only 15.26% of the sampled households have a primary school education or below, indicating that most respondents have a relatively moderate level of education. Regarding cadre status, 13.48% of households have at least one family member serving as a village cadre. Drawing on Liu et al. [37], this study classifies farm households into three categories based on farming time, the proportion of agricultural labor, and land operation scale.

Table 1. Basic characteristics of sampled farmers.

Characteristics		Frequency	Percentage	Characteristics	Category	Frequency	Percentage
Age	40 and below	52	6.37%	Educational attainment	Primary school or below	125	15.26%
	41–50 years old	183	22.37%		Junior middle school	474	58.07%
	51–60 years old	378	46.37%		Senior high school	181	22.16%
	60 and above	203	24.89%		Above senior high school	36	4.51%
Gender	Male	565	69.19%	Farmer differentiation	Small-scale pure farmers	175	21.40%
	Female	251	30.81%		Part-time farmers	571	69.97%
Position	Village cadre	110	13.48%		Large, specialized farmers	70	8.56%
	Not village cadre	706	86.52%				

3.2. Variable Selection

(1) Core Explanatory Variables. The core explanatory variable in this study is the level of interest linkage between agricultural enterprises and farmers. A higher level of interest linkage indicates a closer relationship between the two parties. Based on this overarching construct, three additional core explanatory variables are derived: the level of value cocreation, risk division, and profit sharing between agricultural enterprises and farmers. These variables reflect the institutional arrangements and behavioral cognition embedded in the cooperative relationship between enterprises and farmers and therefore cannot be directly observed. Accordingly, this study employs the Likert scale to assess the above core explanatory variables, thereby capturing respondents' subjective evaluations and perceptions of the relevant dimensions of the enterprise–farmer relationship. Since the core explanatory variables are latent constructs measured using multi-item Likert scales, reliability and validity tests were conducted before the regression analysis. The results indicate satisfactory internal consistency, with Cronbach's alpha and composite reliability (CR) values above 0.70. The KMO statistic exceeds 0.70, and Bartlett's test of sphericity is significant at the 1% level ($p < 0.001$), confirming the suitability of the data for factor analysis. Moreover, all constructs exhibit acceptable convergent validity ($AVE > 0.50$). Overall, these results demonstrate that the Likert-scale measurements are reliable and valid for capturing the interest linkage mechanism and its three dimensions.

(2) Dependent Variable. This study adopts farmers' income as the dependent variable. Following the study of Pan [38], farmers' income is measured by total household income in the current year, including agricultural operating income, wage income, property income, and transfer income. These income variables are quantifiable economic outcomes that can be objectively represented by numerical values and are therefore measured as continuous variables. Compared with ordinal or categorical variables, continuous variables preserve more information contained in income data and avoid information loss caused by artificial grouping, thereby improving the precision and statistical power of model estimation. The data are derived from a household survey conducted by the research team. Respondents were asked to report the amounts of various income sources based on their actual household circumstances during the survey year. Therefore, the income data are considered to have a relatively high degree of accuracy and reliability.

(3) Control Variables. Individual characteristics of household heads, such as gender, age, and educational attainment [12], as well as production and operational characteristics, farmland conditions, and locational characteristics, including cooperative participation and geographical location [39], may affect farmers' income. Drawing on the studies of Luo et al. [40] and Yu et al. [41], this study selects control variables from four dimensions:

individual characteristics, household characteristics, farmland characteristics, and regional characteristics. Specifically, individual characteristics include the household head's gender, age, educational attainment, and Communist Party membership. Household characteristics include village cadre status, the number of household members engaged in farming, the number of household members engaged in off-farm employment, household health status, and cooperative participation. Farmland characteristics include farmland fertility, irrigation convenience, land fragmentation, and cultivated land area. Regional characteristics include whether the village is located in a plain area, whether it is located in a suburban area, and the distance to the township government. In terms of variable measurement, variables with clear binary attributes, such as household head gender, Communist Party membership, village cadre status, cooperative participation, whether the village is located in a plain area, and whether it is located in a suburban area, are measured as dummy variables. Variables such as household head age, the number of household members engaged in farming, the number of household members engaged in off-farm employment, land fragmentation, and cultivated land area are measured as count variables. Variables including educational attainment, health status, farmland fertility, irrigation convenience, and distance to the township government are measured using Likert scales. Detailed definitions of all variables are presented in Table 2.

Table 2. Variables and definitions.

	Variables	Indicator and Calculation Method/Unit
Dependent variable	<i>income</i>	Total annual household income (10,000 RMB)
Core independent variables	<i>level</i>	Interest linkage level between land trusteeship enterprises and farmers, Likert scale
	<i>value</i>	Value cocreation level between land trusteeship enterprises and farmers, Likert scale
	<i>risk</i>	Risk division level between land trusteeship enterprises and farmers, Likert scale
	<i>share</i>	Profit sharing level between land trusteeship enterprises and farmers, Likert scale
Individual control variables	<i>sex</i>	Gender of the household head: male = 0; female = 1
	<i>age</i>	Age of the household head, measured as the number of full years (years)
	<i>education</i>	Educational attainment of the household head: primary school or below = 1; junior middle school = 2; senior high school = 3; above senior high school = 4
	<i>party</i>	Whether household head is a member of the Communist Party of China: yes = 1; no = 0
Household control variables	<i>position</i>	Whether any household member serves as a village cadre: yes = 1; no = 0
	<i>farmer</i>	Number of household members engaged in farming (persons)
	<i>labor</i>	Number of household members engaged in off-farm employment (persons)
	<i>health</i>	Health status of household members, Likert scale
	<i>cooperate</i>	Cooperative participation: participating = 1; not participating = 0
Farmland control variables	<i>fertilizer</i>	Fertility of contracted farmland: barren = 0; average = 1; fertile = 2
	<i>watering</i>	Reflecting irrigation and agricultural water infrastructure conditions, Likert scale
	<i>plot</i>	Degree of land fragmentation, Likert scale
	<i>area</i>	Contracted cultivated land area (Mu)
Regional control variables	<i>plain</i>	Whether the village is located in a plain area: yes = 1; no = 0
	<i>rural</i>	Whether the village is located in a suburban area: yes = 1; no = 0
	<i>distance</i>	Distance to township government location, Likert scale

Note: The five-point Likert scale used in this study is defined as follows: very low = 1, low = 2, moderate = 3, high = 4, and very high = 5. Mu is a Chinese unit of land measurement that is commonly 666.7 square meters.

3.3. Model Specification

(1) Baseline Regression Model. Considering the significant regional differences in agricultural resource endowments, economic development levels, the development of agricultural socialized services, and the institutional environment for land trusteeship promotion, these unobservable factors may simultaneously affect both farmers' income and the level of interest linkage between land trusteeship enterprises and farmers, thereby leading to biased estimation results. To mitigate the omitted variable problem, this study follows Carter and Yao (2002) [42] to build a fixed-effects model. The model is shown in Equation (13).

$$Income_i = \alpha + \beta_1 level_i + \sum_{j=2}^{18} \delta_j Z_{ij} + \mu_p + \varepsilon_i \quad (13)$$

In the model, $income_i$ denotes the income of farmer i ; $level_i$ represents the level of interest linkage between farmer i and land trusteeship enterprises; Z_{ij} denotes the j -th control variable of farmer i , where j indexes the set of control variables; μ_p represents regional fixed effects, which are used to control for unobserved heterogeneity across different regions; ε_i denotes the random error term; α is the constant term; and β_1 and δ_j represent the estimated coefficients of the core explanatory variable and the control variables, respectively.

(2) Random Forest Model. Following Huang and Qiu (2021) [43], this study employs the random forest machine learning model for estimation. Random forest is a non-parametric statistical method first proposed by Breiman (2001) [44]. It constructs an ensemble of regression trees based on bootstrap sampling techniques and obtains the final prediction by aggregating the results of multiple decision trees. A regression tree recursively partitions the data into different subsamples, and the mean value of y_i within each subsample is used as the final prediction value. Node τ contains n_τ observations, and each node can be further split into two nodes, node τ_L and node τ_R , which contain n_L and n_R observations, respectively. The sum of squared deviations within node y_i is defined as $SSR(\tau) = \sum_{i=1}^{n_\tau} (y_i - \bar{y}_\tau)^2$, where $\bar{y}_\tau$ denotes the mean value. When splitting the n_τ observations in node τ into two parts, τ_L and τ_R , the selection of the splitting variable and the splitting threshold follows the principle of maximizing the reduction in the sum of squared residuals (SSR), as shown in Equation (14). Nodes τ_L and τ_R can be treated as new nodes and further split. This procedure starts from the top of the tree (the full sample) and applies the same splitting rule to all subsequent nodes until a pre-specified stopping criterion for node splitting is satisfied. The nodes at which the splitting process terminates are referred to as terminal (leaf) nodes. Each leaf node l corresponds to a subset of observations X_l , and these subsets are pairwise disjoint, while their union equals the full sample X . The final predicted fitted value is the mean value $\bar{y}_l$ of y within the subsample X_l to which variable x belongs. Regression trees typically have low bias but high variance because even small changes in the observed data can lead to substantially different tree-splitting structures. Random forests address this problem by correcting for this instability.

$$\Delta = SSR(\tau) - SSR(\tau_L) - SSR(\tau_R) \quad (14)$$

(3) Neural Network Model. The BP artificial neural network is a feedforward network consisting of an input layer, one or more hidden layers, and an output layer. It continuously adjusts the connection weights of the network to minimize the overall error or until a pre-specified number of training iterations is reached. In this study, it is assumed that the input layer contains m neurons, the hidden layer contains n neurons, and the output layer contains p neurons. The initial weights of the neurons are set as small, random positive values, and the training dataset matrix is then input into the model. In this study, the total

sample size is N , of which 70% is used as the training set and the remaining 30% as the test set. The learning process of the neural network is as follows:

Step 1: Computation of the output value. The input of the i neuron in the hidden layer is denoted as $Input_i = \sum_{j=1}^m w_{ij}x_j - \mu_i$, where w_{ij} represents the connection weight between the j neuron in the input layer and the i neuron in the hidden layer, x_j denotes the input value of the i neuron in the hidden layer, and μ_i denotes the threshold (bias) of the i neuron in the hidden layer. The output of the i neuron in the hidden layer, $Output_i$ is shown in Equation (15), where $f(x)$ denotes the activation function of the hidden layer, which is typically the sigmoid function $f(x) = 1/(1 + e^{-x})$. The output $Output_i$ of the i neuron in the hidden layer is transmitted to the output layer through weight coefficients. The input of the k neuron in the output layer is denoted as $TInput_k = \sum_{i=1}^n w_{ki}Output_i - \mu_k$, where w_{ki} represents the connection weight between the i hidden-layer neuron and the k output-layer neuron, and μ_k denotes the threshold (bias) of the k output-layer neuron. The output value of the k output-layer neuron, $TOutput_k$ is shown in Equation (16).

$$Output_i = f\left(Input_i = \sum_{j=1}^m w_{ij}x_j - \mu_i\right) \quad (15)$$

$$TOutput_k = f\left(TInput_k = \sum_{i=1}^n w_{ki}Output_i - \mu_k\right) \quad (16)$$

Step 2: Computation of training error. The total error of the neural network system is shown in Equation (17), where EX_k denotes the expected output of the k neuron in the output layer. Step 3: Weight adjustment. If the error does not meet the predefined requirement, the weight coefficients are adjusted along the negative gradient direction of the error function. The adjustment of the input-layer weights is denoted as $\Delta w_{ij} = -\theta x_j \partial Error / \partial Input_i$, and the adjustment of the output-layer weights is denoted as $\Delta w_{ki} = -\theta Output_i \partial Error / \partial TInput_k$. Here, Δw_{ij} and Δw_{ki} represent the weight updates for the input and output layers, respectively, and θ ($\theta > 0$) denotes the learning rate. Through continuous training, the process continues until the total error reaches an acceptable level.

$$Error = \frac{1}{2} \sum_{k=1}^N \sum_{p=1}^P (EX_k - TOutput_k) \quad (17)$$

4. Empirical Results and Analysis

4.1. Baseline Regression Results and Analysis

Table 3 presents the baseline regression results on the impact of the land trusteeship interest linkage mechanism on farmers' income. Model 1 uses the overall level of interest linkage as the core explanatory variable, while Models 2–4 respectively take value cocreation, risk division, and profit sharing as the core explanatory variables. The R^2 values across the four models range from 0.139 to 0.224. While these values are relatively modest, this is not uncommon in cross-sectional studies of farm household income, which is influenced by a wide array of complex and often unobservable factors. More importantly, R^2 measures the overall explanatory power of the model for the variance in the dependent variable and should not be equated with the validity of the causal inference or the quality of the model specification. The F-statistics for all models range from 3.110 to 8.274 and are statistically significant at the 1% level, confirming the joint significance of the included explanatory variables. The signs and significance of the core explanatory variables—as well as the control variables, which largely align with theoretical expectations—provide substantive evidence for the hypothesized relationships. Thus, the relatively low R^2 does not undermine the core findings of this study.

Table 3. Baseline regression results.

Variable	Model 1 Income		Model 2 Income		Model 3 Income		Model 4 Income	
	Coefficient	p-Value	Coefficient	p-Value	Coefficient	p-Value	Coefficient	p-Value
<i>level</i>	0.696 ***	0.002						
<i>value</i>			0.555 *	0.078				
<i>risk</i>					0.297 ***	0.001		
<i>share</i>							0.417 ***	0.013
<i>sex</i>	0.673	0.133	0.153 **	0.045	0.662	0.112	0.176 **	0.036
<i>age</i>	−0.279 **	0.036	−0.068 **	0.017	−0.034 ***	0.009	−0.386 **	0.020
<i>education</i>	0.129 **	0.025	0.461 **	0.010	0.021 **	0.018	0.129 *	0.072
<i>party</i>	0.283 **	0.017	0.146 **	0.012	0.589 ***	0.003	0.484 **	0.011
<i>health</i>	0.194 **	0.037	0.178 **	0.025	0.538 **	0.013	0.514 **	0.023
<i>position</i>	0.149 **	0.034	0.301 **	0.015	0.091 **	0.047	0.213 **	0.035
<i>farmer</i>	−0.104 ***	0.003	−0.164 **	0.010	−0.16 *	0.066	−0.136 **	0.042
<i>labor</i>	0.55 **	0.017	0.256 **	0.026	0.117 **	0.018	0.453 **	0.043
<i>cooperate</i>	0.132 ***	0.006	0.162 *	0.059	0.034 **	0.013	0.219 ***	0.008
<i>fertilizer</i>	0.606 **	0.033	0.175 ***	0.004	0.003 ***	0.003	0.108 *	0.067
<i>watering</i>	0.137 **	0.031	0.044 **	0.017	0.019 **	0.017	0.333 ***	0.008
<i>plot</i>	−0.125 ***	0.006	−0.098 **	0.041	−0.881 **	0.037	−0.26 **	0.029
<i>area</i>	0.416 ***	0.001	0.313 ***	0.007	0.184 **	0.035	0.121 **	0.015
<i>plain</i>	0.066 **	0.035	0.179 ***	0.008	0.558 **	0.017	0.138 **	0.023
<i>rural</i>	0.574 ***	0.004	0.308	0.222	0.215 *	0.065	0.404	0.122
<i>distance</i>	−0.195	0.324	−0.119 ***	0.004	−0.112	0.347	−0.204 **	0.023
<i>_cons</i>	108.153 **	0.021	125.086 ***	0.005	110.255 **	0.014	142.010 ***	0.007
<i>N</i>	816		816		816		816	
<i>R²</i>	0.155		0.224		0.155		0.139	
<i>F</i>	6.881		8.274		4.884		3.110	

t statistics; * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Model 1 shows that the coefficient of the interest linkage level is 0.696 and is statistically significant at the 1% level, thereby supporting Hypothesis H1. This indicates that a higher degree of interest linkage between land trusteeship enterprises and farmers is associated with higher farmer's income. Smallholder farmers are generally constrained by insufficient access to capital, technology, market information, and sales channels. In contrast, land trusteeship enterprises possess stronger capabilities in market development, technical services, and organizational coordination. Through the establishment of interest linkage mechanisms, farmers are integrated into enterprise-led agricultural value chains, enabling them to access inputs, technical guidance, contract-based sales, and market information. This effectively alleviates resource constraints, improves production efficiency and market participation, and ultimately promotes income growth. This result confirms that the interest linkage mechanism, as an important institutional arrangement connecting smallholders with modern agriculture, enhances farmers' income through resource integration and optimized allocation of production factors. The findings of this study clarify the key mechanism underlying these mixed results: it is not the mere entry of capital that determines income effects but the strength of the interest linkage mechanism. A stronger interest linkage reduces information asymmetry between enterprises and farmers, limits opportunistic behavior, and facilitates a more effective transmission of cooperative surplus to farmers.

Model 2 shows that the coefficient of value cocreation is 0.555 and is statistically significant at the 10% level, thereby supporting Hypothesis H2. The estimated coefficient is larger than those of risk division and profit sharing, suggesting that improvements in value cocreation are associated with relatively greater marginal gains in farmers' income under the current sample. Rather than indicating that one dimension is inherently more important than the others, the coefficient differences reflect the distinct economic functions through

which the three dimensions influence farmers' income, which is consistent with the theoretical expectation that "value cocreation is the foundation". The underlying mechanism is that in traditional agricultural production, farmers mainly perform production-related functions. In contrast, under a value cocreation arrangement, farmers and enterprises jointly participate in product standard setting, production management, and market development, facilitating a transition from pure producers to value creators. As farmers' participation deepens, their ability to acquire advanced production technologies and market information is continuously enhanced, leading to simultaneous improvements in production efficiency and product value added, thereby generating higher income returns. Moreover, value cocreation directly expands the total amount of "distributable surplus" rather than merely adjusting the distribution ratio. By integrating fragmented land parcels to achieve large-scale operations, land trusteeship enterprises spread mechanized costs across larger areas while reducing unit input costs through centralized procurement of agricultural materials. This fundamental change in production organization increases both total output value and farmers' net income simultaneously, rather than representing a simple redistribution of existing gains.

Model 3 shows that the coefficient of risk division is 0.297 and is statistically significant at the 1% level, thereby supporting Hypothesis H3. From an economic perspective, the income-enhancing effect of risk division does not operate through an increase in expected returns but rather through a reduction in income variance. Agricultural production is characterized by substantial natural and market risks, while smallholder farmers typically have limited risk-bearing capacity. In the absence of a risk division pathway, risk-averse farmers tend to scale down production or reduce investment in new varieties and advanced technologies in order to avoid uncertainty, thereby falling into a low-level equilibrium trap characterized by "self-restraint due to risk aversion". When land trusteeship enterprises share risk with farmers through mechanisms such as contract farming, minimum price guarantees, agricultural insurance subsidies, and disaster loss-sharing arrangements, farmers' perceived uncertainty is effectively reduced. This, in turn, mitigates conservative production decisions driven by market volatility concerns and encourages greater production investment and technology adoption. As a result, agricultural productivity improves, and farmers' income increases.

Model 4 shows that the coefficient of profit sharing is 0.417 and is statistically significant at the 5% level, thereby supporting Hypothesis H4. The profit-sharing pathway enables farmers not only to obtain returns from agricultural production but also to share value-added gains along the industrial chain through mechanisms such as guaranteed minimum returns, profit rebates, and equity dividends. When farmers are able to continuously benefit from the development of the value chain, their willingness to participate in agricultural socialized services and agricultural industrialization is significantly strengthened, thereby forming a virtuous cycle of income growth. Therefore, profit sharing is not only an important guarantee for the stable operation of interest linkage mechanisms but also a key channel for promoting sustained income growth among farmers. Overall, the interest linkage mechanism promotes farmers' income growth through multiple channels, including value cocreation, risk division, and profit sharing. Among these, value cocreation exhibits the strongest effect, indicating that under agricultural modernization, farmers' income growth depends not only on increased input of production factors but more importantly on their participation in industrial chain specialization and value creation processes, which enhance both capabilities and value added. This also suggests that future improvements in interest linkage mechanisms should place greater emphasis on enhancing farmers' ability to participate in high value-added segments of the agricultural value chain, rather than focusing solely on traditional income distribution arrangements.

4.2. Heterogeneity Analysis

(1) Heterogeneity by Farmer Type. Due to the heterogeneity among farmers, this study further examines differences in the income effects across different types of farm households. Following Sui and Yu [45], farmers are classified into three categories: small-scale pure farmers, part-time farmers, and large, specialized farmers. In this section, household income for each type of farmer is used as the dependent variable. The levels of interest linkage, value cocreation, risk division, and profit sharing are, respectively, used as core explanatory variables. The same set of control variables and estimation methods as in the baseline regression are applied. The heterogeneity results are presented in Table 4.

Table 4. Heterogeneity regression results of farm households.

	Small-Scale Pure Farmers				Part-Time Farmers				Large, Specialized Farmers			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income
level	0.401 *** (3.541)				0.275 *** (5.612)				0.532 *** (4.723)			
value		0.353 *** (3.961)				0.216 *** (5.313)				0.504 *** (4.713)		
risk			0.311 *** (4.215)				0.197 *** (3.521)				0.418 *** (8.246)	
share				0.395 *** (6.852)				0.248 *** (8.134)				0.516 *** (10.255)
_cons	1.599 *** (3.173)	1.449 *** (3.536)	1.513 *** (5.659)	1.915 *** (6.356)	1.636 *** (2.871)	0.752 *** (4.562)	0.863 *** (4.927)	0.972 *** (5.266)	1.647 *** (3.871)	1.231 ** (3.783)	1.118 *** (3.486)	1.126 ** (3.810)
control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	175	175	175	175	571	571	571	571	70	70	70	70
R ²	0.453	0.448	0.448	0.455	0.210	0.208	0.208	0.211	0.452	0.445	0.430	0.447
F	8.190	8.014	8.008	8.243	8.643	8.542	8.539	8.719	2.526	2.450	2.303	2.468

t statistics in parentheses; ** $p < 0.05$, *** $p < 0.01$.

As shown in Models 1, 5, and 9 of Table 4, the coefficients of the interest linkage level are significantly positive, indicating that the interest linkage mechanism has a positive impact on the income of all three types of households. From the perspective of the overall interest linkage mechanism, its positive effect on large, specialized farmers and small-scale pure farmers is more pronounced than that on part-time farmers. This can be attributed to the fact that the former two types of households are more dependent on agricultural production and therefore are more likely to benefit from technical services, market access, and organizational coordination provided by enterprises. In contrast, part-time farmers have more diversified income sources, with agricultural income accounting for a relatively small share of total household income; hence, the marginal income effect of the interest linkage mechanism is comparatively limited.

As shown in Models 2, 6, and 10, the coefficients of the value cocreation level are significantly positive, indicating that value cocreation between land trusteeship enterprises and farmers has a positive impact on the income of all three types of households, including small-scale pure farmers, part-time farmers, and large, specialized farmers. Notably, value cocreation has the strongest effect on large, specialized farmers. This is because large, specialized farmers typically operate at a larger scale and have a higher degree of specialization, enabling them to more effectively absorb new technologies, improved varieties, and

advanced management practices provided by enterprises. Through scale operations, they can further facilitate technology diffusion and amplify income gains. Therefore, compared with other household types, large, specialized farmers are more capable of translating value cocreation into actual productive capacity and economic returns.

As shown in Models 3, 7, and 11, the coefficients of the risk division level are significantly positive, indicating that risk division between land trusteeship enterprises and farmers has a positive impact on the income of all three types of households, including small-scale pure farmers, part-time farmers, and large, specialized farmers. The income-enhancing effect of risk division is also most pronounced among large, specialized farmers. This is because large, specialized farmers typically operate at a larger production scale and therefore face higher market and operational risks. When enterprises share risks through mechanisms such as contract farming, price guarantees, and loss compensation, it effectively reduces production uncertainty, enhances farmers' willingness to expand production and increase input use, and ultimately generates a stronger income growth effect.

As shown in Models 4, 8, and 12, the coefficients of the profit-sharing level are significantly positive, indicating that profit sharing between land trusteeship enterprises and farmers has a positive impact on the income of all three types of households. The income-increasing effect of profit sharing is most pronounced among large, specialized farmers, followed by small-scale pure farmers, while the effect is relatively weak for part-time farmers. This is mainly because large, specialized farmers operate on a larger scale and achieve higher output, which leads to deeper cooperation with land trusteeship enterprises. As a result, they can obtain greater absolute income gains through mechanisms such as guaranteed returns, profit redistribution, and dividend sharing. The large-scale and standardized production of specialized farmers also gives them stronger bargaining power and a higher degree of participation in the agricultural value chain. Therefore, the income-enhancing effect triggered by profit-sharing arrangements is more significant for this group. In contrast, part-time farmers derive a relatively small share of their household income from agricultural production, and their production scale is limited. Consequently, the additional income they can obtain from the profit-sharing pathway is relatively small, resulting in the weakest income effect among the three groups.

(2) Heterogeneity by Income Type. Farm household income is classified into four categories: agricultural operating income, wage income, property income, and transfer income. Since land trusteeship is expected to have a relatively limited impact on farmers' property income, this category is not included in the analysis. Accordingly, this study uses agricultural operating income, wage income, and transfer income as dependent variables. The level of interest linkage, value cocreation, risk division, and profit sharing are used as core explanatory variables. The same control variables and estimation methods as in the baseline regression are applied. The heterogeneity regression results are presented in Table 5.

As shown in Models 1, 5, and 9 of Table 5, the coefficients of the interest linkage level are significantly positive, indicating that the interest linkage mechanism between land trusteeship enterprises and farmers has a positive impact on farmers' agricultural operating income, wage income, and transfer income. The income-enhancing effects of the interest linkage mechanism across different income types can be ranked as follows: agricultural operating income, wage income, and transfer income. The interest linkage mechanism integrates farmers into modern agricultural value chains through contract farming, technical guidance, agricultural input supply, and market access services, thereby effectively improving agricultural productivity and product market value and directly increasing agricultural operating income. Compared with traditional fragmented farming systems, farmers can leverage the organizational advantages of enterprises to reduce both

production and transaction costs and improve resource allocation efficiency. As a result, agricultural operating income becomes the primary channel through which the interest linkage mechanism generates income growth effects.

Table 5. Heterogeneity regression results of farmers' income.

	Agricultural Operating Income				Wage Income				Transfer Income			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income
<i>level</i>	0.461 *** (8.234)				0.387 *** (3.076)				0.161 *** (3.762)			
<i>value</i>		0.309 *** (8.252)				0.312 *** (3.124)				0.139 *** (5.751)		
<i>risk</i>			0.402 *** (4.297)				0.289 *** (4.123)				0.105 *** (9.013)	
<i>share</i>				0.458 ** (2.092)				0.351 ** (2.103)				0.158 *** (0.741)
<i>_cons</i>	0.435 (1.173)	0.652 (1.536)	0.754 (1.659)	0.531 (1.356)	0.765 *** (4.765)	0.654 *** (7.342)	0.865 *** (4.751)	0.533 *** (8.754)	0.253 *** (8.634)	0.265 *** (5.355)	0.264 *** (8.541)	0.264 *** (3.765)
<i>control</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	816	816	816	816	733	733	733	733	816	816	816	816
<i>R²</i>	0.243	0.345	0.343	0.402	0.368	0.531	0.359	0.287	0.419	0.369	0.386	0.269
<i>F</i>	8.352	8.083	6.457	12.345	34.567	23.134	8.236	9.375	7.468	6.346	8.456	21.456

t statistics in parentheses; ** $p < 0.05$, *** $p < 0.01$.

As shown in Models 2, 6, and 10, the coefficients of the value cocreation level are significantly positive, indicating that value cocreation between land trusteeship enterprises and farmers has a positive impact on farmers' agricultural operating income, wage income, and transfer income. The income-enhancing effects of value cocreation across different income types can be ranked as follows: wage income, agricultural operating income, and transfer income. Notably, value cocreation has the strongest effect on wage income. Land trusteeship enterprises promote full-process mechanized operations, replacing labor inputs from farm households. This substitution not only reduces labor costs in agricultural production but also releases a substantial amount of labor time previously tied to field management, allowing it to be reallocated to non-farm employment. As a result, the income effect extends beyond agricultural production itself and generates significant spillover effects in the rural labor market. Therefore, improving the level of value cocreation not only contributes to higher agricultural output but also indirectly enhances the vitality of the rural labor market, providing an effective pathway for diversified income growth among farm households.

As shown in Models 3, 7, and 11, the coefficients of the risk division level are significantly positive, indicating that risk division between land trusteeship enterprises and farmers has a positive impact on farmers' agricultural operating income, wage income and transfer income. The income-enhancing effects of risk division across different income types can be ranked as follows: agricultural operating income, wage income and transfer income. Notably, risk division has the most pronounced effect on agricultural operating income. Agricultural operating income is directly derived from agricultural production activities and is therefore most vulnerable to risks such as natural disasters, market price fluctuations, and changes in production costs. When enterprises share risks with farmers

through various risk protection mechanisms, the improvement in income first materializes in the agricultural production sector.

As shown in Models 4, 8, and 12, the coefficients of the profit-sharing level are significantly positive, indicating that profit sharing between land trusteeship enterprises and farmers has a positive impact on farmers' agricultural operating income, wage income, and transfer income. The income-enhancing effects of profit sharing across different income types can be ranked as follows: agricultural operating income, wage income, and transfer income. The effect of profit sharing on agricultural operating income is the most pronounced. This is because arrangements such as guaranteed returns, profit rebates, and surplus-sharing schemes are directly linked to agricultural production outcomes, and the additional remuneration farmers receive from value-chain appreciation is primarily reflected in agricultural operating income. Compared with other types of income, the transmission channel between operating income and the profit-sharing pathway is the most direct: the higher the proportion of benefits farmers receive in the distribution mechanism, the greater their agricultural production income. Meanwhile, profit sharing can also enhance farmers' production incentives and optimize resource allocation, thereby releasing additional labor for off-farm employment and indirectly generating a secondary positive effect on wage income. In contrast, transfer income is largely determined by policy arrangements and has a relatively weak connection with market-based profit-sharing pathways. Therefore, its promotion effect is the smallest among the three types of income.

(3) Heterogeneity by Crop Type. Due to differences in production processes across crop types, farmers require different land trusteeship services when planting different crops [35]. Therefore, it is necessary to distinguish crop types and examine the heterogeneous effects of the land trusteeship interest linkage mechanism on farmers' income. In this section, farmers' income from wheat trusteeship, maize trusteeship, and vegetable trusteeship is used as the dependent variable, respectively. The level of interest linkage, value cocreation, risk division, and profit sharing are used as core explanatory variables. The same control variables and estimation methods as in the baseline regression are applied. The heterogeneity regression results are presented in Table 6.

As shown in Models 1, 5, and 9 of Table 6, the coefficients of the interest linkage level are significantly positive, indicating that the interest linkage mechanism has a positive impact on the income of wheat, maize, and vegetable trusteeship farmers. The income-enhancing effects of the interest linkage mechanism across different crops can be ranked as follows: vegetables, wheat, and maize. Compared with grain crops, vegetable production is more market-oriented, with stronger linkages across production, circulation, and sales stages. As a result, farmers are more dependent on enterprise-based organizational coordination and market access. Therefore, when farmers establish closer interest linkage relationships with enterprises, they are more likely to obtain additional income gains. In contrast, maize production has a shorter value chain and a higher degree of product standardization, which reduces the need for close coordination between farmers and enterprises, thereby weakening the income-enhancing effect of the interest linkage mechanism.

Models 2, 6, and 10 indicate that value cocreation between land trusteeship enterprises and farmers has a positive impact on farmers' income from wheat, maize, and vegetable trusteeship. The income-enhancing effects of value cocreation across different crops can be ranked as follows: vegetables, wheat, and maize. This is primarily because different crops vary in their demand for knowledge, technology, and market information. Vegetable production is relatively technology-intensive, requiring higher capabilities in variety selection, production management, and responsiveness to market information. As a result, it is easier for enterprises and farmers to form cooperative relationships in value cocreation. In contrast, grain crop production is relatively standardized, with lower dependence on

technological innovation and market information, so the income gains generated through value cocreation are relatively limited.

Table 6. Heterogeneity regression results by crop type.

	Wheat Trusteeship				Maize Trusteeship				Vegetable Trusteeship			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income	Income
<i>level</i>	0.502 *** (4.135)				0.223 *** (5.396)				0.639 *** (3.641)			
<i>value</i>		0.414 *** (4.241)				0.254 *** (7.324)				0.612 *** (6.232)		
<i>risk</i>			0.478 *** (6.237)				0.219 *** (9.326)				0.637 *** (3.234)	
<i>share</i>				0.589 *** (11.494)				0.249 * (1.894)				0.628 *** (5.341)
<i>_cons</i>	0.653 *** (8.324)	0.523 *** (6.346)	0.681 * (1.732)	0.975 *** (9.084)	0.467 *** (12.34)	0.347 ** (2.004)	0.468 ** (2.184)	0.821 ** (2.204)	0.368 *** (6.234)	0.684 *** (2.683)	0.642 *** (5.326)	0.368 *** (3.762)
<i>control</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	816	816	816	816	816	816	816	816	135	135	135	135
<i>R²</i>	0.324	0.234	0.643	0.452	0.314	0.338	0.401	0.278	0.397	0.286	0.249	0.378
<i>F</i>	12.345	11.397	8.345	9.432	7.346	6.346	9.435	10.275	11.964	9.556	8.436	8.269

t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Models 3, 7, and 11 indicate that risk division between land trusteeship enterprises and farmers has a positive impact on farmers' income from wheat, maize, and vegetable trusteeship. The income-enhancing effects of risk division across different crops can be ranked as follows: vegetables, wheat, and maize. Vegetable prices fluctuate frequently and are highly sensitive to changes in market supply and demand. In contrast, wheat and maize benefit from China's grain procurement price protection policies, under which part of their price risk is already absorbed by government interventions. As a result, vegetables must bear full market price risk independently, while the scope for risk mitigation through risk division arrangements is relatively limited for wheat and maize. Therefore, enterprise-provided risk division pathways generate a more pronounced income-stabilizing effect, particularly for vegetable production.

Models 4, 8, and 12 indicate that profit sharing between land trusteeship enterprises and farmers has a positive impact on farmers' income from wheat, maize, and vegetable trusteeship. The income-enhancing effects of profit sharing across different crops can be ranked as follows: vegetables, wheat, and maize. The vegetable industry is characterized by higher value added and a longer value chain, allowing farmers to capture more value-added returns through mechanisms such as profit rebates, equity-based cooperation, and secondary distribution. In contrast, the value-added space in grain crop value chains is relatively limited, leaving fewer surplus returns available for farmers. Therefore, the income effect of the profit-sharing pathway is comparatively weaker in grain production.

4.3. Robustness Checks

(1) Econometric Model Replacement Test. This study conducts regression analysis using Stata 15.0. With farmers' income as the dependent variable, and the level of interest linkage, value cocreation, risk division, and profit sharing as core explanatory variables,

the Propensity Score Matching (PSM) estimation results are reported in Table 7 Models 1–4, the Heckman two-step estimation results are reported in Models 5–6, and the Endogenous Switching Regression (ESR) results are reported in Model 7.

Table 7. Robustness check results based on alternative econometric models.

	PSM				Heckman		ESR
	Model 1 Entropy Matching	Model 2 Nearest-Neighbor Matching	Model 3 Kernel Matching	Model 4 Caliper Matching	Model 5 Selection Equation	Model 6 Outcome Equation	Model 7
<i>level</i>	0.486 *** (3.491)	0.543 *** (4.336)	0.499 ** (2.046)	0.501 *** (3.075)		0.662 *** (7.341)	0.597 ** (2.471)
<i>_cons</i>	0.462 *** (3.119)	0.641 * (1.703)	0.562 *** (5.832)	0.531 *** (4.982)	0.452 *** (3.176)	0.314 *** (2.821)	0.461 *** (2.964)
<i>Control</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>IMills</i>					−1.752 ***		
<i>N</i>	816	816	816	816	816	816	816
<i>R²</i>	0.155	0.214	0.364	0.321	0.155	0.235	0.139
<i>F</i>	4.893	4.004	6.875	6.086	4.881	3.113	3.110

t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

PSM Results and Analysis. Farm households with interest linkages to land trusteeship enterprises are defined as the treatment group, while those without such linkages are defined as the control group. A Logit model is employed to estimate the propensity scores of establishing interest linkages between farmers and enterprises, based on which the sample is matched. The matching results show that the standardized bias of all covariates after matching is below 5%, and the *t*-test results further indicate that there are no systematic differences between the treatment and control groups after matching. This suggests that the control group (farmers without interest linkages) is well matched with the treatment group (farmers with interest linkages). Accordingly, this study estimates the average treatment effect under three matching specifications—*k*-nearest neighbor matching, caliper matching, and kernel matching—and reports only the results under the best-performing caliper matching specification. As shown in Models 1–4, the coefficient of the interest linkage level is statistically significant at the 1% level, indicating that the interest linkage mechanism between land trusteeship enterprises and farmers has a positive impact on farmers' income. The signs of the coefficients of the control variables are consistent with expectations. According to the results of Models 5 and 6, the inverse Mills ratio is −1.752 and is statistically significant at the 1% level, indicating the presence of sample selection bias and confirming the appropriateness of the Heckman two-step model. In the outcome equation of the Heckman model, the coefficient of the interest linkage level is 0.662 and is statistically significant at the 1% level, indicating that the interest linkage mechanism between land trusteeship enterprises and farmers has a positive impact on farmers' income. In ESR Model 7, the average treatment effect of the interest linkage mechanism on farmers' income is significantly positive at the 5% statistical level.

(2) **Variable Substitution Test.** The variable substitution test includes replacing both the independent and dependent variables. Accordingly, this study replaces the dependent variable of farmers' income with an income degree variable and replaces the core explanatory variable of interest linkage level with an interest linkage rank variable. The new variables are constructed as follows: Farmers' income is divided into five quantiles. Farmers whose income falls within 0–20% are assigned income rank = 1; those within 20–40% are assigned income rank = 2; those within 40–60% are assigned income rank = 3; those within 60–80% are assigned income rank = 4; and those within 80–100% are assigned income rank = 5. Similarly, the level of interest linkage is also divided into five quantiles

to construct the interest linkage rank variable. Since the dependent variable is an ordered categorical variable, an ordered Probit model is employed for estimation. The results are presented in Table 8. First, when replacing the dependent variable with income degree, Models 1–4 show that the level of interest linkage, value cocreation, risk division, and profit sharing all have positive effects on farmers' income. Second, when replacing the core explanatory variables with interest linkage rank, Models 5–8 show that interest linkage rank, value cocreation rank, risk division rank, and profit-sharing rank all have positive effects on farmers' income. Across all specifications, the coefficients of the control variables are generally consistent with those in the baseline regression. Overall, these results confirm that the baseline findings are robust.

Table 8. Robustness check results based on variable substitution.

	Replace Dependent Variable				Replace Core Independent Variables			
	Model 1 <i>Degree</i>	Model 2 <i>Degree</i>	Model 3 <i>Degree</i>	Model 4 <i>Degree</i>	Model 5 <i>Income</i>	Model 6 <i>Income</i>	Model 7 <i>Income</i>	Model 8 <i>Income</i>
<i>level</i>	0.499 *** (5.491)							
<i>rank</i>					0.531 ** (3.341)			
<i>value</i>		0.451 ** (1.998)				0.516 ** (2.075)		
<i>risk</i>			0.406 ** (2.012)				0.492 ** (1.994)	
<i>share</i>				0.386 ** (2.135)				0.402 ** (2.285)
<i>_cons</i>	0.465 *** (3.119)	0.542 *** (3.107)	0.543 *** (3.219)	0.358 *** (3.176)	0.246 *** (2.821)	0.209 *** (2.964)	0.653 *** (3.071)	0.632 *** (3.016)
<i>control</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	816	816	816	816	816	816	816	816
<i>R²</i>	0.155	0.155	0.155	0.155	0.139	0.139	0.139	0.139
<i>F</i>	4.893	4.884	4.881	4.881	3.113	3.110	3.108	3.106

t statistics in parentheses; ** $p < 0.05$, *** $p < 0.01$.

4.4. Machine Learning Models as Complementary Predictive Exercises

Machine Learning Models as Complementary Predictive Exercises. In addition to the baseline model, this study employs machine learning methods as complementary analytical tools. It should be noted that these methods serve a purpose distinct from that of the baseline model. The baseline model is designed to estimate the association between the interest linkage mechanism and farmers' income while controlling for observed individual and regional heterogeneity. Machine learning models, by contrast, are primarily prediction-oriented and do not rely on the same parametric assumptions about functional form or distribution. We present them as supplementary exercises to examine whether the empirical patterns identified in the baseline specification are also detectable under alternative nonparametric and nonlinear modeling frameworks. This approach provides additional perspective on the consistency of the observed associations across different methodological paradigms.

Complementary Predictive Analysis Using Machine Learning Methods. This study employs the Random Forest package in R to estimate the random forest model. The random forest algorithm relies on bootstrap sampling. To control randomness, the number of bootstrap iterations is set to 10,000 to ensure the robustness of the results. In addition, the support vector machine (SVM) model is estimated using the libsvm toolbox in MATLAB 2019b, and the neural network model is estimated using the sklearn library in Python 3.5. The estimated effects of the explanatory variables on the dependent variable are reported

in Table 9. According to the results of the SVM, the coefficient of the interest linkage level is 0.117, indicating that the interest linkage mechanism between land trusteeship enterprises and farmers can increase farmers' income. The coefficients of the control variables are generally consistent with those in the baseline regression results. According to the random forest results, the coefficient of the interest linkage level is 0.026, also indicating a positive effect of the interest linkage mechanism on farmers' income. Similarly, the neural network model shows that the coefficient of the interest linkage level is 0.018, further confirming a positive impact of the interest linkage mechanism on farmers' income.

Table 9. Complementary predictive analysis results based on machine learning models.

	Support Vector Machine Model				Random Forest Model				Neural Network Model			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
<i>level</i>	0.117				0.026				0.018			
<i>value</i>		0.314				0.351				0.371		
<i>risk</i>			0.124				0.127				0.174	
<i>share</i>				0.251				0.263				0.241
<i>sex</i>	0.082	0.018	0.578	0.275	0.064	0.024	0.106	0.575	0.076	0.761	0.686	0.124
<i>age</i>	−0.722	0.263	0.388	0.446	−0.032	0.441	0.278	0.049	−0.347	0.287	0.502	0.214
<i>education</i>	0.023	0.211	0.67	0.051	0.025	0.178	0.083	0.449	0.019	0.688	0.362	0.069
<i>party</i>	0.501	0.832	0.651	0.177	0.023	0.407	0.641	0.736	0.223	0.788	0.625	0.281
<i>health</i>	0.448	0.717	0.383	0.349	0.083	0.527	0.334	0.545	0.474	0.619	0.065	0.571
<i>position</i>	0.561	0.663	0.883	0.978	0.051	0.737	0.052	0.659	0.223	0.651	0.054	0.246
<i>farmer</i>	−0.156	0.599	0.133	0.914	−0.091	0.165	0.729	0.721	−0.123	0.252	0.394	0.046
<i>labor</i>	0.102	0.051	0.401	0.943	0.553	0.194	0.006	0.184	0.683	0.103	0.653	0.204
<i>cooperate</i>	0.094	0.286	0.947	0.378	0.065	0.325	0.706	0.013	0.103	0.288	0.235	0.429
<i>fertilizer</i>	0.026	0.323	0.653	0.059	0.064	0.168	0.054	0.974	0.153	0.989	0.117	0.608
<i>watering</i>	0.071	0.824	0.464	0.795	0.054	0.254	0.231	0.214	0.065	0.196	0.021	0.207
<i>plot</i>	−0.064	0.278	0.031	0.811	−0.073	0.201	0.489	0.183	−0.086	0.672	0.379	0.274
<i>area</i>	0.095	0.238	0.092	0.671	0.024	0.117	0.197	0.469	0.097	0.016	0.367	0.358
<i>plain</i>	0.083	0.978	0.522	0.261	0.086	0.583	0.151	0.907	0.036	0.333	0.805	0.999
<i>rural</i>	0.059	0.211	0.315	0.484	0.076	0.683	0.293	0.832	0.076	0.442	0.166	0.497
<i>distance</i>	−0.093	0.144	0.145	0.895	−0.076	0.165	0.713	0.009	−0.086	0.774	0.563	0.706

5. Conclusions and Policy Implications

5.1. Conclusions

In the context of China's pursuit of common prosperity and the comprehensive advancement of rural revitalization, how to promote sustained and stable income growth for farmers has become a key issue in agricultural modernization and rural governance. This study examines the income effects of the land trusteeship interest linkage mechanism. Using regression analysis, the study verifies the income-enhancing effect of this mechanism and further conducts heterogeneity analyses across farmer types, income structures, and crop types. Finally, the consistency of the empirical patterns is examined using alternative econometric specifications, variable substitution, and complementary predictive exercises based on machine learning methods. The main findings are as follows:

First, the land trusteeship interest linkage mechanism has a significant positive effect on farmers' income, and this conclusion remains robust after a series of robustness and endogeneity tests.

Second, the interest linkage mechanism consists of three core dimensions: value cocreation focuses on the process of value generation, while risk division and profit sharing regulate how the costs, risks, and benefits arising from cooperation are allocated. These three dimensions are not substitutes but complementary institutional arrangements. Value

cocreation has the strongest income-enhancing effect, followed by profit sharing, while risk division has a relatively weaker effect.

Third, heterogeneity analysis further shows that from the perspective of farmer types, the income effect of the land trusteeship interest linkage mechanism is greatest for large, specialized farmers, followed by small-scale pure farmers, and is weakest for part-time farmers. From the perspective of income structure, the land trusteeship interest linkage mechanism significantly increases agricultural operating income, followed by wage income and transfer income. In particular, value cocreation mainly drives wage income growth, while profit sharing and risk division primarily enhance agricultural operating income. From the perspective of crop types, both the overall interest linkage mechanism and its sub-dimensions show the strongest income-enhancing effects in vegetable production, with generally stronger effects in wheat production than in maize production. Based on the above findings, the following policy implications are proposed:

5.2. Policy Implications

(1) Establishing an incentive-compatible mechanism. The key to improving the interest linkage mechanism lies in building an incentive-compatible system that aligns the interests of new agricultural business entities and ordinary farmers, thereby stimulating the initiative, enthusiasm, and creativity of different stakeholders. This approach should provide farmers with broader platforms and more opportunities. Equal emphasis should be placed on capability enhancement and income growth, with priority given to supporting new agricultural business entities that can effectively enhance farmers' capabilities and increase their incomes. Different types of business entities should be guided toward tiered and differentiated development, forming a new pattern of division of labor, complementary advantages, mutual benefit, and risk division. To achieve effective integration between smallholders and modern agriculture, policy efforts should focus on developing agricultural producer services, encouraging land trusteeship enterprises and industrial capital to lead and support smallholders, and enhancing smallholders' capacity to integrate into modern agricultural systems. The local governments should adopt tiered subsidy systems favoring enterprises with inclusive profit-sharing arrangements and establish county-level demonstration programs with clear performance indicators including farmers' income growth and number of smallholders benefited.

(2) Strengthening government guidance and services. Guided by the goals of helping, improving, and enriching smallholders, an agricultural enterprise mentorship system should be explored. At the county and township levels, agricultural economists, technicians, township officials, university graduates, and rural entrepreneurs can be hired as part-time mentors to guide, support, and coordinate the modernized, scientific, and standardized development of various business entities. A comprehensive farmer training system should be established to cultivate a large number of agricultural operators and new-type professional farmers who are passionate about agriculture, skilled in technology, and competent in management. In addition, a pilot program for creating demonstration counties for interest linkage mechanisms should be implemented nationwide. This would encourage local governments to make overall plans and coordinated efforts in agricultural enterprise development and interest linkage construction, optimize the layout of stakeholders, industries, and regions, and explore diversified support approaches to promote coordinated development among family farms, farmer cooperatives, leading enterprises, and smallholders. In terms of government guidance, it is suggested that a part-time mentor system be implemented at the county and township levels. Local agricultural experts and retired officials should be invited to assist in designing contracts and resolving disputes. At

the same time, standardized training courses should be formulated, requiring participating farmers to receive at least two training sessions each year.

(3) Improving factor allocation mechanisms within the interest linkage system. While stabilizing contract-based transactions, enterprises and farmers should be encouraged and guided to establish closer linkages through capital and production factor participation. Farmers can participate in mechanisms such as “guaranteed returns + secondary dividend distribution” and equity-based profit sharing through collective capital investment and the integration of poverty alleviation and industrial funds. The participation of farmers’ own land and capital in equity arrangements should primarily be market driven, while the government should focus on publicity, promotion, platform construction, and follow-up services. In terms of factor allocation, it is suggested to pilot the “minimum guaranteed income + secondary dividend distribution” model in some townships. The dividend calculation formula should be clearly defined, and a county-level contract registration and information disclosure service platform should be established.

Author Contributions: Conceptualization, G.L. and S.Z.; Methodology, G.L.; Software, G.L.; Writing—original draft, L.Y.; Writing—review & editing, L.Y.; Visualization, S.Z.; Supervision, S.Z., K.G. and L.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the National Natural Science Foundation of China (72503011), the China Postdoctoral Science Foundation (2024M76012), the Humanities and Social Sciences Research Project of the Ministry of Education of China (25YJCZH398), the Shandong Provincial Social Science Planning Fund Program (25CSDJ49), and the Shandong Provincial Natural Science Foundation (ZR2025QC768).

Data Availability Statement: The datasets used and/or analyzed during the current study are available from the authors upon request.

Acknowledgments: We thank the anonymous reviewers for their pertinent suggestions.

Conflicts of Interest: The authors declare no conflicts of interest.

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