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From 'separation' to 'reconstruction': An analytical framework and empirical test for the adjustment of the relationship between agriculture and animal husbandry of farm households

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Abstract: The negative benefits derived from the long-term separation of agriculture and animal husbandry in China have hindered the sustainable development of agriculture and the transformation of agricultural modernisation. The relationship between agriculture and animal husbandry is reconstructed from separation to reintegration. Focusing on the micro-agricultural production level, it relies on farmers to moderately adjust the existing family management structure and choose the family management mode combining planting and breeding. Structural and synergistic contradictions exist between agricultural economic development and ecological protection in the main corn-producing areas. Therefore, based on the micro-survey data of Jilin Province, China, the paper analyses the factors and mechanisms that influence farmers' choice of the combined management mode of planting and breeding. The results showed that the scale of land management, the stability of cultivated land management rights, the policy insurance of animal husbandry, the average profit of beef cattle head, and the cognition of income growth of animal husbandry were positively correlated with farmers' choice of the combined management mode. The spatial distance between farming and animal husbandry was negatively correlated with farmers' choice of management mode. There are mediating effects of animal husbandry breeding technology in farmers' choice of combined management mode, and there is regional heterogeneity in farmers' choice of combined management mode. Therefore, the reconstruction of the relationship between agriculture and animal husbandry should rely on large-scale farmers, optimise the planting structure of the main corn-producing areas, take multiple measures to stabilise the management right of cultivated land, and further improve the policy insurance and breeding technical support system of animal husbandry. This study can provide a theoretical framework and practical reference for reconstructing the relationship between agriculture and animal husbandry in China and other developing countries.

Keywords: combination of planting and breeding; main corn-producing areas; management structure adjustment; sustainable agricultural development

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The adjustment of agricultural internal management structure or the evolution of relations between different departments results from the change in productivity, and the change in the relationship between agriculture and animal husbandry can be regarded as its epitome. At present, China's agriculture is at the critical point of the transition from traditional agriculture to modern agriculture, and the main problem is the deviation or irrelevance of economic and ecological benefits within the production unit system, which is fundamentally the problem of agricultural management structure. The significant change in China's agriculture started with the reform of the rural management system. The management system with farmers as the basic unit injected great vitality into the development of agricultural productivity, thus initiating the historical transformation process from traditional agriculture to modern agriculture. The conventional agricultural stage is a natural and closed production system. Family production and operation are dominated by farming, and animal husbandry mainly exists in the form of sideline (excluding the production mode of nomadic ethnic groups specialising in grasing). The farming industry provides feed sources for them, mainly to meet the needs of domestic livestock products and fertilisers required to maintain cultivated land and draft animals, forming an agriculture and animal husbandry cycle mechanism within the family. The unity of economic and ecological benefits has been realised, resulting from conforming to the needs of production and life. The application of modern agricultural production technology and exogenous agricultural production means that agricultural production has completed the transformation of traditional agriculture (Theodore 1964), significantly changed production mode, and promoted the adjustment of the management structure of peasant families. Specifically, the application of modern agricultural technology and exogenous means of production has improved agricultural production efficiency and agricultural output rate and gradually completed the replacement of the manure of working animals and livestock and poultry, resulting in the separation of the dependence between planting and breeding industry within the framework of traditional family management. The derivation of several specialised farming households with a particular scale, and the agricultural production efficiency and family operating income have been significantly improved. In terms of animal husbandry, the large-scale policy preference and the policy of prohibiting and limiting animal husbandry have released the crowding out effect on the participation of small farmers in animal husbandry, accelerated the separation process of animal husbandry and family management, and gradually simplified the family management structure of farmers to the basic pattern of monoculture.

The specialised division of labor in agriculture formed under the intervention of external factors has made a significant marginal contribution to improving agricultural production efficiency. However, this specialised production in agriculture and animal husbandry has gradually evolved into a relatively independent production and management body during China's agricultural development due to the one-sided pursuit of production efficiency and the guarantee of market equilibrium in the supply and demand of agricultural products. The inter-industry linkages within the spatial scope and the interdependence within the family management structure have weakened, resulting in the separation of agriculture and animal husbandry. Separation of agriculture and animal husbandry. This long-term separation causes the material and energy cycle chain between agriculture and animal husbandry to be broken. The by-products such as straw, animal and poultry manure, and sewage produced in the agriculture and animal husbandry production chain have lost their utilisation pathways and evolved into agricultural wastes, giving rise to adverse effects on the agro-ecological environment, leading to the deterioration of agro-ecological environment in the long run, and becoming a lagging factor that affects the continuity of agricultural development, which ultimately results in the stagnation of the agricultural economic development, The result is a slowdown in the development of the agricultural economy and the loss of farmers' income. To enhance the sustainable development of agriculture and realise the green transformation of agricultural production methods, the long-term separation of agriculture and animal husbandry should be amended as soon as possible, and the relationship between agriculture and animal husbandry should be reconstructed. The so-called reconstruction establishes the inter-industry linkage between agriculture and animal husbandry in the spatial scope and the business model of combining agriculture and animal husbandry in the framework of family agricultural production. Compared with the natural integration of agriculture and animal husbandry in the traditional agricultural stage, the reconstruction of agriculture and animal husbandry relations depicted in the current stage focuses on the

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micro-management level, where the scale of operation of agricultural producers has significantly increased. The proportion of agriculture and animal husbandry tends to be coordinated to ensure that agricultural wastes can be fully embedded in the internal material-energy recycling chain within the family business structure and ensure that agricultural producers can obtain a relatively large income and no longer be limited to the closed framework of the traditional agricultural stage. This harmonisation aims to ensure that agricultural waste is fully embedded in the material-energy cycle within the family business structure and that agricultural producers receive a substantial income, no longer confined to traditional agriculture's closed, small, and dispersed operations. For China's basic agricultural situation, in which small farmers are still the main business entities, the reconstruction of the agricultural relationship still needs to pay attention to small farmers as a group. Therefore, establishing an analytical framework from the perspective of micro-agricultural producers and analysing how to promote the reconstruction of agriculture and animal husbandry relations by relying on farmers is an indispensable and essential measure to synergise the economic and ecological benefits of agriculture, protect the quality of arable land, improve food security, and expand the space for increasing the income of farmers, which is of great theoretical significance and practical value (Table 1).

From a global perspective, agricultural modernisation is improving the backward production technology and mode of production in the traditional agricultural stage, equipping agriculture with modern technology and means of production (Shi et al. 2023), emphasising the sustainability of production mode and agricultural ecological development (Maclaren 2022; Tao et al. 2023). Its essence is to adjust production factors to achieve a reasonable allocation of resources and improve the agricultural sector's competitiveness through structural reform. To build a modern agricultural production system with high yield, high quality, and low consumption (Bartolini and Viaggi 2013), the most obvious one is adjusting the relationship between agriculture and animal husbandry. Before the Green Revolution, the most critical role of livestock farming was to provide fertiliser for cereal crops, which were delivered to arable land in the form of grasing (Tilman et al. 2002). In the second half of the 20th century, the critical role of animal husbandry in providing fertiliser to the planting industry was gradually replaced by industrial waste (Cowlim and Galloway 2022). Animal husbandry has been transformed from an indispensable part of the traditional agricultural system to an independent production system and has shown a large-scale and intensive development trend (Lohrum et al. 2024). While meeting consumption demands, livestock production generated negative environmental im-

Table 1. Comparison between the integration of traditional agriculture and the reconstruction of the relationship between agriculture and animal husbandry

Index	The integration of agriculture and animal husbandry in traditional agriculture	Reconstruction of the relationship between agriculture and animal husbandry at this stage
Background	constraints on agricultural production means and household resources	improve the agricultural ecological environment and farmers' income level
Form of expression	the interdependent relationship between planting and animal husbandry in the family agricultural structure of small farmers for the demand for production materials	the material and energy circulation of planting and animal husbandry within the family agriculture structure of scale farmers at the micro level; macro-level agriculture, and animal husbandry industry integration
Mode of operation	decentralised and closed	large-scale operation and intensive production
Economic effect	low production efficiency; mainly self-sufficiency within the household, and a small amount of agricultural products are used for market trading	high production efficiency; save production costs and increase profit margin; the operational income of rural households increased significantly
Ecological effect	there is little negative effect on the ecological environment	solve agricultural non-point source pollution; improve agricultural ecological environment

Source: Author's own elaboration

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pacts hindering sustainable agricultural development (Naylor et al. 2005). The government gradually realised the adverse external effects of the deteriorating agricultural ecological environment on the farm economy and strengthened regulation by formulating relevant systems and policies (Boix and Vente 2023). When it comes to the practical aspects of agricultural production, it relies on farmers to expand the scale of their operations by integrating arable land and engaging in animal husbandry on the side to establish an integrated farming system within the production unit, which is also known as the agriculture-animal husbandry cycle, to enhance the sustainability of agricultural production (Burger 2001). Despite such integrated farming systems on traditional smallholder-run farms, growing population pressures, regional and global market forces, and sometimes misguided modern farming philosophies have shifted towards market-oriented and intensified agriculture. Such external factors have forced smallholder farmers to integrate established resources. In some countries in Southeast Asia, producers have constructed and promoted the use of a variety of integrated farming systems by gradually improving the adverse agro-ecological effects of past intensification and specialisation and by seeking synergies between the elements within the system to improve resource use efficiency (Tassilo and Sabine 2023). Specifically, by constructing integrated farming systems, some agricultural resources can be recycled and reused within the production unit and transformed into valuable products, such as organic fertiliser for crops and feed for cattle. A reasonable scale of operation can achieve the goal of zero emissions within the integrated farming system and promote sustainable economic and environmental development (Le et al. 2020).

Like other developed countries, the relationship between agriculture and animal husbandry in China has also undergone a process from the internal integration of production units to the current separation of animal husbandry from the household management structure (Guo 2021). The high input of exogenous agricultural production materials (Zhang et al. 2024), agricultural technological progress (Hu et al. 2022), and related agricultural systems have created this long-term separation of agriculture and animal husbandry (Jiang et al.2022), promoting the rapid development of Chinese agriculture, but also leading to agricultural severe ecological problems (Liu 2021; Tian et al. 2024) and hindering the sustainability of agricultural development. Additionally, after the Lewis turning point, successful practices of increasing farmer income have maintained the traditional development model and improved agricultural production efficiency, and this vicious cycle has become one of the obstacles to agricultural modernisation development (Zhang et al. 2020). China's agricultural development faces the dual problems of declining household economic benefits and deteriorating agricultural ecology, the main reason for which is the contradiction between the family-based production structure of farmers and the agricultural modernisation transformation stage. How can effective measures be taken to encourage farmers to change their production methods and achieve unified economic and ecological benefits? There are many existing studies from the micro-household perspective that have argued for various aspects of agricultural green transformation, such as farmers' value perceptions (Liu and Liu 2024), allocation of production factors (Li et al. 2023 a), driving small farmers through new agricultural operators (Zou et al. 2023), agricultural socialisation services (Li et al. 2023 b), digitalisation drive (Shen et al. 2022), policy constraints and incentive mechanisms (Ke and Huang 2024), etc. These studies have formed a multi-faceted discussion. Research on integrated farming systems has focused on reducing greenhouse gas emissions (Guo et al. 2023; Huo et al. 2024), examining and evaluating models of agro-pastoral integration and multifunctionality (Zhang et al. 2023), and optimising the benefits of production systems (Zhang et al. 2023; Jeng et al. 2024). They usually discuss the green transformation of farmers' production mode and farmers' income increase separately, pay insufficient attention to the dependence relationship between the two, lack the construction of a coordination mechanism, lack the exploration of the law of modern agricultural development, only the combination of planting and raising as an optimal countermeasure to promote the green transformation of agriculture, and less focus on the theoretical construction and mechanism analysis of the production and management subject to participate in the adjustment of the relationship between agriculture and animal husbandry. This paper's research significance lies in its focus on the micro-level decision-making of farmers' production behaviour and the reconstruction of the agriculture and animal husbandry at the macro level, specifically emphasising household business structure adjustment. The paper analyses influencing factors and action mechanisms guiding farmers' selection of combined production and operation modes within this context. The findings provide a theoretical basis and practical reference for reconstructing the agricultural-pastoral relationship.

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This paper is based on the theory of circular economy. The American economist K. Polding first proposed the circular economy in the 1960s. The main content of circular economy is to transform the traditional linear growth economy relying on resource consumption into an economy relying on ecological resource circular development in the whole process of resource input, enterprise production, product consumption, and waste in the extensive system of people, natural resources and science and technology. The circular economy theory expresses the contradiction between economic development and environmental protection. In the 1990s, the '3R' principle (Reduce, Reuse, Recycle) was put forward to extend the circular economy theory, reflecting people's understanding of development and environmental protection. Through the analysis of circular economy theory, it is found that the content expressed in this theory tends to the circular development of different systems at the macro level. Still, it lacks attention to the internal circular mechanism of micro-subjects. This paper focuses on the main body of micro agricultural management and builds the internal circulation mechanism of family agricultural management structure. At the present stage, the adverse effects of the development mode of separating agriculture and animal husbandry have become increasingly prominent in the ecological environment, farmers' income, agricultural product quality, and other aspects, especially the destruction of the ecological environment, which hinders the sustainable development of agriculture and animal husbandry and violates the circular economy theory. The micro-manifestation of the reconstruction of the relationship between agriculture and animal husbandry is that farmers choose the management mode of a combination of planting and breeding. Under the production mechanism of family agriculture, the planting industry can provide feed raw materials (including silage and straw) for animal husbandry, effectively solving the straw problem. At the same time, cultivated land can carry manure produced by animal husbandry, avoid non-point source pollution caused by random discharge of manure, and improve the quality of cultivated land. This material and energy recycling mechanism between agriculture and animal husbandry within the family fully uses agricultural waste. It solves the contradiction between economic development and ecological protection, which aligns with the essential content of the circular economy theory. This kind of circular economy established in the micro-management subject further expands the circular economy theory.

MATERIAL AND METHODS

Analytical framework and research hypothesis

Analysing the impact mechanism of large-scale land operations on farmers' decision-making in integrated agriculture and animal husbandry. Scale and ordinary farmers are the different results of the management scale in farmer differentiation. They are the essential components of the management form of family agriculture. The criteria for defining large-scale farmers have changed over time considering changes in systems, technology, and other conditions. At the present stage, a large-scale farm household is defined as one with 100 mu (approximately 6.67 ha) or more of land under open-field crop cultivation in areas with one year of ripening and 50 mu (approximately 3.33 ha) or more under open-field crop cultivation in regions with two or more years of ripening. However, in terms of production efficiency, management mode, and endogenous power of technological progress, 'scale farmers' highlight the benefits and advantages of moderate scale, which aligns with the development direction of agricultural modernisation (Zhang et al. 2024). From the perspective of animal husbandry operation, the long production cycle of animal husbandry and the production characteristics requiring almost all-weather care occupy the farm's leisure time, and there is a substitution relationship between non-agricultural employment and concurrent animal husbandry. For large-scale farmers mainly engaged in agricultural operations, field management is more complex than for ordinary farmers and requires more labor input. The family labor force is already bound in agriculture, and concurrently engaging in animal husbandry can fully release the labor force in leisure time and increase agricultural operating income. On the other hand, the relationship between the scale and productivity of Chinese farmers has moved towards or is moving towards an 'inverted U-shaped' relationship, and a land management scale that is too large or too small is not conducive to improving productivity. There are still more than 200 million small farmers in China. Under the basic agricultural situation of tight constraints on cultivated land resources, there are practical constraints on expanding the cultivated land area of large-scale farmers. When the marginal contribution of scale expansion to income decreases, and there is no time to engage in non-agricultural employment to broaden income channels, animal husbandry provides the possibility of income increase. From the perspective

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of agroecology, the large-scale policy preference for animal husbandry development and the policy of prohibiting and limiting animal husbandry within the framework of environmental regulations restrict the form of courtyard farming of ordinary farmers and further separate animal husbandry from the family operation of small farmers. Even under the conditions of meeting the relevant policy requirements and technical thresholds, ordinary farmers concurrently engage in animal husbandry and have a scale. Still, limited to the scale of cultivated land operation, they cannot carry the manure generated in the production link of animal husbandry, which quickly causes non-point source pollution and aggravates agricultural ecological problems, which are outside the characteristics of modern agriculture. On the contrary, large-scale farmers have capital reserves for concurrent animal husbandry, through which they can obtain relatively considerable income. At the same time, the cultivated land they operate can carry a certain amount of manure and avoid non-point source pollution caused by manure. In addition, the positive externalities of long-term manure return on cultivated land quality will be reflected in the direct form of crop yield increase. Then, there will be the possibility of an income increase. Therefore, the research hypothesis is proposed:

H_1: Implementing large-scale land management is a prerequisite for the practice of integrated agriculture and animal husbandry, and farmers involved in large-scale operations are inclined to adopt the integrated agriculture and animal husbandry family farming model.

The impact mechanism of land management rights stability on farmers' adoption of integrated agriculture and animal husbandry farming

Private ownership provides institutional support for the establishment of stable land rights in Western developed countries, so farmers take the initiative to care for agricultural ecology, pay attention to the synergy and interdependence of agricultural economic benefits and ecological benefits, and farmers often consciously choose the management mode of combining planting and breeding. However, collective land ownership is practiced in rural China and is the basis of the socialist system. The rural land system of separation of three rights makes it clear from the legal level that land ownership belongs to the collective. Farmers' ownership of cultivated land is only manifested as the contracting rights and management rights during the contract period, so the system design lacks the incentive mechanism of property rights, forming an extensive production mode that unilaterally pursues economic benefits and ignores soil ecology. The relationship between agricultural economic benefit and ecological benefit is destroyed. For lease farmers, verbal agreements and frequently changed farmland transfer contracts fail to establish a stable contractual relationship with the farmland transfer households, resulting in generally apathetic adoption of protective measures for farmland by lease farmers. The use of agricultural waste in the household production unit is a long-term investment behavior for the quality of cultivated land, which has the characteristics of economy and convenience. However, the ecological benefits released need to catch up. Unstable management rights cannot ensure farmers can obtain the positive externalities generated by improved cultivated land quality and therefore, need more internal motivation to invest in cultivated land quality. Farmers do not need to consider establishing a stable mechanism for utilising agricultural waste resources within their families. In this context, the potential risks of agricultural ecological deterioration on the stability and sustainability of economic benefits will still exist. Moreover, the production cycle of animal husbandry is generally longer than that of crop farming, and unstable management rights cannot guarantee the continuity of animal husbandry production, increase operational risks and transaction costs, and inhibit risk-averse farmers from concurrently running animal husbandry. Therefore, there is a correlation between the stability of land rights and farmers' attention to agroecology. Based on this, a research hypothesis is proposed:

H_2: Steady land management rights enable farmers to adopt an integrated household production model that combines agriculture and animal husbandry raising.

An analysis of the impact mechanism of animal husbandry insurance policies on farmers' decision-making in integrated agriculture and animal husbandry

Under typical market conditions, the income from animal husbandry generally exceeds that from crop cultivation. However, managing a livestock farm involves heightened production and market risks, particularly sudden disease outbreaks. These can have catastrophic effects on family-based livestock operations and compel farmers to withdraw from the indus-

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try, further widening the gap between crop cultivation and animal husbandry. The inherent risks associated with animal husbandry are crucial for farmers to consider when making decisions regarding integrated agriculture and animal husbandry.

Agricultural insurance offers pre-event risk management and post-event loss compensation (Mensah et al. 2023; Rastgoo et al. 2024). As a crucial tool for managing agricultural risks, policy-based agricultural insurance effectively compensates the post-disaster losses of new types of agricultural operators while also altering their expected marginal returns from agricultural production, thereby influencing their production behavior. It has been utilised to guide and adjust the behavior of new types of agricultural operators toward adopting green production methods. Furthermore, with financial subsidies from the central government covering the costs of raising pigs and cows through agricultural insurance. In Jilin Province, local government-sponsored feature-specific agricultural products insurance includes meat cattle, with insured individuals paying 20% of the premium while various levels of government cover the rest (Jilin Province, Department of Finance 2023). This approach allows insured individuals to obtain high coverage by paying a low premium, providing partial coverage for animal death-related losses, and guaranteeing business stability. Moreover, differentiated compensation standards based on cattle weight at the time of death have been implemented in Jilin Province's meat cattle insurance scheme to avoid neglecting differences in input costs among cattle farmers under a single standard. The comprehensive animal husbandry insurance system serves as a risk control foundation for scale farmers engaged in this sector. Additionally, timely payouts are essential for subsequent production inputs by farmers involved in animal husbandry due to significant investments and long occupying cycles associated with this industry. Therefore, the research hypothesis is proposed:

H_3: The comprehensive animal husbandry policy facilitates adopting an integrated agriculture and animal husbandry system as a family-operated entrepreneurial model.

The mediating effect analysis of animal husbandry training on farmers' adoption of integrated agriculture and animal husbandry

Animal husbandry has a high technical access threshold, especially in transitioning from traditional to modern agriculture. The professional characteristics of animal husbandry are more prominent, and higher requirements are put forward for operators regarding technology and management. Currently, farmers possess concentrated agricultural technologies and production experience in crop farming, with limited systematic knowledge and technology related to animal husbandry. Consequently, they struggle to meet the qualification requirements of combined agriculture and animal husbandry raising within the framework of modern agriculture due to insufficient skills and scattered traditional agricultural context experience in animal husbandry. Therefore, even if farmers have sufficient farmland scale for combined farming and animal husbandry but lack the necessary skills, they are inclined to avoid engaging in it. Henceforth, moderate training programs focused on animal husbandry can equip farmers with new technologies and management skills while enabling them to adapt to the demands of combined agriculture-animal husbandry modes. Currently implemented measures in Jilin Province aimed at enhancing technical training and establishing grassroots veterinary service systems have positively guided farmer participation in animal husbandry rearing activities by providing essential support. Therefore, the research hypothesis is proposed:

H_4: Animal husbandry techniques are pivotal in shaping farmers' selection of agriculture and animal husbandry business model (Figure 1).

Model selection

Probit model. This study the factors and mechanisms that influence farmers' selection of the combination of farming and breeding by adjusting the family management structure. The criterion for determining whether farmers choose the combination is based on income and the scale of the carrying capacity of cultivated land manure. In particular, the household operating income is not lower than the disposable income of urban residents, and the scale of cultivated land operated by households can bear the manure generated by the breeding industry. The explained variable is a discrete variable of 'yes' or 'no', so a binary selection model, namely the Probit model, is selected, and the model is constructed as follows:

$$P(y=1|x) = \varphi + \alpha \times Agr\_a + \beta \times \\ \times Man\_s + \theta \times Ins + \gamma \times X_{ij} + \mu_{ij} \quad (1)$$

where: P – likelyhood of farmers opting for integrated agriculture-animal husbandry; *Agr_a, Man_s* and *Ins* – alternative variables; *Agr_a* – agricultural acreage; *Man_s* – managerial stability; *Ins* – policy-based animal

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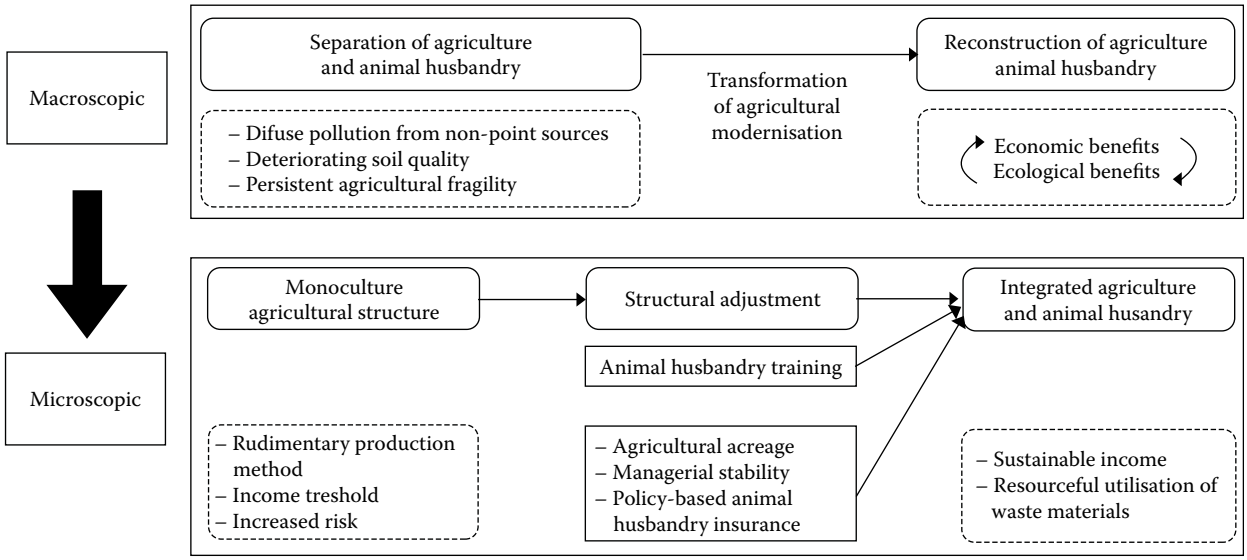

Figure 1. Diagram of the logical framework

Source: Author´s own elaboration

husbandry insurance; respectively, which are the key explanatory variables of this paper; X_{ij}– other explanatory and control variables

The other explanatory including agricultural and pastoral spatial distance (*Dis*), average profit per head of bovine animal husbandry (*Ave_p*), wages for non-agricultural payroll employment (*Wag*), raising animal husbandry on the side can increase income (*Inc_i*), effect of straw returning to the soil (*Eff_s*) and quality of cultivated land (*Qua_l*). The control variables including rural labor migration (*Rur_m*), financial ecosystem (*Fin_e*), structure of family business (*Str_b*), age, gender (*Gen*), education (*Edu*), whether village cadre (*Vil_c*) and risk tolerance (*Ris_t*). The regression coefficients α, β, θ, γ are assigned to each explanatory variable; however, it is essential to note that these coefficients do not possess direct economic significance. Further interpretation of their economic implications necessitates additional calculation of the average marginal effects of the regression coefficients. φ and μ_{ij} represent constant terms and random disturbance terms.

The selection of variables is mainly based on the following reasons. According to the general law of agricultural development and the experience of developed countries that have completed the transformation of agricultural modernisation, the combined farming business model under the framework of modern agriculture is based on a certain scale of arable land and relatively intensive management. Hence, the choice of arable land area as an explanatory variable is to explore whether there is a threshold of arable land scale for constructing the combined farming business model in China's the main maize producing areas. Cultivated land is an essential factor in agricultural production. It is also a reference factor for farmers to make production and management decisions, especially for farmers whose income from farm operations is the primary source of family income. On the other hand, unlike private ownership, the ownership of arable land in China has been clarified at the legal level, which has led to a lack of farmers' initiative to take care of the ecology of their arable land in agricultural production. The main concern that farmers generally do not make protective investments in cultivated land is that unstable management rights may cause them to fail to obtain the positive externalities generated by investment in cultivated land. Under the conceptual framework of the reconstruction of the relationship between agriculture and animal husbandry, livestock and poultry manure are embedded in the agricultural production process and used for returning farmland to improve the quality of cultivated land. Therefore, selecting the variable of farmland management stability is to explore the relationship between it and farmers' choice of combined management mode. At present, the stability of cultivated land management rights is mainly quantified by the period of signing contracts on transferred cultivated land (Li et al. 2022). Moreover, as a rational economic and risk-averse group, farmers are cautious about the inherent

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high risks of animal husbandry, and animal husbandry policy insurance can help farmers reduce risk losses. At the same time, agricultural insurance is recognised as an element promoting agricultural modernisation development (Wang et al. 2023). The spatial distance between farming and animal husbandry is one of the feasible conditions for reconstructing the relationship between farming and animal husbandry.

Regarding economic benefits, three variables were selected: average profit of beef cattle head, non-agricultural employment wage, and farmers' cognition that income can be increased by engaging in animal husbandry. For farmers, there is a conflict in the utilisation of family labor when choosing non-agricultural employment or concurrent animal husbandry. As a rational economic man, if there are relatively considerable financial benefits in the cooperation of animal husbandry, it may prompt him to choose the mode of combining farming and breeding. Two variables regarding ecological benefits were selected: the straw return effect and cultivated land quality. Although straw returning to the field can help improve the quality of cultivated land, the cold climate conditions in the main corn-producing areas in Northeast China limit the decomposition cycle of straw, resulting in the accumulation of straw in the soil, affecting the crop emergence rate and causing diseases and pests. To improve straw treatment and cultivated land quality problems, farmers may improve the utilisation rate of straw and livestock and poultry manure resources by using the combined management model of planting and breeding to solve the issues of straw treatment and cultivated land quality (Table 2).

Data collection

The data for this study is obtained from micro-level research, The main reason for taking Jilin Province as the sample area is the existence of the agricultural structural contradiction and the contradiction between agricultural economic growth and agro-ecological environmental protection, which are commonly faced by China's agricultural areas, and at the same time, as the hinterland of the main maize-producing areas, Jilin Province has the innate advantage of reconfiguring the relationship between agriculture and animal husbandry because of the location advantage and resource endowment conditions. The surveyed samples encompass the eastern, central, and western regions of Jilin Province, spanning 6 cities, 14 counties, and 52 villages. They include crop growers, livestock breeders, integrated farming entities combining both activities, part-time farming households, and non-farming households. Interviews were conducted using random sampling with a total distribution of 550 questionnaires; 521 valid responses were collected, resulting in a sample effectiveness rate of 94.73% and ensuring representativeness.

RESULTS AND DISCUSSION

Influential factors affecting the selection of integrated agriculture-animal husbandry by households: A comprehensive analysis

Baseline regression. Before conducting the baseline regression, a variance inflation factor (VIF) test was first employed to examine multicollinearity to ensure the stability and accuracy of the model's regression results. The results indicated that the VIF values for each variable were all less than 10, suggesting no multicollinearity among the explanatory variables in the model. Therefore, the Probit model can be used for regression analysis. In contrast, ordinary least square (OLS) was first used for linear probability model estimation. Model 1 reports the regression results. Model 2 adopts the Probit estimation method. The regression results show that agricultural acreage, managerial stability, and policy-based animal husbandry insurance pass the significance test at 5% and 1%, respectively, and the coefficient of each explanatory variable is positive. Specifically, the expansion of the cultivated land area, the more stable the management right of cultivated land, and the timely entry into force of animal husbandry policy insurance can incentivise farmers to choose the mode of combining farming and breeding with family management. Unlike the small and scattered production and management state presented by the natural integration of agriculture and animal husbandry in the traditional agricultural stage, the combined farming and breeding management mode required to be constructed at this stage requires moderate scale and intensive management. Therefore, under less than approximately 0.67 ha of arable land per household and scattered plots, farmers must transfer cultivated land and reach a particular scale to establish a prerequisite foundation for farming and breeding. With the deepening of urbanisation and industrialisation, the degree of differentiation of farm households has deepened, and for some farmers, the fragmented and decentralised contracted land is challenging to form a scale of efficiency, and as the price of agricultural production materials rises, compared with non-farm employment, agricultural operations gradually lose comparative advantage, so such

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Table 2. Variable settings and explanations

Variable settings	Primary indicators	Secondary indicators	Variable explanation	Mean	Standard deviation
Dependent variable	*Y*	–	0 = no; 1 = yes	0.1939	0.3957
Explanatory variables	*Agr_a*	–	hm^2	3.6609	5.9888
	Man_s	contract period for transferring farmland	year	1.0894	2.1105
	Ins	–	0 = uninsured; 1 = insured but ineffective; 2 = insured and effective	0.2860	0.5519
	Dis	the mean spatial separation between the cultivation and breeding areas	km	1.7853	1.9531
	Ave_p	the mean annual profit generated by animal husbandry farmers in the village over the preceding three years	USD 1 000 / per animal	0.7791	0.5335
	Wag	monthly wage criteria for part-time agricultural workers in the rural community	USD 1 000 / month	0.5972	0.1194
	Inc_i	–	1 = strongly disagree; 2 = disagree; 3 = indetermination; 4 = agree; 5 = strongly agree	4.2452	0.7350
Control variables	*Eff_s*	–	1 = extremely unsatisfactory; 2 = unatisfactory; 3 = average; 4 = satisfactory; 5 = extremely satisfactory	2.7255	1.4921
	Qua_l	–	1 = poor; 2 = fair; 3 = good	2.1658	0.6503
	extrinsic milieu	*Rur_m*	non-farm employment-population / total population	0.2919	0.1186
	–	*Fin_e*	1 = extremely unsatisfactory; 2 = unatisfactory; 3 = average; 4 = satisfactory; 5 = extremely satisfactory	3.6947	1.0680
	characteristics of farmers	*Str_b*	operational income from agricultural activities / aggregate income	0.6174	0.3629
		Age	years	56.3185	11.0924
	–	*Gen*	0 = male; 1 = female	0.1834	0.3874
	–	*Edu*	1 = elementary school or below; 2 = primary school; 3 = junior high school; 4 = senior high school; 5 = college or university	2.9575	0.9123
	–	*Vil_c*	0 = no; 1 = yes	0.3689	0.4918
		Ris_t	0 = low; 1 = high	0.3666	0.4823
Mediating variable	animal husbandry training	quantity of training sessions attended (*Qua_a*)	times	3.0250	5.4109

Source: Author's own elaboration

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groups of farmers gradually transfer their arable land to take part in non-agricultural employment, which provides a prerequisite basis for the expansion of the scale of operation of the farmers who have the endowment. Therefore, these farmers gradually transferred their arable land to non-farm employment, providing a prerequisite for farmers with endowments to expand their business scale. For farmers who are still involved in agricultural production, transferring arable land to expand the scale of operation and achieve intensive management is conducive to generating scale benefits, which is in line with the characteristics of modern agriculture. Regarding production and management structure, relying on a particular scale of arable land to also engage in animal husbandry, the arable land can carry animal husbandry and poultry manure. It can provide stable and diversified feed supply channels for animal husbandry. At the same time, in normal market conditions, this management structure can ensure that farmers obtain a relatively significant income increment.

Stable management rights can ensure the continuity of agriculture and animal husbandry production and establish reasonable income expectations for farmers. Specifically, against the backdrop of China's primarily entrenched agricultural land system, the only way for farmers to expand their scale of operation is through the transfer of arable land, which is essentially a transfer of the right to operate arable land between farmers, with the arable land belonging to the rural collective economic organisations. Operating a particular scale of arable land in addition to animal husbandry will absorb a large amount of capital, and it is difficult to recover it quickly in the short term, so it is crucial to ensure the long-term and sustainable nature of the operation. At the same time, the most economical and convenient way to deal with the manure generated by animal husbandry production is to return it to the field. The stable right to operate the farmland will help farmers obtain the positive externalities derived from the long-term application of organic fertilisers to the farmland in the plantation production process, which will, in turn, increase the yield of the farmland, improve the quality of the crops, and increase the income of the farmers. Therefore, stable management rights can encourage some farmers to choose the business model combining farming and raising.

Generally, a family farm with 10 ha of arable land can raise at least 50 beef cattle, 120 pigs, or 10 to 15 dairy cows. This agriculture and animal husbandry ratio can ensure that farmers can obtain considerable profits and realise the return of all manure to the field, combining farming and breeding management models with modern agricultural characteristics. But at the same time, it also increases farmers' breeding risk and income uncertainty. Especially in recent years, sudden outbreaks of epidemics have caused significant fluctuations in animal husbandry product prices in the market, and farmers have suffered losses in their earnings. Agriculture is a weak industry, subject to natural and market risks, the unpredictability of such risks increasing the uncertainty of the future earnings of farmers. For rational farmers, the adjustment of the family business structure needs to be a comprehensive trade-off to make decisions. Animal husbandry policy insurance undoubtedly gives farmers some protection for future earnings. Farmers only need to pay a part of the premium for a higher compensation standard. Although this can not fully cover farmers' production costs, it can reduce the economic losses that may result from the breeding risk to prevent the farmers from withdrawing from animal husbandry production and management due to the high losses again.

The spatial distance of agriculture and animal husbandry was negatively correlated with farmers' choice of family management mode, indicating that the average distance between the farming area and the breeding area was longer and the average distance between the farming area and the breeding area was longer, which inhibited farmers' choice of farming and breeding combination. The main reason is to increase the labor input and transportation cost in the production link. In particular, the existing policies strictly restrict the use of cultivated land, and family animal husbandry is limited to the courtyard, which sets up obstacles for the integration of agriculture and animal husbandry space. The cognition of income growth of beef cattle head profit and concurrent animal husbandry positively correlates with farmers' choice of combined farming and family management mode, passing the significance test at 1% and 5%, respectively. Non-agricultural employment wage negatively correlates with farmers' choice of combined farming and family management mode, failing the significance test. Specifically, concurrent animal husbandry and migrant work are the leading choices for farmers who want to use seasonal slack to achieve employment, and there is a relationship between them. According to the livelihood ladder theory, not all households can enter high-yield livelihood strategies or exit low-yield livelihood strategies due to the constraints of household asset endowment or capital endowment. For small-scale farmers, their livelihood strategies remain unchanged. Farmers with a particu-

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lar scale of arable land have the advantage of resource endowment, which can upgrade strategy transformation. As a rational economic person, compared with ordinary farmers, they have a more full and comprehensive cognition of the income increase of concurrently running animal husbandry. Farmers usually have a wait-and-see mentality when making production behavior decisions. Regarding animal husbandry operation, the profit level of other farmers in the village has a specific reference value for their production decisions. The higher the profit level, the more it can drive farmers to concurrently engage in animal husbandry, which aligns with the profit maximisation goal of farmers' family operations. Straw return effect and cultivated land quality also passed the significance test at 1% level (Table 3).

Robustness test. This paper uses two strategies to test robustness: one is to replace the model, and the second is to intercept the sample. Model 3 adopts the Logit estimation method, and the results show that the core explanatory variables all pass the significance test at the 1% level. The coefficient is positive, consistent with the benchmark regression. Model 4 is the regression result of excluding the sample of non-farmers. The basis for judging non-farmers is that the proportion of household operating income in total income is less than 20% (Wen et al. 2017), and the primary consideration is that agricultural operating income is not the main source of income for this group, lacking the internal motivation and labor input time to adjust the household management structure. In the regression results, the core explanatory variables all passed the significance test at the 1% level. The coefficient was positive, consistent with the baseline regression (Table 4), and research hypothesis 2 and research hypothesis 3 were verified.

Heterogeneity analysis. To further test whether the difference in cultivated land scale of farmers' management affects their choice of combined farming mode, this paper divides farmers into large-scale and ordinary farmers. China's criteria for large-scale farmers are combined with the crop ripening system. For areas with one cropping system a year, farmers with a cultivated land area of more than 6.67 ha are defined as large-scale farmers, among which the main corn-producing regions of Northeast China belong to the one cropping system a year. The regression results of Model 5 shows that the core explanatory variables have passed the significance test, and the regression coefficient is consistent with the benchmark regression. The regression results of model 6 shows that the core explanatory variables fail to pass the significance test. In a word, the cultivated land area and stable management rights of large-scale farming are essential factors for farmers when choosing between farming and farming. The cultivated land that ordinary farmers have not reached the threshold of large-scale management cannot support their choice of the combination of farming and farming, which is reflected in the small scale of the cultivated land they manage, the lack of resource endowment advantages, and the seasonal characteristics of planting production provide them with relatively continuous and sufficient time for concurrent farming. On the contrary, large-scale farmers, that is, farmers with arable land operating area of more than 6.67 ha, have formed a binding relationship with agriculture. The combination of farming and farming mode has made up for the opportunity cost caused by family labor, giving up non-agricultural employment and obtaining considerable income. At the same time, it can effectively carry the manure generated by the breeding process. Therefore, large-scale farmers are the dependent subjects in reconstructing the relationship between agriculture and animal husbandry, and research hypothesis 1 has been verified (Table 5). Further analysis shows a significant demand for capital in animal husbandry operations, and ordinary farmers usually have shortcomings in agricultural production funds, so it isn't easy to support the extension of family agricultural operations to animal husbandry. Ordinary farmers generally maintain a cautious attitude towards concurrent animal husbandry. Compared with ordinary farmers, large-scale farmers have advantages in obtaining production capital accumulation through agricultural operation, which can support their production behavior of concurrently engaging in animal husbandry, and large-scale operation conforms to the law of agricultural modernisation.

The sample farmers were classified according to maize and rice-growing areas to test whether there is regional heterogeneity in farmers' selection of the combined management model. The regression results of model 7 shows that the core explanatory variables all pass the significance test in the area dominated by corn planting. Model 8 reports the results of sample estimation based on rice planting, and none of the core explanatory variables passes the significance test.

The main reason is that rice and maize's functional attributes differ. Rice is China's basic food ration, mainly food consumption, and plays a vital role in guaranteeing food security and the construction of a combined planting and raising business model in rice-growing areas is not yet able to effectively form a closed loop of the material-energy cycle, and the

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Table 3. Baseline regression result

Variable name	Model 1 OLS regression	Model 2 Probit regression
Agr_a	0.0083***	0.0566**
	(0.0029)	(0.0231)
Man_s	0.0523***	0.2325***
	(0.0075)	(0.0586)
Ins	0.1657***	0.5214***
	(0.0268)	(0.1705)
Dis	-0.0355***	-0.2577***
	(0.0078)	(0.0961)
Ave_p	0.1767***	1.1333***
	(0.0361)	(0.2790)
Wag	-0.1316	-1.5718
	(0.1551)	(1.2452)
Inc_i	0.0431**	0.3970**
	(0.0172)	(0.1676)
Eff_s	-0.0397***	-0.2435***
	(0.0088)	(0.0739)
Qua_l	0.0591***	0.5458***
	(0.0207)	(0.1951)
Rur_m	0.0012	0.6306
	(0.1140)	(0.9439)
Fin_e	0.0056	0.1209
	(0.0125)	(0.0977)
Str_b	0.0483	0.9925**
	(0.0424)	(0.4148)
Age	-0.0017	-0.0021
	(0.0013)	(0.0105)
Gen	0.0073	0.1375
	(0.0319)	(0.2606)
Edu	0.0127	0.0693
	(0.0156)	(0.1288)
Vil_c	0.0101	0.0792
	(0.0273)	(0.2104)
Ris_t	0.0919***	0.5084**
	(0.0323)	(0.2301)
_cons	-0.0766	-3.9281***
	(0.1464)	(1.2850)
F	33.3913	–
R-squared	0.5302	–
Adj *R*-squared	0.5143	–
Prob > F	0.0000	–
Prob > chi2	–	0.0000
N	521	521

***,**,* Indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Author's own elaboration

Table 4. Robustness test

Variable name	Replacement model	Reduced sample
	model 3 logit regression	model 4 probit regression
Agr_a	0.1227***	0.0689***
	(0.0453)	(0.0248)
Man_s	0.3853***	0.2467***
	(0.1072)	(0.0598)
Ins	0.9414***	0.5194***
	(0.3155)	(0.1798)
Dis	–0.5885***	–0.3041***
	(0.2111)	(0.1049)
Ave_p	2.0935***	1.2123***
	(0.5420)	(0.2884)
Wag	–2.6241	–2.0443
	(2.4102)	(1.3080)
Inc_i	0.6971**	0.3817**
	(0.3255)	–0.2945***
Eff_s	–0.4692***	(0.0794)
	(0.1390)	0.6587***
Qua_l	0.9521***	(0.2146)
	(0.3655)	–0.2945***
Control variables	controlled	controlled
_cons	–7.1884***	–2.7092*
	(2.4206)	(1.4261)
Prob > chi2	0.0000	0.0000
N	521	407

***,**,* Indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Author's own elaboration

link between agriculture and animal husbandry may be established as a single cycle in which animal husbandry and poultry manure are returned to the field for utilisation as organic fertiliser and there is a lack of economy of scale. The link between cultivation and animal husbandry may be a single cycle of animal husbandry and poultry waste being used as organic fertiliser, and there is no economy of scale. Corn, from the functional attributes of the level of observation, is completed by the ration to the transformation of feed grains, whether it is seed corn or silage corn, is an important feed material for animal husbandry, especially silage maize is a modern agricultural framework, animal husbandry in the feed structure of an essential part of the components. At the same

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Table 5. Regressional findings on heterogeneity in agricultural land holdings

Variable name	Large-scale farmers	Ordinary farmer
	model 5 probit regression	model 6 probit regression
Agr_a	0.0634*	0.9499
	(0.0336)	(0.6302)
Man_s	0.2215**	0.2407
	(0.0920)	(0.2241)
Ins	0.9558***	0.0442
	(0.3149)	(0.6500)
Dis	–0.3433**	–0.5586
	(0.1345)	(0.4576)
Ave_p	3.2936***	2.2890**
	(0.7159)	(1.1378)
Wag	–2.7506	0.8460
	(1.8247)	(4.6293)
Inc_i	0.6292*	0.9004
	(0.3261)	(0.7145)
Eff_s	–0.7214***	-0.0715
	(0.1910)	(0.2688)
Qua_l	1.8222***	2.0929**
	(0.5606)	(0.8947)
Control variables	controlled	controlled
_cons	–7.7476***	–11.1904*
	(2.8683)	(6.4320)
Prob > chi2	0.0000	0.0000
N	159	362

***,**,* Indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Author's own elaboration

Table 6. Regional heterogeneity regression results

Variable name	Corn cultivation region	Regions suitable for rice cultivation
	model 7 probit regression	model 8 probit regression
Agr_a	0.0802**	0.0809
	(0.0348)	(0.0989)
Man_s	0.2069***	1.5694
	(0.0760)	(0.9877)
Ins	0.9470***	4.2549
	(0.2537)	(3.4519)
Dis	–0.4629***	–0.9162
	(0.1509)	(0.6797)
Ave_p	0.5957*	5.9339
	(0.3646)	(3.7186)
Wag	–5.7641**	–2.9234*
	(2.4463)	(1.6909)
Inc_i	0.2551	3.6965*
	(0.2261)	(2.1694)
Eff_s	-0.2600**	0.4005
	(0.1119)	(0.7275)
Qua_l	0.4590*	4.9089*
	(0.2555)	(2.9644)
Control variables	controlled	controlled
_cons	0.5047	–7.7036**
	(1.8324)	(3.3996)
Prob > chi2	0.0000	0.0000
N	289	232

***,**,* Indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Author's own elaboration

time, the reduction of seed maize to plant silage maize, complete the transformation of maize form, is the main maize producing area for a long time, and the deformed structure of seed maize planting is the main effective adjustment. The combined farming business model established in the maize production area can form a closed loop of material and energy circulation and agricultural waste is transformed into production factors and embedded in the agricultural production chain again. Moreover, rice planting in Jilin Province has a comparative advantage over corn in terms of net profit per unit area [National Cost-Benefit Data Compilation for Agricultural Products (2019–2023)]. With the expanded cultivated land scale, rice farmers can gain scale benefits and increase income. Therefore, even if the cultivated land area reaches the scale management standard, it can not be a factor in encouraging rice farmers to choose the combination of planting and breeding. Thus, it is verified that there is regional heterogeneity in the choice of farming households to combine family business models, which is based on differences in the functional attributes of crops and comparisons of the economic efficiency of agriculture (Table 6).

Mediation analysis testing

This study has chosen animal husbandry training as the mediating variable and utilised stepwise regression to identify and test the mediation effect (Edwards

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Table 7. Mediation effect test

Variable name	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 7
	Y	*Qua_a*	*Y*	*Y*	*Qua_a*	*Y*	*Y*	*Qua_a*	*Y*
Agr_a	0.0198***	0.1607***	0.0140***	–	–	–	–	–	–
	(0.0028)	(0.0390)	(0.0024)	–	–	–	–	–	–
Man_s	–	–	–	0.1028***	0.9913***	0.0753***	–	–	–
	–	–	–	(0.0070)	(0.1050)	(0.0069)	–	–	–
Ins	–	–	–	–	–		0.3859***	6.5679***	0.2363***
	–	–	–	–	–		(0.0265)	(0.3195)	(0.0344)
Qua_a	–	–	0.0362***	–	–	0.0278***	–	–	0.0228***
	–	–	(0.0027)	–	–	(0.0027)	–	–	(0.0035)
_cons	0.1213***	2.4367***	0.0331	0.0815***	1.9423***	0.0276	0.0835***	1.1466***	0.0574***
	(0.0194)	(0.2737)	(0.0179)	(0.0164)	(0.2474)	(0.0158)	(0.0165)	(0.1985)	(0.0164)
F	51.3100	16.9500	125.6800	217.4700	89.1700	186.2900	211.6100	422.5500	135.2500
R-squared	0.0900	0.0316	0.3267	0.2953	0.1466	0.4184	0.2896	0.4488	0.3431
Adj *R*-squared	0.0882	0.0298	0.3241	0.2939	0.1450	0.4161	0.2883	0.4477	0.3405
N	521	521	521	521	521	521	521	521	521

***,**,* Indicate statistical significance at the 1%, 5%, and 10% levels, respectively
Source: Author's own elaboration

and Lambert 2007). Model 9 is considered the baseline regression, while Model 10 demonstrates a significantly positive regression coefficient of farmland area on animal husbandry techniques. In Model 11, the regression coefficient for farmland area decreases when considering its impact on farmers' adoption of integrated agriculture-animal husbandry systems, providing initial evidence for the mediating effect of animal husbandry techniques. Further verification using Sobel testing for mediation effects yields a *Z*–value of 3.9380, significant at the 1% level, thus confirming the presence of a mediation effect. Models 12–17 also support this finding (Table 7), validating research hypothesis 4 by indicating that upon reaching a particular scale of cultivated land and with stable farmland operating rights in place, timely implementation of animal husbandry policy insurance alongside matured animal husbandry techniques can facilitate farmers' choice to adopt integrated agriculture-animal husbandry systems.

CONCLUSION

The marginal contribution of this paper is to focus on the macro-institutional design of the reconstruction of agriculture and animal husbandry relations on the micro-agricultural business subjects, to construct the theoretical analysis framework of this paper, to analyse the main agricultural business subjects at this stage in China, and how farmers should be integrated into the mechanism of the reconstruction of agriculture and animal husbandry relations, which provides the theoretical basis and practical references for the advancement of the transformation of the modernisation of agriculture, and the articulation of the small-scale farming households with the modern agriculture. The results of this paper show that, firstly, there is a positive correlation between the area of operating arable land, the stability of arable land management rights and animal husbandry policy insurance, and the choice of farming households to combine agriculture and animal husbandry with the business model, which is the main influencing factors. Scale operation of arable land is the generating condition for farmers to choose the combination of agriculture and animal husbandry, and scale farmers are the relying main body of reconstructing agriculture and animal husbandry relationship, and stable arable land management right and timely and effective animal husbandry policy insurance is conducive to promoting farmers to choose the combination of agriculture and animal husbandry management mode. Secondly, there is a negative correlation between agriculture and animal husbandry

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spatial distance and farmers to choose the combination of agriculture and animal husbandry family business mode, and the further the spatial distance between agriculture and animal husbandry, the more inhibited farmers to choose the combination of agriculture and animal husbandry family business mode. Thirdly, the average profit per head of beef cattle and the perception of income growth from part-time animal husbandry are positively correlated with farmers' choice of combined farming and raising family business model, i.e., farmers' good income expectations of animal husbandry will motivate farmers to rationally arrange the scale of animal husbandry business based on the scale of their existing arable land. Fourthly, there is regional heterogeneity in farmers' choice of combined farming and raising, and there is a mediating effect of animal husbandry training in farmers' choice of combined farming and raising business model. Corn-growing areas are more endowed than rice-growing areas in promoting the combined farming and raising business model. Animal husbandry has a high technical threshold, and mature farming techniques can support farmers in choosing a combined farming and family business model. Therefore, to promote the restructuring of agriculture and animal husbandry in an orderly manner, China should rely on large-scale farmers and follow the principle of 'land-based farming' to establish a moderately large-scale family business model combining agriculture and animal husbandry to achieve the full transformation of agricultural wastes into usable inputs that can be embedded in the family business mechanism of agriculture, and to realise the unity of economic and ecological benefits. At the same time, to ensure the continuity and stability of farmers' operations, to motivate farmers to choose the combined family business model, and ensure that they can obtain the positive external effects of this business model, efforts should be made to maintain the stability of arable land management rights, regulate the land transfer market, establish a sound land transfer mechanism, provide farmers with arable land transfer information service platform, and the transfer of land to both sides of the farmers in the process of multiple violations of the farmers' behavior into the credit blacklist. Secondly, the government should further improve the animal husbandry policy insurance through financial subsidies, reduce the proportion of premiums paid by farmers, and, according to changes in the market situation of the animal husbandry industry, adjust the insurance payout standards, reduce the economic losses, of farmers due to the death of animal husbandry. At the same time, in the face of sudden outbreaks of disease caused by the market price of animal husbandry products due to the imbalance between supply and demand, the government should take the necessary measures to maintain market equilibrium promptly, for example, through the market storage or put the relevant animal husbandry products and so on. Furthermore, it should focus on promoting the reconstruction of agriculture and animal husbandry relations by relying on corn-growing areas and allowing farmers to use general arable land to set up animal husbandry barns without destroying the basic functions of the arable land to strengthen the spatial connection between the cultivation industry and the animal husbandry industry. For farmers in rice-growing areas, financial incentive measures can be taken to promote the integration of the single operation subjects of planting industry and animal husbandry, and the exchange and utilisation mechanism of straw and livestock and poultry manure between rice farmers and animal husbandry farmers can be established mainly through proximity cooperation. Appropriate subsidies can be given to farmers and farmers according to the weight of straw collection and the area of manure application. Reduce the cost of agricultural waste resource utilisation and form the integration of agricultural and animal husbandry simple management subjects. Finally, the technical support system for animal husbandry should be improved to provide farmers with the latest farming technology and management experience.

The reconfiguration of agriculture and animal husbandry relations explored at this stage is a composite concept, including both macro agriculture and animal husbandry spatial inter-industry linkages, but also includes micro-level integration within the production structure of the main body of the production and the integration between different business subjects, and this paper only explores the integration of agriculture and animal husbandry within the structure of the micro business subject family business. The limitation of this study is that the sample farmers selected only include the hinterland of the main corn-producing area in Northeast China and the sample farmers in Jilin Province, and the sample data of other agricultural areas are lacking, so the sample data capacity may be small. Therefore, in the follow-up study, we will focus on increasing the sample data of common ag-

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ricultural areas to enhance the study's scientific results further. In selecting variables, this paper only analysed the correlation between the spatial distance between farming and animal husbandry and farmers' choice of the combination mode of breeding and cultivation. It did not further explore the correlation between the threshold value of spatial distance and farmers' choice of the combination mode of breeding and cultivation. Our subsequent research work will adjust this point. At the same time, based on the study of micro farmers, we will explore how to reconstruct the relationship between agriculture and animal husbandry in other agricultural areas (including other crop varieties growing areas) and at the macro level.

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